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HIGH EXPLOSIVES SOURCE TERM AT TA-16

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1.0 Introduction

Facilities at what is now known as TA-16 have been used for High Explosives (HE) processing for weapons research and development since the 1940s. The earliest facilities included V Site, the 30s line, the 40s line, and the 90s line as well as others. These facilities were not designed for high production and were hastily built to serve the needs for building the small number of weapons that were initially built at Los Alamos. The start of the Cold War with the Soviet Union initiated the building of higher capacity buildings for much greater levels of research and development than had been done previously. This building boom saw the construction of TA-16-260, and the 300 series buildings. According to the Facilities and Waste Operations database, MOADS, TA-16 Building 260 was constructed between 9/21/1949 and 2/16/1951 by R.E. McKee. The original building number designation was S-132. Data collected from LANL Archives concerning the amount of HE processed is included in CD form as Appendix B. The objective of this report is to document information relative to HE (and in particular RDX) releases at TA-16.

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2.0 TA-16 Building 260, RDX Discharge

The HE component of primary interest for this study was RDX because of its (1) relatively high solubility, (2) potential mobility in the subsurface (3) resistance to degradation and, (4) low EPA health advisory limit. Because there was not rigorous monitoring of discharge volumes or concentrations, several different methods were used to estimate the RDX discharged to the environment by TA-16-260 during the period from 1951 until 1996, when the Building 260 outfall was closed (Hickmott, unpublished data).

2.1 Assumptions About RDX Discharge at TA-16 Building 260

A major assumption that has been made for all the source estimation methods is that all water discharged from TA-16-260 was contaminated with RDX at the solubility limit of 44 mg/L. (This is the solubility of RDX at standard temperature as measured by Layton et al. (1987)). This assumption was used because it appears to be the best way to bound RDX concentrations and it is a conservative approach. Data from sump water sampling analysis done at WX-3 Building TA-16-302 in 1979 supports the solubility assumption where RDX analyses have a maximum of 63 mg/L, a minimum of 16 mg/L and an average of 32 mg/L. In addition, data from 1953-1954 for water samples from machining and casting operations are in the 25 ppm to 36 ppm range (Pg 2, HE Source Term Data file, Appendix B). Another reason that the solubility assumption is reasonable is that as long as RDX compounds were being machined, machining and wash down water would nearly always have been in contact with small pieces of RDX (with large exposed surface area) in the sumps. This would have been true except immediately after the sumps were cleaned and a RDX containing part had not yet been machined. Finally, there is not a consistently collected long-term data set to justify and defend using a lower concentration. However there are weekly data for Building

260 from 1972 where HMX/RDX ranges from 0 ppm to 3.2 ppm with an average for July 1972 being 2.7 (Pg 3, HE Source Term Data file, Appendix B). Which suggest the solubility limit is likely conservative. A final reason that supports the solubility assumption is that the water used for machining was heated to room temperature (tempered) to reduce thermally induced dimensional changes in the machined parts. A final major assumption is that all HE discharged was in solution.

2.2 Method 1 Discussion:

This initial discharge estimate (equation 1) used the water flow rate data collected while monitoring for the NPDES application program, which began in 1977, and the assumed RDX solubility.

$$D = F * C * T \qquad (1)$$

Where: F is the NPDES average yearly flow rate for the years 1977 to 1989 (7,573,882 L/Yr), C is the concentration (4.4E-005 Kg/L), (C is the solubility of RDX at standard temperature as measured by Layton et al. (1987)), T is Time (45 Yr), and D is the estimated mass of RDX discharged from the TA-16-260 outfall, which turns out to be 15,000 Kg. The NPDES application data from the Discharge Monitoring Reports (DMR) were basically unusable because they lump four different outfalls together for reporting purposes, in addition, the flows used for the NPDES applications were not actual measured/totalized flows. Therefore, the best available data for 1977 are the Section II Basic Discharge Descriptions. From 1978 to 1989, the best available data are the handwritten records of the discharge data. These data have been entered into Excel summarized by year, and the average

annual flow rate was then calculated for use in equation 1. (See Worksheet NPDES_Flows 1977-1989, in the HE Source Term Calculations File (.xls) in Appendix B.).

2.2.1 Method 1 Uncertainties: Assuming that the solubility limit assumption is reasonably representative, the predicted discharge is possibly an overestimate for the 1977 to 1996 period because the NPDES data are conservative for the later years in that they assume twenty-four hour per day continuous discharge. The predicted discharge is probably an underestimate for 1952 to 1957 because there were more machinists working. The NPDES data represent flow rates from Building 260 at a time when only one shift of machinists was working and previously as many as 3 shifts/day, with up to 14 machinists/shift, were working (this is addressed in Method 4b). Another caveat is that prior to the NPDES measurements, the wash down systems and methods generated more discharge water than was used during the NPDES measurements (Rivera, pers. comm., 2003). Before this modification substantially more water was used for wash down and the sumps may have discharged solid HE prior to 1962 as discussed in Sec. 2.1.

The average NPDES discharge for 1980, which is the last year there were thirteen machinists, has the same average discharge as 1989, when there were eight machinists (See Worksheets Method4a_Noe, NPDES_Flows 1977-1989, HE Source Term Calculations File, Appendix B.). This illustrates the difficulties associated with accurately estimating the flows based on manpower and NPDES flow measurements.

2.3 Method 2 Discussion: Another method for estimating RDX discharge was based on data collected during the Interim Measure (IM) removal of HE contaminated soil from the TA-16 Building 260 outfall pond and drainage. The removal allowed us to bound how much HE was removed from the outfall pond area and thus provided an estimate (though an incomplete one) of the amount of HE discharged. In this approach the source release was estimated using the following equation:

$$D = WP * MSR \qquad (2)$$

where: WP is the weight percent of HE in the soil removed (2 wt %) (Gram, pers. comm., 2002; Los Alamos National Laboratory, 2002); and MSR is the amount of soil removed (1,608,540 Kg). Using these values, equation 3 yields a discharge of approximately 32,000 Kg of RDX. However, there are significant uncertainties and problems with this RDX estimate which are discussed in section 2.3.1.

2.3.1 Method 2 Uncertainties: HMX was the largest HE component in the soil removed during the IM. Thus, Method 2 may be a better estimate of HMX release than RDX release. This observation is supported by the higher solubility of RDX vs. HMX (44mg/L vs. ~5 mg/L) and the fact that the majority of HE machined during the highest production period (1952-1957) at TA-16 Building 260 contained mostly RDX. (See Worksheet 52_Inv_Summary, HE Source Term Calculations File, Appendix B.). In other words, given the high solubility and approximately 40 year transport period, much of the 1950's era RDX was likely mobilized into the vadose zone or Cañon de Valle. The dominance of HMX in the soils removed during the IM is also supported by Baytos (1972), which shows mostly HMX in soil samples taken from the pond and drainage ditches below Building 260 from 1969

through 1971. For example, HMX/RDX ratios reported in Baytos (1972) range from 3 to 26, and 8 of the 13 analyses have values over 10. Another uncertainty related to Method 2 is that the 2 wt% HE assumption is a maximum bound, and the actual amount of HE removed could have been lower (Gram, pers. comm., 2002). Therefore, because of these uncertainties and the dominance of HMX in the outfall area during the IM, we have not reduced the RDX release estimates of methods 1, 3 and 4 using the implied 32,000 kg removal from Method 2.

2.4 Method 3 Discussion: This method is based on statistical analysis of casting and machining data gleaned from the archived monthly progress reports from GMX-3 and WX-3 (Former HE processing groups at Los Alamos National Laboratory). These reports were continually changing as programs, processes, weapons designs, and manufacturing processes changed. During this period the HE processing program moved from using mostly cast HE parts to mostly pressed HE parts, and went from hand compilation of the report data to computer-generated reports. The lack of continual, consistent datasets made it impossible to use a single dataset for calculating the RDX discharge. As the monthly reports were reviewed, the inventory, casting, and machining data were entered into Excel spreadsheets. Much more data were collected than was used for the analysis. There were so many different formats used during this time that the usefulness of any one piece of data was not known until all of the data were compiled together (See Worksheet "DischargeCalcMethod3", HE Source Term Calculations File, Appendix B.).

There are two long-term data sets that were used to develop Method 3: (1) detailed casting data from 1952 to 1956 and less detailed casting data from 1958 to 1972; and (2) a machining data set from 1962-1980, with variable detail and some data gaps.

Beginning with the 10/15/1962 progress report there are data for the number of operations performed per month for remote, inert, and operator attended HE machining. Remote machining is machining that is done automatically and monitored via closed circuit television without an operator present in the bay during machining. The plastic bonded explosive (PBX) parts were remotely machined soon after the February 24, 1959 accident in TA-16 Building 260 and the October 14, 1959 accident at the Burning Grounds. Inert parts were used for testing purposes and most were made from barium compounds that were selected for their physical property similarity to HE materials without being explosive (Bazzell, pers. comm. 2003). The data for machining of inert parts shows that not all of the machining time was spent machining HE materials that required water for coolant. Operator attended HE machining was performed on the cast types of HE such as Comp B, TNT, Baratol etc. which are less sensitive than the PBX compounds.

There was less RDX used in the PBX materials, but the PBX compounds 9401, 9405, 9407, and 9010 are all RDX mixtures, which saw some use. A comment in the 8/15/1972 progress report states that in earlier batches of HMX there was 8-10 weight percent RDX impurity, but for the past 4 years it had been running less than 1 weight percent. HMX was noted in the inventory in 1954, (in very limited quantities) and doesn't seem to have been used much until later in 1955. Because of the RDX impurity in HMX, and the fact that there were PBX

compounds that contained RDX, all of the remote machining water has also been included in the source term calculations (which is probably a conservative assumption).

Between 1/15/1964 and 2/15/1968 there are data for: number of pieces cast, number of operator attended operations, number of remote operations, man hours of operator attended operations, man hours of remote operations, man hours of operator attended setup, man hours of remote setup, man hours of inert machining, man hours of inert setup, man hours of tile machining, man hours of tile setup. This data is especially valuable because it gives a complete picture of the hours spent machining as well as the hours spent on setup. Because there are data for the number of parts machined as well as the number of operations and the number of parts cast as well as the man hours spent doing the work this data gives a detailed picture of the processing done in TA-16 Building 260 during that time period.

2.4.1 Method 3 Calculations:

The calculation of the RDX discharge from TA-16 Building 260, by Method 3, was done in 3 steps using the two long-term datasets mentioned earlier.

Step 1 (1952-1963). The first step was to calculate the discharge from 1952 until 1963. During this period the HE components for the early weapon designs, which used larger cast charges than later designs, were machined (Hatler, pers. comm., 2002). A majority of the RDX would have been discharged during the early 1950s when the high numbers of these large castings were being machined as shown in Fig. 1. The peak of casting operations was March of 1953 when over 12,800 pieces were cast that month with over 408,200 Kg of HE in

inventory (See Worksheet 52_Inv_Calc, in the HE Inventory and Castings.xls in Appendix B). There are two main reasons for the huge drop in numbers cast between 1956 and 1958; (1) Much of the production was moved to Pantex; (2) Pressing techniques were developed to make smaller charges for new weapons designs (Hatler, pers. comm., 2002). These weapon design changes are also documented in the online Pantex history, which talks about a radical change in weapons design and how the Pantex plant was reconfigured to make the new designs. http://www.pantex.com/ds/pxgena2b.htm (Pantex web site).

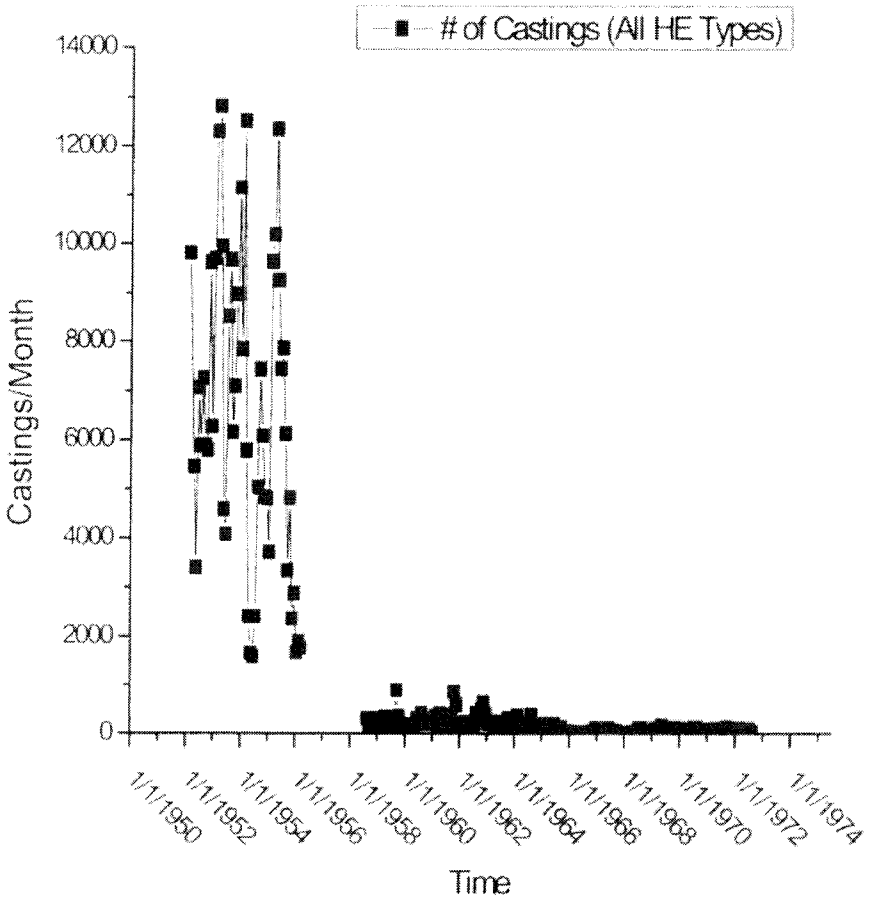

Figure 1 Number of HE parts (all types of HE) cast per month. (Gaps represent periods when no data were available).

To calculate discharge from 1952 until 1963, detailed machining information from 1964 was used to calculate the mean machining time (man hours) per operator-attended part (this was the first per part machining data available). The mean machining time (man hours) plus 2 σ (2 Standard Deviations) was then multiplied by the number of parts cast from 1952 until

1956 (The mean plus 2 σ was used to be conservative). This value was also multiplied by the interpolated annual casting data between 1956 and 1958 as shown in equation 3.

$$T_1 = MMT * NC \qquad (3)$$

Where: T_1 is the man-hours of machining from February 1951 to October 1962, MMT is the mean machining time/operator-attended part (man hours) plus 2 σ, and NC is the number of castings. The uncertainties associated with this step are discussed in Section 2.5.2. The value for 1951 was assumed to be 10/12 of the 1952 value because TA-16 Building 260 was completed in February of 1951. This would be a conservative number because startup problems would have prevented full production for a time after building completion.

Step 2 (1963-1980). From October 1962 until January 1964 the dataset in the monthly progress reports was in a constant state of change. There are data from October 1962 until October 1980 for the number of remote and operator attended operations. The dataset from 1/15/1964 to 2/15/1968, which is the most complete dataset for the entire 45 years, has data on the man hours required for each type of operation per month, which allows the calculation of the average man hours per operation. The average man hours per operation allows the calculation of time spent machining for both operator attended operations and remote operations from October 1962 until October 1980 using equation 4.

$$T_2 = NO * TPO \qquad (4)$$

Where: T_2 is the man hours of machining from October 1962 to October 1980, NO = Number of operations/month, and TPO = Mean time/operation plus 2 σ (Mean time/operation plus 2 σ was used to be conservative);

Because this dataset includes setup time, inert machining setup, and machining time, it makes it possible to calculate the discharge without including time when water was not running through the sumps.

Step 3 (1980 - 1996). Extrapolation was used to calculate the HE discharges after the 10/15/1980 progress report because that was the last WX3 monthly report available in Los Alamos National Laboratory Archives. For the period from 1980 until the outfall was shutdown in 1996 there is no machining data available so the mean plus 2 σ of the hours of machining per month as calculated above from 1970 to 1980 was used. This approach was used because the hours of machining were highly variable from 1970 to 1980. However, the regression line is basically flat with a -0.038 slope for a linear regression of the hourly machining data between 2/15/1970 and 10/15/1980. This method assumes a steady flow rate from 1980 until 1996.

$$T_3 = H_{1970\ to\ 1980\ average} * NMonths_{1980\ to 1996} \qquad (5)$$

Where T_3 is the extrapolated man hours of machining from 1980 to 1996, $H_{1970\ to\ 1980\ average}$ is the average man hours per month of coolant type machining from 1970 to 1980, and $NMonths_{1980\ to 1996}$ is the number of months from 1980 to 1996.

The total discharge from all 3 steps was then determined from equation 6.

$$D = (T_1 + T_2 + T_3) * 11.4 \text{ (Lpm)} * 60 \text{ minutes/hours} * C \qquad (6)$$

Where: T_1 is the total hours of machining for the early castings. T_2 is the total hours for the remote and operator attended operations from Step 2, and T_3 is the total machining hours from Step 3. Method 3 results are graphically displayed in Figure 2 and the total discharge is estimated as 52,000 Kg of RDX..

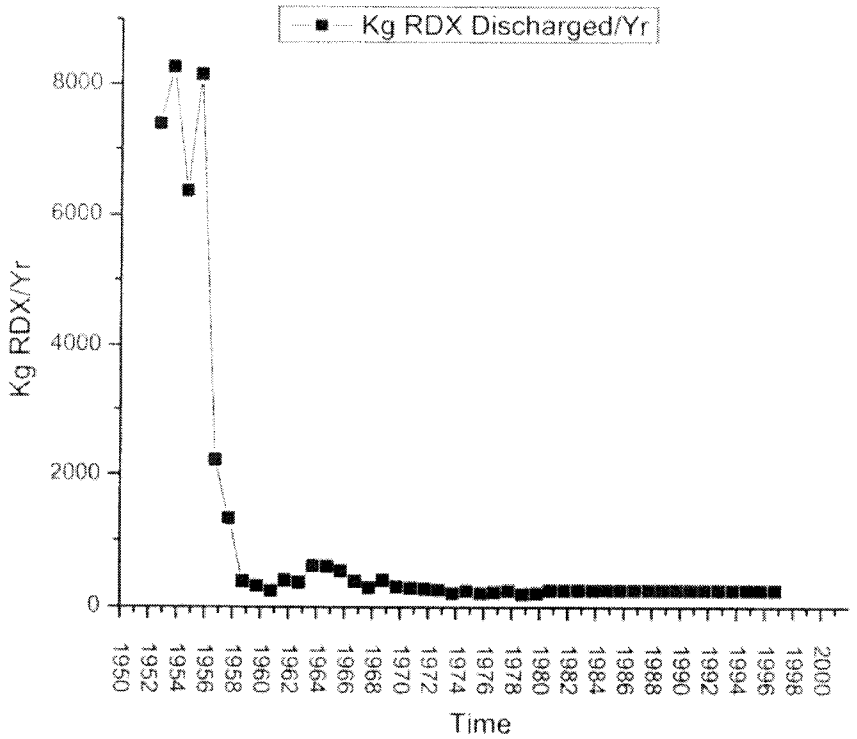

Fig. 2. Kg of RDX Discharged using Method 3

2.4.2 Method 3 Uncertainties:

The uncertainties for all steps associated with Method 3 are listed below followed by uncertainties for each step. None of the steps include any wash down water for bay cleanup. Wash down water was significant and is included in Method 4. Wash down water is water that was applied by hand from a ¾" hose to wash machinings off of and away from the machines and force the machinings down the gutters into the sumps. The sumps allowed the machinings to settle out of the wash down and coolant water and then the water overflowed into the drain to the outfall. Flow rate from the wash down hoses has not been determined and the wash down system was modified to reduce the amount of wash down water used in later years. Wash down water was also used to clean the machining bays on a weekly basis as a safety measure. Uncertainties related to the sump modifications discussed in section 2.1 would also apply to this method.

Step 1. This step assumed the hours of machining were correlated with the number of castings during the period from 1952 until 1963, and there wasn't much change in that correlation over time. The values for hours of machining time from 1951 to 1955 are too high because it would require more than 3 times as many machinists than were working in order to work the hours calculated by this method for 1952. Thus, this step may overestimate the discharge from 1952 to 1963.

Step 2. This step assumes that the time/operation is constant for the period from 1962 until 1980. This is unlikely given the increasing efficiency of computer numerically controlled

machine tools during this period. Another uncertainty is that before 1972, water was also used keep the dust down while machining inert materials (Bazzell, pers. comm., 2003). Even though the dust abatement water was not running on HE parts it was still running through the sumps where it would be exposed to solid HE. Because the mean time/operation * number of operations plus 2 σ was used for this step it is probably conservative. When the mean time/operation * number of operations plus 2 σ was compared to the 1964 to 1968 data where we have the actual hours of machining the mean time/operation * number of operations plus 2 σ calculation is always greater than the actual data and yields an extra 787 Kg of RDX more than the actual data. The lack of data for the amount of wash down water used is the shortcoming of this otherwise substantial data set.

Step 3. This step of Method 3 maybe a closer estimate of the actual amount of RDX discharged from 1980 until 1996 because the estimate assumes a steady flow rate from 1980 until 1996. That estimated flow rate is lower than the NPDES flow rate because it was based on actual machining times and not three or four measurements per year. However, as HE research progressed, less RDX was used and HMX was used more extensively. Later in the mid 1970's TATB became available and was used extensively (Hatler, 2003). Because the actual RDX concentration in the machining water may have been lower than the solubility limit, it is more likely to be a net overestimate for this period. Because there is no continual RDX concentration data from the discharge water, the higher values are used in order to be conservative, bearing in mind the data from Building 302 in 1979 mentioned in section 2.1 that averaged 32 ppm RDX (Pg 1, HE Source Term Data file, Appendix B).

2.5 Method 4 Discussion:

This method is based on interviews with current and former LANL employees and it gives the most complete qualitative picture of actual operations. The method delineates how many shifts were worked, the approximate number of machinists per shift, as well as estimates of the flow rates and usage of wash down water. There were no records found in the progress reports that speak of three-shift machining and casting operations, however there are retirees that recall those days. TA-16 Building 260 production dropped from 3 shifts to 2 shifts in 1957 (Lujan, pers. comm., 2003; Marr, pers. comm., 2003). This agrees with the huge drop in the number of pieces cast during the 1956 to 1958 period. Operations then dropped to a single shift, with occasional overtime, in the 2/15/1969 progress report. During the early 1970s there was Saturday overtime in TA-16 Building 260 about 2 months of Saturdays per year (Bazzell, pers. comm., 2003). Overtime was ignored in the calculations because there is seldom a full crew working when all employees have 24 days of vacation and 18 days of sick leave per year.

2.5.1 Method 4 Calculations:

Formulas were used in Excel (Worksheet Method4a_Noc, HE Source Term Calculations File, Appendix B.) to calculate the mass of discharged RDX per year using a compilation of information from these interviews. The totals for each year were then summed to give a total estimated discharge.

$$D = \sum_{1956}^{1985} (((N_{MS} * (F_{Lpm} * 60 * (T_p - T_c)) * S) + (WD_c * W_w * S)) * D_{PY}) + (F_{wd} * W_w * 51)) * C)$$

(7)

Where: N_{MS} = Number of Machinists per shift, F_{lpm} = Coolant water flow (11.4 L/m) Lujan (pers. comm., 2003), T_P = Productive time per shift (hours), T_s = Setup time per shift (hours), S = Number of shifts per day, WD_s = Wash downs per shift, W_w = Wash down water per wash down (liters), D_{PY} = Days worked per year, and F_{wd} = Number of Friday weekly wash downs/year

Approximately 37,000 kg of RDX was discharged using equation 7 if fifty gallons of water were used per wash down and the coolant water flow rate was three gallons/minute as estimated by Noe Lujan. Approximately 32,000 kg of RDX was discharged using equation 7 if twenty gallons of water were used per wash down and the coolant water flow rate was two gallons/minute as estimated by W.A. Spencer in the 1976 speed letter to H. Ballance (Pg 8, HE Source Term Data file, Appendix B), (Worksheet Method4a_20GalWashd, HE Source Term Calculations File, Appendix B.).

2.5.2 Method 4 Uncertainties:

The greatest uncertainties with this method are in the amount of water used per wash down and the coolant water flow rates.

2.6 Method 5 Discussion:

Method 5 is a composite of Method 3 and Method 4. This Method utilizes the calculations from Method 3 and Method 4 and uses the highest masses from each yielding an estimated total RDX discharge of 65,000 Kg. (See Worksheet Composite3_4=5, **HE Source Term**

Calculations File, Appendix B.) Method 3 is highest for the years 1952-1956 and Method 4 is highest for the remaining years.

2.6.1 Method 5 Uncertainties:

Like Method 3, Method 5 would overestimate the number of hours spent machining castings during the 1951 - 1956 time period. Similarly it does not account for wash down water flows for those years. Likewise, Method 5 has the same uncertainties as Method 4 for the later period (See Section 2.72).

2.7 Summary of Method Results for TA-16 Building 260

RDX discharge estimates for the various methods are included in Table 1 and the annual time series are shown in Figure 3.

Table 1. Estimates of RDX Release at TA-16-Building 260

Method#	Method Description	Kg of aqueous RDX Discharged in ~ 45 years
1	Average NPDES outfall flow data from1 shift	15,000 Kg
2	IM report data	32,000 Kg
3	Progress Report Statistics	52,000 Kg
4a	Interviews - # of machinists/shift - # shifts 50 gal washdown	37,000 Kg
4b	Interviews - # machinists/shift - #shifts 20 gal washdown	32,000 Kg
5	Method 5 -- Most Conservative Composite	64,000 Kg

*Shifts means how many 8-hour rotations of facility staff per day.

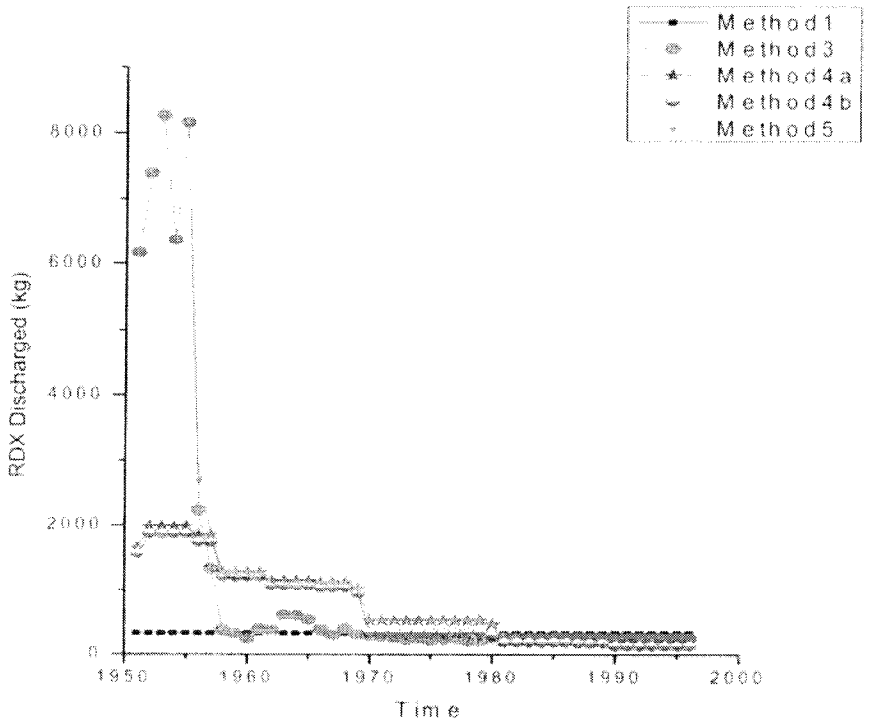

Figure 3. Estimated RDX discharge with time from TA-16-260 using four different methods.

To test whether these estimates are reasonable (in other words, are they physically realistic given the amount of HE processed at TA-16) we compared the estimates from Method 5 to usage estimates based on actual inventory data. We calculated the minimum usage of RDX compounds for the four years that inventory data were available by subtracting the ending inventory for each month from the previous months inventory (See Appendix C for more details). The estimated usage of RDX compounds, Comp B, RDX, and Cyclotol, from February 1952 to April 1956 was between 738,992 Kg and 1,298,677 Kg. The total estimated 45-year RDX discharge of 65,000 kg, using Method 5, is between 5 and 8.8% of the

minimum usage for the 1952-1956 period. Thus, even our maximum estimate is physically realistic given the large inventories and extensive HE processing that occurred at the site. An important observation is that all of the five methods yield values that are within an order of magnitude. The most conservative estimate is just over 4 times the least conservative estimate. This relatively narrow range using a variety of methods suggests that these may be reasonable bounds for RDX release.

2.7.1 TA-16 Building 260, Other Considerations: Water sealed vacuum pumps were used to generate the vacuum that was used to clamp the HE on the TA-16 Building 260 machines for machining. The sealing water did not run through the sumps where the HE cuttings were accumulated, but it did combine with the flow from the sumps and runoff from the roof as it was discharged into the TA-16 Building 260 outfall pond, which then flowed into Canyon De Valle. This added water would have diluted the contaminated water from machining activities and increased HE transport, away from TA-16 Building 260 into Canon del Valle, and down into the vadose zone.

3.0 Discussion of Additional RDX Discharges at other TA-16 locations

Additional source terms at TA-16 include discharges from grinding, inspection and casting operations, as well as other machining facilities. The limited data from these facilities is described below.

3.1 90s Line Facility:

The 90s Line Facility was built prior to Building 260 and there was no mention of it in any progress report available between 1952 and 1980. It is assumed that there was only minor HE processing done there after TA-16 Building 260 came online (Spencer, pers. comm., 2003). HE has been detected in the 90's Line area (e.g. 90's Line Pond), but the inventory and extent has not yet been determined. The total absence of records prevents any estimation of 90's Line releases.

3.2 300 Line Facilities -- Buildings TA-16-301 and TA-16-303:

Buildings TA-16-301 and TA-16-303 were used for sawing the cast HE parts. Cast parts had risers, formed where the molten material was poured into the mold. These were sawn off prior to machining or other use. Pieces of different shapes were also sawn from larger cylinders and slabs as needed. Sawing operations generated fine cuttings that were solubilized by the coolant water the same as during machining. Water from these facilities was discharged into Martin Canyon. The 10/15/1960 progress report discusses the addition of water control flow meters to HE sawing tables in TA-16-301 and TA-16-303 where the sawing of the cast HE parts was done.

3.2.1 Buildings TA-16-301 and TA-16-303 Calculations: Because there was no historical data found for calculating the discharge from sawing, the sawing discharge could only be calculated using information gleaned from interviews. During the 1951 to 1957 period, Lujan (pers. comm., 2003) estimates that 3 men spent one half day, 3 days per week sawing the risers. The casting operations in Buildings TA-16-301 and TA-16-303 were shut down by

the early 1980's with the increase in HE pressing. To be conservative the discharge calculations were run for a 10-year period to account for the casting between 1957 and 1980 when the number of castings was greatly reduced.

$$D_s = H_{pd} * D_{pw} * W_{py} * Q * C \quad (8)$$

Where H_{pd} is Hours per Day (4), D_{pw} is days per week (3), W_{py} is weeks worked per year (51), Q is liters per minute (11.4), and D_s is discharge from sawing operations in the 300s Buildings. Approximately 563 Kg of RDX was discharged according to this method.

3.2.2 Buildings TA-16-301 and TA-16-303 Uncertainties: If solid HE materials were carried out of the TA-16-301 and TA-16-303 Buildings in the discharged water, prior to the 1962 sump modifications, this could have substantially increased the total HE discharged.

3.3 300 Line Facilities -- Building TA-16-300:

Building TA-16-300 was the location used for casting the HE into the desired shapes. The casting operations used steam to heat the melting kettles as well as for cleaning the melting kettles and molds. The steam used for cleaning, condensing on the kettles and molds, as well as the wash down water used to hose down the facilities after the processing activities would have generated some RDX discharge. However the majority of water used in Building TA-16-300 was pumped through the jackets of the molds to maintain the proper temperature of the molds prior to, and during the pour of molten HE, to prevent the HE from setting up too quickly (Maes, pers. comm. 2005). None of this water came into contact with the HE.

3.3 Building TA-16-340:

Formulation operations in TA-16-340 used large amounts of water. Some water was used in the formulation process for mixing HE with plastic bonding materials that were dissolved in organic solvents (Hatler, 2005). The majority of the water was used by water sealed vacuum pumps when the mixing process was finished. Nine or ten vacuum pumps that used 3 gallons per minute of sealing water were used to vacuum dry the mixture of HE, water, solvent, and plastic (Hatler, pers. comm. 2005). There could have been some RDX in the vacuum sealing water discharged, but it is very unlikely that much of the vacuum sealing water was contaminated with RDX. Other consumption of water was wash down water used to hose down the facilities after the processing activities.

3.3.1 Building TA-16-340 Calculations:

The NPDES measured flow for 1994 for TA-16-340 was 46,587,469 L/year.

3.4 Building TA-16-460:

Analytical Chemistry operations in TA-16-460 generated water from vacuum pumps and other processing activities.

3.4.1 Building TA-16-460 Calculations:

The NPDES average measured flow from 1977 to 1994 for TA-16-460 was 6,209,486 L/year.

3.5 Building TA-16-400:

TA-16-400 was used for washing trucks used for transporting HE to remove any HE residue that may have collected in or on the body and frame of the truck. There would have been RDX discharges from the water used to wash out these trucks (McCorkle, 1977). This water ran through multi weir sumps and was discharged into Water Canyon.

3.5.1 Building TA-16-400 Calculations:

The NPDES average yearly flow from 1977 to 1994 for TA-16-400 was 458,436 L/year. This would give a discharge of 900 Kg of RDX for the 45-year period if all of the trucks were contaminated with RDX.

4.0 Other TA-16 RDX Considerations:

Information about various buildings at TA-16 that were used for HE processing and storage was retrieved from the Los Alamos National Laboratory online database called MOADS.

4.1 Other Historical Site Considerations: V Site, 30s line machining facilities as well as the old casting building would also have been points of discharge. However, the amounts discharged here are probably within the uncertainty of what was discharged from TA-16 Building 260 and the 300s Buildings. This is a topic that needs more study, soon, before we lose more of the old-timers that could shed some light on this topic. Burning Ground facilities would have also discharged some RDX into Canon de Valle from the Basket Washing Facilities.

Appendix A

Noe Lujan (pers. comm. 2003) worked at LANL from 1953 until he retired in 1987. From 1953 until 1955 he worked as an expediter moving HE materials to and from the rest houses where HE was stored when it was going into TA-16 Building 260 to be processed or after it had been processed. From 1955 to 1959 he left TA-16 Building 260 to work in Transportation and then returned to TA-16 Building 260 where he retired as a supervisor in 1987. He was working in TA-16 Building 260 and had just left the bay where the explosion occurred in February 1959. His father was killed in the accident at the Burning Grounds in October 1959.

Notes from Noe Lujan

1. 12 to 13 machinists per shift plus 2 supervisors from 1953 to 1980 in TA-16 Building 260.
2. 7-8 machinists plus 2 supervisors from 1980 to 1987 in TA-16 Building 260
3. 3 shifts until 1957, 2 shifts until 1969, 1 shift until retired in 1987
4. The high-pressure water hoses (3/4" hoses with city water pressure at 40 to 60 psi (Nuttall, pers. comm., 2003)) used to wash down the bays while machining were quite powerful and would squirt 30 to 40 ft. Depending on the part being machined, the amount of machinings generated, and individual preferences, a machinist would wash down an average of 2 times per shift. This would entail hosing all of the machinings that were on the machine and on the floor into the sumps. This was done for safety and to reduce the mess around the work area.

5. These same high-pressure hoses were used during swing shift cleaning on Fridays. At this time every bay was given a complete wash down from the ceiling to the floor.

Notes from Bob Marr

1. He worked at LANL from 1957 until he retired in 1980 from TA-16 Building 260 as a supervisor.
2. 14 machinists on day shift and 12 machinists on evening shift plus 2 supervisors from 1957 to 1980.
3. The detailed machining data found in the monthly progress reports after 1962 was collected after the accidents in order to better track activities in case of more explosions.
4. Marr confirmed the use of the high-pressure hoses for wash down and Friday swing shifts complete bay hose downs.

Notes from Dewight Bazzell

Used water to reduce dust when machining some inert materials.

Notes from Bill Spencer

Started at LANL 10/1952 retired 4/1984.

Used tempered water for machining to prevent thermally induced dimensional changes in HE parts as they were being machined.

Shift schedules ~14 men on day shift and 12 on night shift from 1952 until 1957.

¼" tube running aerated water on most parts as coolant.

¾ hose used for hose down and clean up.

Rivera (pers. comm., 2003), the current supervisor in TA-16 Building 260, indicated that the wash down hoses and system had been changed since the early days and less water was now being used for wash down. Since the wash down system has been changed it will be very difficult to get the actual flows used for wash down. The use of flow meters, on the current system, would give a low flow boundary. Question – How to get a measure on the flow out of the wash down hoses?

Hayden (pers. comm., 2003) From 1990 until 1996 there were approximately 6 machinists working at TA-16 Building 260.

Appendix C

RDX Usage: We calculated the usage of RDX compounds for the four years that inventory data were available. The minimum usage was calculated by summing the months where RDX compound inventory was less than the previous months RDX compound inventory. Minimum usage of the RDX compounds, Comp B, RDX, and Cyclotol, from February 1952 to April 1956 was 738,992 Kg. However by this way of calculating minimum usage there were 25 months where apparent RDX usage was less than zero, 22 months where apparent Cyclotol usage was less than zero, and 22 months where apparent Comp B usage was less than zero. Out of 49 months of data, usage could not have been zero for those months because there were castings being made and the calculated usage was less than zero because incoming shipments were greater than usage. Average usage for the months when usage was

greater than zero was 26,500 Kg. Average monthly usage of 26,500 Kg would give 1,298,677 Kg of RDX compounds used in 49 months. The estimated average usage of 26,500 Kg is low because any shipments received during the months that were positive would have reduced estimated usage for that month. Another method to calculate usage would be to multiply the weight of each type of casting times the number of castings. This was attempted but a record of the weight of HE or dimensions of many of the old castings has been lost and made this method unfeasible (Worksheets (Shapes, 52_Inv), in the HE Source Term Calculations File.

References:

Baytos, J. (1972). "Analyses for Residual Explosives in Drainage Ditch Soil at Sump Effluent Outlets" Los Alamos National Laboratory, LA-4925

Bazzell, D. 2003. Personal Communication, February 4, 2003

Courtright, C. 2003. Personal Communication, February 4, 2003

Hatler, L. 2002. Personal Communication, multiple conversations 2002-2005 http://www.esa-wmm.esa.lanl.gov/Documents/SOP_Documents/ESA-WMM-SOP-%201.1.0T1.pdf

Hayden, D., 2003 Personal Communication, multiple conversations 2003

Hyde, E., 2003 Personal Communication, October 29, 2003

Layton, D., Mallon, B., Mitchell, W., Hall, L., Fish, R., Perry, L., Snyder, G., Bogen, K., Malloch, W., Ham, C., and Dowd, P. (1987). "Conventional weapons demilitarization: A health and environmental effects database assessment, Explosives and their co-contaminants, Final report, Phase II," AD-A220588, Lawrence Livermore National Laboratory, Livermore, CA, for the U.S. Army Medical Research and Development Command, Frederick, MD.

Los Alamos National Laboratory, 2002. Interim Measure Report for Potential Release Site 16-021(c)-99. Los Alamos National Laboratory Report LA-UR-02-4229.

Lujan, N. 2003. Personal Communication, February 4, 2003

Maes, G. 2002. Personal Communication, multiple conversations 2002-2003

Marr, R., 2003. Personal Communication, January 29, 2003

McCorkle, M.L. Memorandum to Hilton, L., Review of National Pollutant Discharge Elimination System (NPDES) Permit Applications, Symbol H7-77-162, July 18, 1977

Nuttall, J. 2003. Personal Communication, February 27, 2003

Rivera, S. 2003. Personal Communication, February 5, 2003