THE NONACTINIDE ISOTOPES AND SEALED SOURCES MANAGEMENT GROUP

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ABSTRACT

The Nonactinide Isotope and Sealed Sources Management Group (NISSMG) is sponsored by the Department of Energy (DOE) Office of Environmental Management and managed by Albuquerque Operations Office (DOE/AL) to serve as a complex-wide resource for the management of DOE-owned Nonactinide Isotope and Sealed Source (NISS) materials. NISS materials are defined as including: 1.) any isotope in sealed sources or standards; and 2.) isotopes, regardless of form, with atomic number less than 90. The NISSMG assists DOE sites with the storage, reuse, disposition, transportation, and processing of these materials. The mission of the NISSMG is to enhance the effective management of NISS materials in the DOE complex by:

- Facilitating the *Paths to Closure* (1) strategy by providing assistance to closure sites and closure facilities to ensure timely shipment of their NISS materials from these sites and facilities.
- Implementing DOE's pollution prevention strategies by providing an effective mechanism for the reuse and recycle of NISS materials.
- Enhancing worker and public safety by reducing inventories of excess NISS materials in the DOE complex and thereby reducing the potential for loss of control of these materials.
- Reducing costs and risks associated with the management of NISS materials by sharing knowledge and developing procedures for common NISS materials management activities.
- Reducing costs associated with acquiring and disposing NISS materials by providing effective systems that ensure that these materials are reused or recycled whenever possible.

The NISSMG has focused its efforts to date at DOE closure sites due to the immediacy of their problems. Recently, these efforts were broadened to include closure facilities at non-closure sites. Eventually, the NISSMG plans to make its resources available to all DOE sites. This paper documents the lessons learned in managing NISS materials at DOE sites to date.

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NUCLEAR MATERIAL INTEGRATION

On January 20, 1998, the DOE Office of the Deputy Assistant Secretary for Nuclear Material and Facility Stabilization (then DOE/EM-60) initiated the Nuclear Material Integration (NMI) Project. The goals of the NMI Project were to inventory and analyze the nuclear materials in the DOE Complex. The scope of this project included not only materials owned by EM but also those owned by other programs and stored in EM facilities. In addition, materials expected to transfer to EM ownership by 2015 were to be considered. The purpose of the analysis was to support both risk and mortgage reduction efforts in the complex and to make recommendations for material management and disposition. The ultimate goal of this effort was to develop a comprehensive nuclear material management plan for the complex in support of EM's accelerated cleanup vision.

Four teams were formed to implement the NMI Project. Three material management teams were responsible for the different groups of materials in the DOE Complex:

- Transuranic (TRU) Team, responsible for most transuranic elements
- Uranium/Thorium Team, responsible for most uranium and thorium materials
- NISS Team, responsible for all radioactive isotopes with an atomic number less than 90 and all sealed sources, irrespective of atomic number.

The fourth team formed was the Integration Team, which has responsibility for overall project direction and coordination among the material teams.

While the TRU and Uranium/Thorium Teams could focus on a relatively small number of sites, the NISS Team had a much broader range of sites and facilities to survey. In the first phase, the NISS team focused on acquiring site inventory data for NISS materials and understanding the site baseline for these materials. During this project phase, the NISS Team met with representatives of more than 30 sites in the DOE Complex. The team developed a complex-wide database of NISS materials, which includes more than 33,000 records and 72 million curies of material, mostly representing small quantities items (<10 curies) in diverse chemical and physical forms. This database provides the most comprehensive overview to date of the magnitude of the complex-wide problems associated with NISS materials. From the database, the NISS Team developed baseline disposition maps to capture site plans for these materials and elicited site perspectives on their capabilities to execute these baseline plans.

In the second phase of the NISS Team effort, the team evaluated site baseline plans and disposition path maturity and explored opportunities for improvement. In this project phase, the NISS Team worked with site material managers and the other NMI material teams to develop a complex-wide view of NISS materials. Several common problems were identified across the sites, and the team developed 15 alternative disposition paths to address issues. Most of the alternatives used cross-site resources to attempt to resolve problems not well suited to single-site resolution. The 15 alternative disposition paths were then applied to the site baselines that had been defined in the initial evaluation. The applied alternatives provided a technically defensible disposal path for the undefined material streams. After this alternatives analysis was completed, a much smaller group of orphan materials with no clear disposition path remained. The NISS team documented these efforts in a material management plan (2).

NISSMG CLOSURE SITE ACTIVITIES

After completing its report, the NISS team continued to assist the sites in transferring or dispositioning orphan materials. The continued need for cross-site support and communication regarding orphaned NISS materials had been recognized as a critically needed activity and was supported by DOE/AL. As a result of these activities, the NISSMG was created from the NISS team, under DOE/AL sponsorship. The initial efforts of NISSMG were focused on closure sites, where NISS materials were either already impacting the critical path to closure, or threatening to do so. The primary sites assisted to date are the Miamisburg Environmental Management Project (Mound Plant), the Fernald Environmental Management Project (FEMP), the Ashtabula Environmental Management Project / Reactive Metals Incorporated Site (RMI), and the Rocky Flats Environmental Technology Site (RFETS). Because the work at the Mound Plant has been completed, it is discussed in detail below.

Mound Plant

To meet the aggressive schedule to close the Mound Plant, the NISS Team began work in April 1998 with the DOE Ohio Field Office and the Mound Plant to disposition the Mound Plant's nuclear materials. The NISS team helped complete the Mound Plant's material disposition planning effort, which led to successful disposal of the high-enriched uranium (HEU) from the Mound Plant's californium reactor in August 1998. Since that time, the business relationship has become a partnership between the Mound Plant and the NISSMG, who were both industrious and innovative in successfully disposing of all excess nuclear material at the Mound Plant by the end of FY 2000. Their accomplishments are described as follows.

1. The Mound Plant program baseline included disposal of ionium (thorium-230 {Th-230}) as low level radioactive waste (LLW). The ionium had been used in the production of protactinium-231 (Pa-231) by neutron capture. This was problematic due to the high activity of the residual Pa-231 as a waste form and the high cost of characterization to meet the waste acceptance criteria (WAC) of the Nevada Test Site (NTS). NISSMG analysis determined that Pa-231 is one of the unique and special isotopes in the DOE complex. The NISSMG leveraged the existing assets at the Oak Ridge National Laboratory's (ORNL's) Chemical and Analytical Sciences Division to receive the contaminated ionium to separate and purify the Pa-231 for beneficial use. The residual material could only be disposed of as LLW after the Pa-231 was separated. Since DOE is no longer producing Pa-231, the Mound Plant's stockpile of Pa-231 was virtually all that remained. The Pa-231 stockpile will allow scientists to perform fundamental research on the physics of protactinium solids and vapor state chemistry of protactinium-based compounds. This process not only disposed of an excess nuclear material, but also provides a valuable isotope (Pa-231) for use in meeting DOE's nuclear material stewardship responsibility of providing national resource materials.

2. Due to the closure activities, the Mound Plant has very limited material characterization capability. Not only did the NISSMG facilitate a meeting with a private sector company that could provide mobile characterization capability, the private sector company provided as a demonstration (at no cost to DOE) the waste profile for the cadmium moderator blades from

the californium reactor. This demonstration met Envirocare's WAC, which enabled the Mound Plant to dispose of the cadmium moderator blades.

3. The Mound Plant had several neutron sources that were very problematic because of the activity level and the chemical composition [plutonium-238 (Pu-238)/ fluoride (F) and Pu-238/oxygen-18 (O-18)]. Los Alamos National Laboratory (LANL) was unable to support their disposition, making these sources orphans. The NISSMG developed a strategy where Pu-238 will be separated from the light elements and recycled for research and development efforts at ORNL in support of Office of Nuclear Energy (NE-50) activities in the Space Program.

4. The Mound Plant had a significant amount of curium-243 (Cm-243) with no path for disposal. NISSMG identified options to reuse this material at ORNL that enabled the Mound Plant to ship the material off site for use in other DOE programs.

5. The Mound Plant program baseline included disposal of one kilogram of thorium as LLW, in agreement with the general recommendations contained in the Material Management Plan for Thorium (Th) (3). NISSMG identified a use for the thorium at the ORNL Thorium Laboratory. The thorium material was subsequently shipped to ORNL, saving the relatively high cost of characterizing and disposing of this material.

6. There were several uranium-233 (U-233) sources left from the Mound Plant's former weapons mission activities. The NISSMG's evaluation revealed that U-233 sources are being manufactured at the ORNL Thorium Laboratory. In integrating the excess U-233 sources into the inventory at Oak Ridge, the Mound Plant was able to ship this material off site for reuse within the DOE nuclear materials complex.

7. A commercial sealed-source vendor estimated a cost of $480,000 to dispose of a large cobalt-60 (Co-60) 600-curie (Ci) source from the Mound Plant as LLW. The Mound Plant and NISSMG determined this was not cost effective and established an alternate disposal path using the NTS as LLW.

8. The Mound Plant had over 200 grams of orphan plutonium-239 oxide ($^{239}PuO_2$) containing 0.8% Pu-238 and 12% Pu-240 (by weight). The Savannah River Site (SRS) had agreed to take the material, but transportation issues relative to hydrogen gas generation had to be resolved before it could be shipped. The NISSMG conducted a gas generation analysis and evaluated Department of Transportation (DOT) and DOE shipping requirements. The characterization of hydrogen gas generation for the Mound Plant's Pu-239 had to be conducted with available historical process knowledge and current radiography, because the Mound Plant did not have even a glove box available to support limited repackaging of the existing containers.

   A method was developed to analyze the pressure buildup and hydrogen concentration within the shipping container. The NISSMG team used bounding calculations with several levels of conservatism for the gas generation, since the history, condition, and moisture of the PuO_2 could not be known to adequate precision. The NISSMG team applied existing theoretical

modeling with available experimental data to a real-world application with limited data, time, and facilities. The NISSMG team developed a technical basis and promoted coordination between the DOE sites that allowed for shipment of these materials on October 9, 2000, meeting a site closure milestone. The truck leaving the site with the Mound Plant plutonium materials is shown in Figure 1.

Fig. 1. FedEx with Pu-239 leaving Mound Plant

9. The Mound Plant program baseline included shipping 38 grams of americium-241 (Am-241) to LANL for disposal. NISSMG explored commercial sale for reuse as feed material for neutron sources. However, the Mound Plant was unable to characterize this material in sufficient detail for this option. After consulting with NISSMG, the Am-241 was transferred to the Mound Plant TRU waste program for disposal.

The NISS materials disposition activities at the Mound site are summarized in the Nuclear Material Disposition Maps presented in Figures 2 through 4. The inventory of NISS materials at Mound is grouped by material category and shown in the boxes down the left side of the figure. The boxes going to the right then summarize the activities required to remove the materials from the site and identify the end states for the materials. All materials indicated in gray were part of the initial assessment performed during the NISS team site visit in 1998; materials indicated in red were identified at later dates. Material streams where the NISSMG provided substantial assistance are indicated. Shipping dates are shown for all materials. As can be seen, the Mound site achieved its goal of removing all major nuclear materials from the site by the end of fiscal year 2000.

The end result of the NISSMG support activities at the Mound Plant is that all the nuclear material has been dispositioned, thus reducing the mortgage costs in security, safeguards, and technical support.

Other Closure Sites

Other closure site activities have included the development of baseline nuclear materials disposition plans for RFETS, FEMP, and RMI. These plans examine the inventories of NISS materials at these sites and group the materials based on similarity of chemical, physical, and

radioactive properties. For each material group, recommendations of disposition alternatives are provided and a disposition path recommended. The NISSMG provides these recommendations in the form of summary reports to each site. The NISSMG can provide technical assistance to the sites on an as-requested basis during the implementation phase of each of these plans. More information on these site assistance activities can be found in Reference 4. It was this implementation assistance that proved essential in completing the successful de-inventory of the Mound Plant.

OTHER NISSMG SITE SUPPORT ACTIVITIES

In fiscal year 2001, the NISSMG continued to provide technical assistance to the RFETS, FEMP, and RMI sites. Also, the NISSMG visited Pacific Northwest National Laboratory (PNNL), Idaho National Environmental Engineering Laboratory (INEEL), the East Tennessee Technology Park (ETTP), and Brookhaven National Laboratory (BNL). During these site visits, disposition plans for all nuclear materials were reviewed and recommendations were provided for materials without a defined disposition path. A formal materials management and disposition plan was provided to PNNL that made recommendations for all NISS materials at the site. At BNL, disposition options were identified for an Am/Be neutron source that was a critical path item in the downgrade of Building 445.

The NISSMG also worked with Lawrence Livermore National Laboratory (LLNL) to develop a plan for accelerating the removal of nuclear materials from their Building 251 facility. This plan identifies reuse and recycle options for more than two thirds of the inventory and saves an estimated $5M over the baseline plan for the facility. In addition, execution of this plan would return rare and unique materials currently stored in Building 251 to beneficial use. The NISSMG plans to continue its partnership with LLNL in FY 2002 to assist in the implementation of this plan.

The NISSMG hosted a small sites needs workshop on September 11-12, 2001. This first-of-a-kind workshop brought together representatives from 19 sites with 8 service providers that could assist them with their materials disposition issues. During the workshop, 49 site-specific needs were matched with service provider capabilities. The NISSMG immediately initiated follow-on activities with two of the workshop participants, Fernald and Grand Junction, to address specific issues identified during the workshop. Another workshop is planned for the spring of 2002 and 27 additional small sites have expressed an interest in attending.

OTHER NISSMG ACTIVITIES

When the NISSMG identifies issues that affect a large number of sites in the complex, or that have substantial impacts at a more limited number of sites, "trade studies" are initiated to bring together groups of technical experts from across the complex to make recommendations regarding these issues. In August 2001, the NISSMG completed a trade study for large curie cesium and strontium items in the DOE complex (5). This trade study determined that there was no driver for major changes in the management of these items, but that an opportunity exists to

dispose of many smaller cesium and strontium items as LLW. Other trade studies currently in progress address neutron sources, liquid technical materials and standards, and special performance assessment required (SPAR) material. All but the SPAR trade study are expected to be completed in FY 2002.

LESSONS LEARNED

The NISSMG work on orphan materials at DOE has produced a number of lessons learned. These include:

- ***NISS materials will impact the critical path to closure for sites and facilities*** - Closure sites naturally focus on the larger quantities of problematic materials that must be removed from the site and tend to delay work on NISS materials until they are close to their closure date. It is easy to underestimate the difficulty associated with identifying appropriate disposition options for a diverse group of NISS materials. The lead times to find receiver sites and make transportation arrangements can also be significant. In addition, NISS materials are often neglected until after critical site facilities have been closed, increasing the challenges associated with characterizing and packaging the materials for off-site shipment. Delays in addressing NISS materials issues can also result in lost opportunities, as key elements of infrastructure, such as processing facilities or transportation containers, may no longer be available. This combination of factors can make NISS materials a significant driver as closure deadlines approach.

- ***Expect growth in NISS materials inventories from initial assessments*** - As most NISS materials are not accountable from a safeguards and security standpoint, many sites do not maintain centralized inventories of these materials. Therefore, it should be expected that additional materials will be identified as facilities are closed and all materials removed. Until a site is confident that all materials have been identified, it is therefore important to maintain some flexibility in site capabilities. At the Mound Plant, seventeen material steams were identified in the initial assessment; six additional material streams, representing more than a 35% increase, were identified in subsequent activities.

- ***Always investigate reuse as the first option when dealing with orphan materials*** - Closure sites are interested in removing their materials as quickly as possible and at minimum cost. Many times it is assumed that disposing material as waste will satisfy these objectives. The NISSMG has shown that reuse options do exist for many NISS materials, which can be cost effective, satisfy closure schedules, and implement DOE pollution prevention objectives. One major success was at the Mound Plant, where thorium capsules originally irradiated for isotope production in 1960 had remained an orphan material for nearly 40 years. Disposition of this material as LLW would be difficult and expensive. An alternative was developed to process this material to recover valuable isotopes which alone will ultimately save taxpayers more than $250,000 over disposal as LLW. At the Mound Plant, reuse options were identified for nine of the seventeen total material streams.

- ***Recognize the limitations that many sites now have in nuclear material operations*** – Most closure sites suffer from a lack of facilities, experienced personnel, and process knowledge. The issue of experienced personnel can be addressed by bringing in outside expertise to address closure site issues. The NISSMG has developed an informal network of technical experts to assist the closure sites with their nuclear material issues and will be formalizing this structure in fiscal year 2001. The lack of process knowledge for previous site activities is requiring sites around the complex to contact former employees to gain knowledge of previous site activities. As many of the activities of interest occurred nearly fifty years ago, this tactic remains viable for only a limited time. The issue of a lack of facilities at a site is a more immediate concern. Often facilities are required to perform certain characterization functions onsite before materials can be transported. This is currently the situation at the Mound Plant, where even a simple glovebox is unavailable to support such activities. In these cases, it is necessary to develop alternatives that function within these facility constraints. The broader issue of identifying critical facilities across the complex to support NISS materials activities will be part of a future NISSMG study.

- ***Seek solutions that leverage resources from across the complex and private industry*** – In the post-cold-war era there is a decreased level of interaction between the DOE sites. This is particularly true at the closure sites, which no longer have an enduring mission for the DOE complex. These sites tend to be less aware of expertise and facilities existing in the DOE complex and private industry. One of the primary functions of the NISSMG has been to stimulate the interaction of the closure sites with other DOE sites and private industry to develop solutions for their NISS materials problems. This is achieved through site visits, workshops, and trade studies, and has been essential to the solution of many NISS materials problems, as the closure sites retain limited capabilities to address these issues.

- ***Challenge all assumptions regarding orphan materials*** – Many orphan materials issues have existed at the sites for many years or sometimes even decades. Initial discussions of these materials are often punctuated with phrases such as "we tried that" and "that will never work." For problem materials, it is important to re-examine all options carefully and not dismiss any option prematurely. It was the application of this principle that led to the development of the alternative for the irradiated thorium capsules discussed above. The option of processing these materials for isotope recovery had been previously determined to be "not cost effective." It was only when this option was re-examined in terms of life-cycle cost that it became the preferred option.

- ***Seek optimal solutions, not just "paths forward"*** – The pressures of trying to achieve closure milestones can push sites to seek the most expedient way possible to get the orphan material off the site, irrespective of the future liabilities that are created. As responsible stewards of these materials, the NISSMG must employ life-cycle approaches to cost, risk, waste generation, and other performance metrics, consistent with site constraints. In many respects, this is one of the most important functions of the NISSMG; no other organization in DOE has a complex-wide, long-term stake for NISS materials.

This discussion has been developed primarily on the basis of interactions with the Mound Plant, but these lessons learned apply equally well at FEMP and RFETS. The NISSMG is beginning to

address NISS materials at closure facilities located at non-closure sites. It is expected that the experience working at these sites will be somewhat different than at the closure sites. As a part of the NISSMG vision, the group will be able to address problems and issues associated with excess NISS materials at all DOE sites and facilities.

CONCLUSIONS

The highly diverse nature of NISS materials poses unique challenges to their management in the DOE complex. As a central management group for EM materials, the NISSMG is proving an effective resource in assisting closure sites in dealing with NISS materials issues. Based on the experience of successful de-inventory of the Mound Plant and ongoing assistance to other sites, a set of lessons learned have been developed that serve as a basis for interactions with other closure sites. The NISSMG continues to expand its activities to address NISS materials issues at additional sites. The NISSMG is also completing studies of key issues for NISS materials management across the complex. These studies form the basis of a more proactive role for the NISSMG in identifying future DOE complex requirements for NISS materials management.

REFERENCES

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3. *Material Management Plan for Thorium (TH)*, Uranium/Thorium Team, Nuclear Materials Integration Project, November 1998

4. *Nonactinide Isotopes and Sealed Sources Management Group: Fiscal Year 2000 Annual Report*, Department of Energy Albuquerque Operations Office, January 2001.

5. *Nonactinide Isotopes and Sealed Sources Management Group: Cesium-Strontium (Cs/Sr) Management Alternatives Trade Study*, Department of Energy Albuquerque Operations Office, July 31, 2001.

Fig. 2 - Mound Nuclear Materials Disposition Map

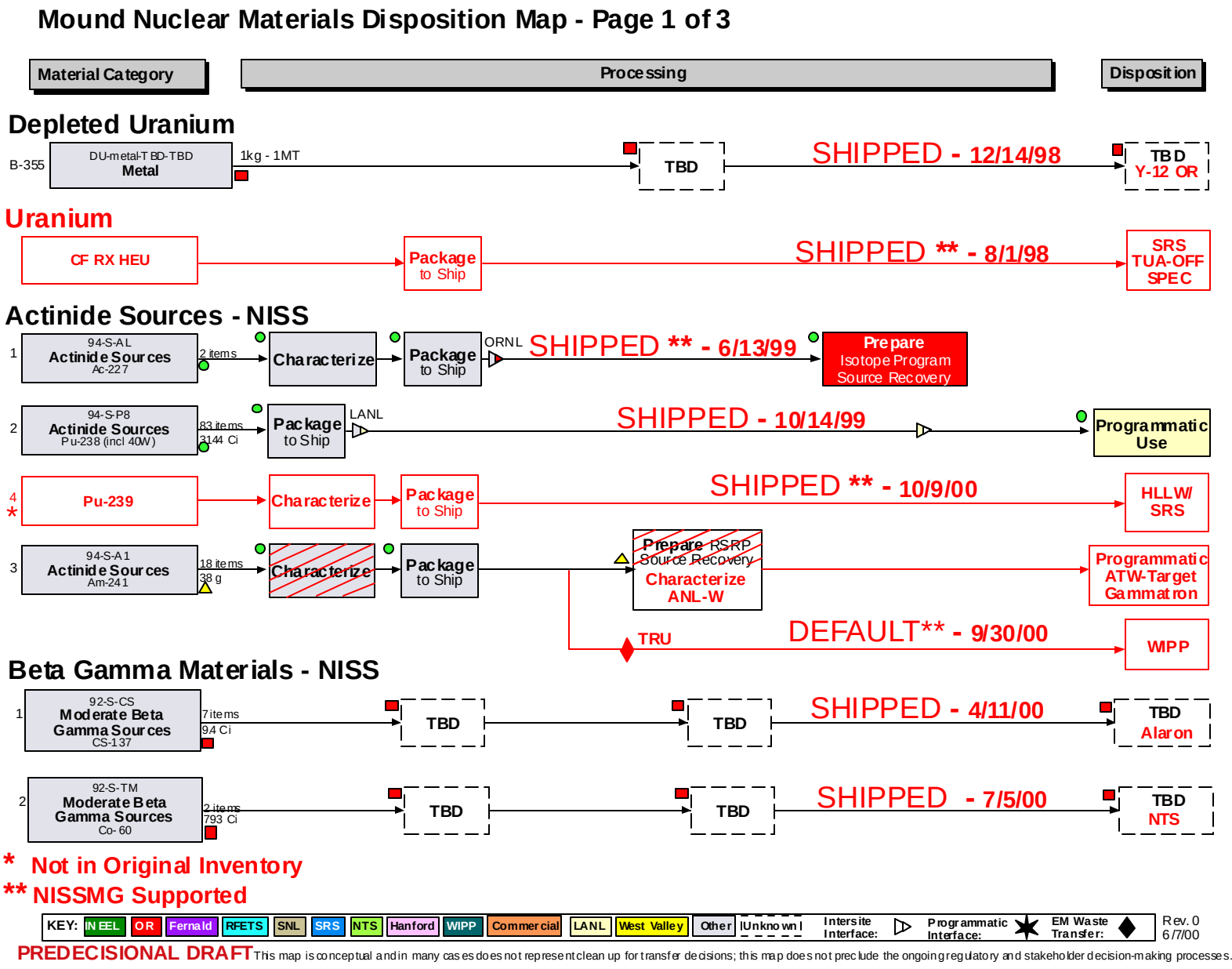

Fig. 3 - Mound Nuclear Materials Disposition Map

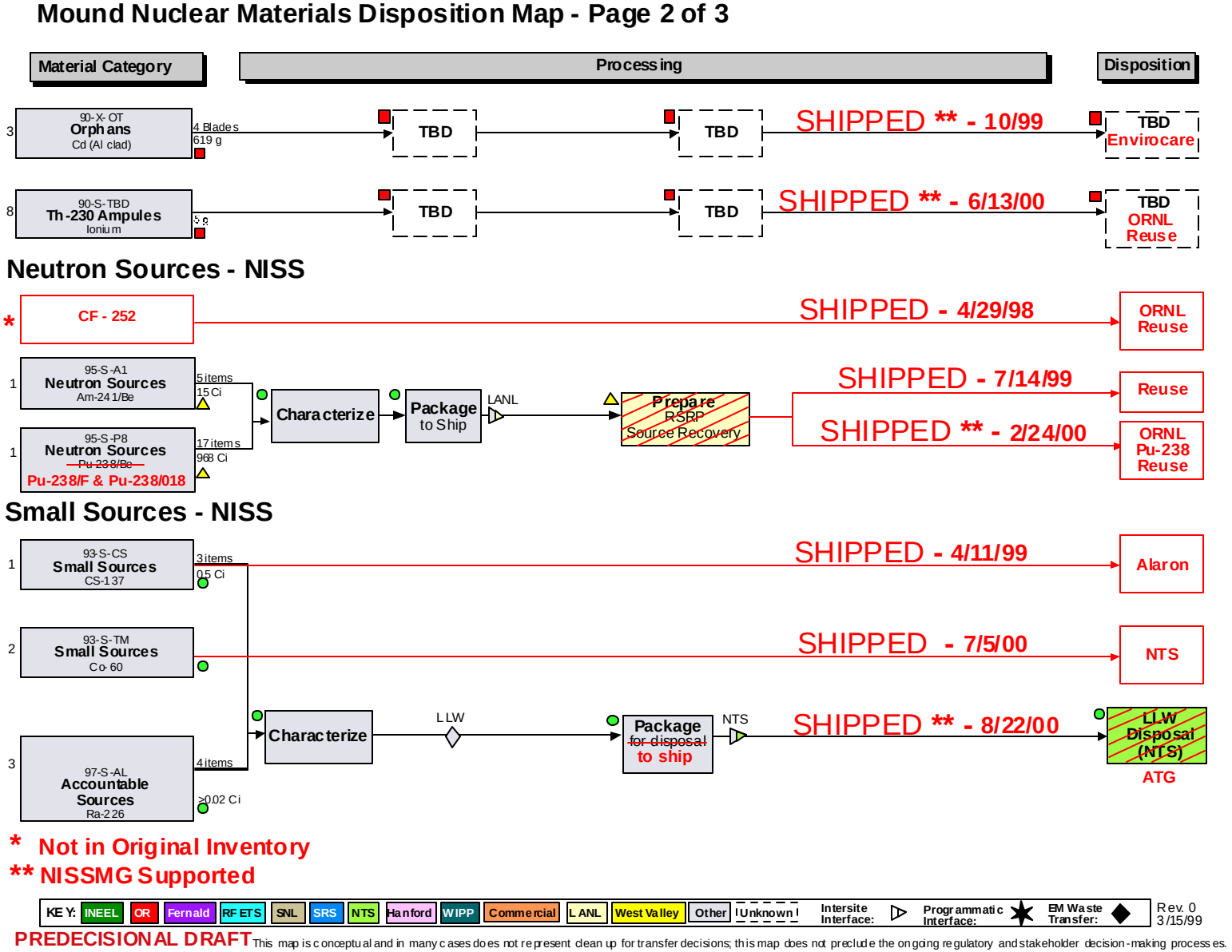

Fig. 4 - Mound Nuclear Materials Disposition