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SUMMARY REPORT

BNRR Hillyard Aluminum Dross Site
Spokane, Washington

EMR Project #338

June 4, 1996

EMR
INCORPORATED

ENVIRONMENTAL MANAGEMENT RESOURCES

Lawrence, KS ▼ Redmond, WA ▼ Duluth, MN ▼ Lincoln, NE

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EXECUTIVE SUMMARY

Environmental Management Resources, Inc. (EMR) was retained by Burlington Northern Railroad (BNRR) to prepare this Summary Report for the Hillyard Aluminum Dross site located in Spokane, Washington. This report provides a summary of the information and data generated during the course of the investigation in order to determine the disposition of the aluminum dross.

The site is currently owned by BNRR. The site was previously used as a secondary aluminum recycling facility resulting in the accumulation of approximately 65,000 cubic yards of aluminum dross on the site. The secondary processing of aluminum dross involves the addition of sodium and potassium chloride (NaCl and KCl). The salts remain in the waste product (dross) after the aluminum is extracted.

Tests conducted during previous investigations of the site indicated the dross might be a dangerous waste due to the equivalent concentration of the NaCl and KCl in the dross and because the dross sits over a sole source aquifer. Further testing, however, indicated that the concentration estimates of NaCl and KCl in the dross were not accurate.

Samples of the dross were tested to determine the concentration and leachability of the salts. The testing results indicate the sample preparation method has a large affect on the analytical results for both total concentrations and leachability. The samples that were pulverized prior to analysis resulted in higher concentrations. This could be due to the increased surface area of the sample material and the breaking of the dross matrix that encapsulates the salts. The testing results from samples not pulverized prior to analysis indicate that sodium and potassium could not be effectively leached from the dross. This is because the sodium and potassium are bound in stable minerals and not in salts. In addition, the dross material serves and an insoluble encapsulating matrix that prevents leaching of the salts that might be present.

Fish and rat bioassay testing of the dross material resulted in a mortality rate of zero. According to the Washington Dangerous Waste Regulations, bioassay testing takes precedence of other testing methods when used to make a dangerous waste determination. Based on the sampling results, the aluminum dross is not a dangerous waste. Therefore, the only remaining issue is the impact to the underlying sole source aquifer, if any.

Groundwater samples were collected from two monitoring wells. Well BN-2 is located just west of the largest dross pile and BN-5 is located over 1,500 feet north of the site. The groundwater samples from BN-2 contained levels of chloride and nitrate above the respective MCLs. The groundwater samples from BN-5 did not contain concentrations of chloride and nitrate above the MCLs. Recent testing indicates the previous estimated concentration of salts in the dross was too high and the leachability of the salts is limited.

The Spokane-Rathdrum Aquifer is several hundred feet thick. The water surface of the aquifer is about 178 feet below the ground surface (bgs) at the site, and only about 50 feet bgs near the eastern boundary of the city of Spokane. The aquifer is so shallow in some areas of the valley that it is exposed in some pits that are used for gravel quarries and concrete operations.

The permeability of the aquifer is high because of its relatively clean sand and gravel composition. According to the Washington Department of Ecology (Ecology), this high permeability, coupled with the aquifer's depth and its hydraulic gradient, results in velocities of approximately 60-90 feet per day. At this rate, the volume of flow is approximately 1,000 cubic feet per second in the Hillyard area. Lower velocities of approximately 10-50 feet per day occur toward the middle and western edge of the aquifer. These rates are high compared with more typical aquifer velocities, which range between 5 feet per day to 5 feet per year.

The generalized groundwater flow in the Spokane-Rathdrum Aquifer (SRA) is to the west and southwest down the Spokane Valley, except at Fivemile Prairie where a nob of the Columbia River group Basalt and pre-tertiary intrusions protrude. The flow divides around this nob and part of it flows through the Hillyard trough. According to Ecology, groundwater flows at a rate of 46 ft/day through the Hillyard trough.

2.3 Topography and Drainage

The surface of the site is basically flat at an elevation 2,000 feet above mean sea level. Several mounds of aluminum dross and one large excavation exist on-site. Much of the surface water runoff either percolates through the surface soils or runs into the pit. A limited amount of rainwater runs off the site to the north to ditches on Wellesley Avenue that lead to the storm water drains on Market Street.

2.4 Ground Water/Surface Water Uses

According to Ecology, the ground water aquifer under the site is called the Spokane-Rathdrum Aquifer and is used by almost 300,000 people in Washington alone. There are 21 public wells and over 150 private wells in a three mile radius of the site. The nearest production well was located on-site and was used by the former aluminum recycling facility. The total depth of that well was 231 feet bgs and the static water level when drilled was 178 feet bgs. This coincides with the typical depth of the SRA in this area. The exact location of this well is not known. Surface water in the immediate area is intermittent existing as runoff from rainwater, although the Spokane River is within 1.5 miles south of the site.

1.0 INTRODUCTION

Environmental Management Resources , Inc. (EMR) was retained by Burlington Northern Railroad (BNRR) to prepare this *Summary Report* which presents all of the relevant details concerning the disposition of the aluminum dross piles at the BNRR site in the Hillyard area of Spokane, Washington. All of the available information regarding the characteristics and disposition of the aluminum dross has been assembled in this report. It includes a detailed site description and history, a summary of chemical testing, a detailed discussion of findings and recommendations for the disposition of the aluminum dross.

2.0 SITE DESCRIPTION

The site is located in the City of Spokane (near the northern city limits) at E 3412 Wellesley Road. It is bounded on the east by Freya Street and Market Street on the west (Figure 1). The site encompasses approximately two acres in an industrial zoned portion of the city. The site is somewhat circular in shape (Figure 2). The elevation is approximately 2,000 feet above mean sea level. The latitude is 47°42'12" and longitude 117° 21'35". The location is in Section 3, Township 25 North, Range G3 East, Willamette Meridian.

2.1 Climate

The climate of the Spokane area is moderated by the Cascade Mountains to the west and the Rocky Mountains to the east. The Cascades provide protection from wetter coastal-weather and the Rockies prevent extremes in continental weather from traveling west into the Columbia Basin. The mean annual precipitation is approximately 17 inches occurring mostly between the months of September and April in the form of rain or snow. The average maximum two year, 24 hour rainfall is approximately 1.4 inches. The Spokane area has a mild climate with summer temperatures ranging from 80° to 90° in the day to 45° to 60° at night. Winter temperatures range from 25° to 40° in the day to 15° to 25° at night. Extremes in temperature are 110° in summer to -45° in winter.

2.2 Geology/Hydrology

The Spokane-Rathdrum sole source aquifer underlies eastern Washington and northern Idaho, extending from Lake Pend Oreille through the Spokane Valley under the city of Spokane, and exists as springs near the Little Spokane River. The aquifer underlies approximately 350 square miles and is contained in glacio-fluvial deposits. The deposits consist mostly of poorly to moderately sorted sands and gravels, with some beds of cobbles and boulders, and a few scattered clay lenses. The sands and gravels are relatively free of fine sand and silt, except in the uppermost 3-5 ft. of the aquifer.

3.0 SITE HISTORY

The site was initially used as a gravel pit for a nearby asphalt plant. In 1955, the site was converted to an aluminum recycling operation called Hillyard Processing using scrap aluminum and dross from Kaiser-Trentwood. In 1979, a new lessee (Lyon, Halpin and Buescher) renamed it Hillyard Aluminum Recovery Corp. and later to Aluminum Recycling Corporation (ARC). In 1987, the property was abandoned by the lessee who left a large volume of aluminum dross in a number of piles spread around the two acre site. In addition, a large volume of semi-processed "white dross" material was left in the old gravel pit (see Section 1.3). Several complaints were made to the City between 1979 and 1983 about wind blown particulates and ammonia odors, caused when the dross became wet and trace amounts of copper ammonium nitrides were released. In 1979, heat caused by a metal oxide reaction apparently started a fire and created smoke and ammonia fumes.

A preliminary assessment (PA) was conducted by Ecology on July 17, 1985. Ecology recommended that wells in the local area be sampled for possible contamination and that air quality be maintained by preventing dust and ammonia vapors from creating a public nuisance. It also recommended that the dross materials be appropriately disposed of. A subsequent inspection, carried out by Ecology under the superfund multi-site cooperative agreement Preliminary Assessment/Site Inspection (PA/SI) program, was conducted. The PA/SI Phase I Site Inspection (SI) was conducted at the facility during the afternoon of October 13, 1987. The PA/SI was conducted by Fred Gardner, Ecology Hazardous Waste Cleanup Program and Sherman Spencer, Ecology Eastern Regional Office.

Previous studies by Morrison Knudsen Engineers (MKE) and Ecology in 1987 were limited to surficial examination and sampling of the piles. At that time, no determination was made as to the designation of the piles under Washington State Dangerous Waste Regulations; however, the site was identified by Ecology as potentially contaminated with hazardous substances in its December 1987 PA/SI Phase I Site Inspection Report. The City of Spokane requested improvements in dust suppression and site security.

In June 1988, BNRR initiated a dust suppression and site characterization program on the aluminum dross piles. The principal object of the program was to cover and contain the dross piles to eliminate summertime dust emissions. The piles were surveyed and sampled at-depth to obtain data on their composition and volume so a probable waste designation under Washington State Dangerous Waste Regulations (WAC 173-303) could be made. Finally, the groundwater under the piles was sampled to test the levels of chlorides, fluorides and nitrates.

A number of dust suppression products were considered before a decision was made to apply Marloc, a polyvinyl acetate solution mixed with wood fiber. This product forms a thin film on the surface of the piles and has been used successfully in the desert southwest part of the US to control dust from mine tailings. Although it ultimately breaks down under ultraviolet radiation, it is effective for at least two years and does not require periodic rewetting. The Marloc was applied to the main dross piles on August 12th, 1988 by Nelson Landscaping of Spokane.

The problem of site security was addressed by the installation an eight foot high chain link fence around the dross piles and pit area. The fence is about 2,300 feet long and has three strands of barbed wire on top. A twenty foot rolling gate was installed on the east side of the site.

4.0 DESCRIPTION OF ALUMINUM DROSS

4.1 Physical Description

Aluminum dross is a by-product of the secondary treatment of aluminum skim and other materials derived from primary smelting operations. Aluminum skim is produced by the fluxing of aluminum metal, alloys and scrap in a molten bath that is charged with chlorine and/or nitrogen gas. The gas causes impurities to rise to the surface of the bath where they are skimmed out of the furnace. This skimmed material is composed of various oxides, aluminum metal, minor carbides and nitrides.

The skim, sometimes called "white dross", was further treated in a secondary recycling plant where it was first ground up in a ball mill to recover the coarse, metal-rich fraction. The fine fraction then was mixed with salt (NaCl and KCl) and cryolite (sodium or potassium aluminofluoride) and heated in a rotary barrel furnace. At elevated temperatures within the furnace, this mixture became liquid and molten aluminum metal settled to the bottom. This metal then was tapped out and cast into ingots. The remaining molten material was cooled and discarded. This residue resulting from secondary treatment is high salt aluminum dross or "black dross" (as distinguished from low salt "white dross").

At the Hillyard site, aluminum skim from a number of primary producers around the northwest was treated on a toll basis in 51 ton lots. In each lot there might be variable amounts of metallic alloys such as copper, iron, manganese, magnesium, and zinc depending upon the alloyed metal being produced by each smelter. Consequently, the aluminum dross piles at Hillyard contain a variety of metals. Besides metals and salt, there are variable amounts of carbides and nitrates in the dross. When wet or moist, the dross may give off a pronounced odor of ammonia from the hydrolysis of nitrates.

The aluminum dross at the Hillyard site is located in numerous piles identified as Piles A through R (Figure 2). In addition, various amounts of aluminum skim and aluminum dross are located in a large pit area as well. The Hillyard dross pit, located in the northwest corner of the site, was formerly a gravel pit that supplied aggregate to a nearby asphalt plant. The pit is 320 feet long and 180 feet wide. The original pit floor is about 20 feet bgs. During operation of the aluminum recycling plant, the pit was used to stockpile semi-processed "low salt" dross. About 22,000 cubic yards of this material remains.

Physically, the Hillyard dross piles appear dark to medium gray in color with a coarse sandy texture. Within the piles below the leached surface layer, the material is often moist with a pinkish brown color and streaks of red, black, or green from metallic oxides. Most of the piles have a mixture of coarse and fine material ranging from boulder sized chunks to fine silty sand. Some piles, notably

C and D, appear to be of uniform grain size which is partially a function of surface weathering. Pile C contains a high percentage of fist-sized cobbles and irregular nodules of a dense, gray, non-metallic material that may be cryolite. Within the pit, the dross is a dark gray to black granular substance that often is fused into a dense, sandstone like mass.

4.2 Volume of Dross

Thompson Land Surveyors of Spokane was contracted by Chempro to survey the dross piles and pit area to determine the volume of each pile. The survey required over 1,020 shots with electronic distance measuring instruments and took over 160 man hours to complete.

Seventeen individual dross piles were delineated and labeled A through R. Individual pile volumes varied between 10 cubic yards and 37,380 cubic yards. The total volume of dross piles was calculated to be 43,310 cubic yards. In addition, an estimated 21,900 cubic yards of material remains in the old gravel pit. These calculations were made, using two foot contour intervals, to the nearest 10 cubic yards with an accuracy of ±10%.

5.0 ECOLOGY SITE CLASSIFICATION

Following their investigations of the site, Ecology assigned a hazard ranking of "2" to the Hillyard site in August, 1991. This ranking is a measure of the assumed threat to human health and the environment. Ecology came to the rank of "2" based on the following:

- The aluminum dross had been "book designated" as a Washington Dangerous Waste based on the estimated amount of salts (NaCl and KCL) in the dross.
- The dross sits above a sole source aquifer.

5.1 Previous Dangerous Waste Classification

The procedure for dangerous waste designation has four steps or tests. The first test is to check the waste against a list of discarded chemical products. The second is to check the waste against a list of dangerous waste sources. The third test is to check the waste for dangerous waste characteristics. The fourth, and final, test is to check the waste for toxicity. These steps must be performed in order. If the waste fails any test, it is designated a dangerous waste. These are the previous results for the aluminum dross:

1. The aluminum dross is not a, and does not contain any, listed discarded chemical products.
2. The aluminum dross is not a listed dangerous waste source.
3. The aluminum dross does not exhibit any dangerous waste characteristics.
4. The aluminum dross contains an estimated ~~equivalent~~ concentration of NaCl and KCl in excess of 10%. This would "book designate" the waste a state-only Category D Toxic Dangerous Waste.

The previous tests on samples of aluminum dross were used to detect the concentration of Na and K in the samples. The concentrations for these individual components were converted to concentrations for the compounds NaCl and KCl by the following formula:

$$\frac{\textit{Molecular Weight of Compound}}{\textit{Atomic Weight of Element}} \times \textit{Element Concentration} = \textit{Compound Concentration}$$

Take sample #1 for example:

Na Concentration =	45,000 ppm
Na Atomic Weight =	11 amu
NaCl Molecular Weight =	28 amu

Therefore, the concentration of NaCl would be:

$$\frac{28}{11} x\ 45{,}000 = 114{,}545\ ppm$$

or 11.45%. This assumes that all of the Na in the sample is in the NaCl.

The amount of K was calculated by the following equation:

K Concentration =	34,000 ppm
K Atomic Mass =	19 amu
KCl Molecular Weight =	36 amu

Therefore the concentration of KCl would be:

$$\frac{36}{19} x\ 34{,}000 = 64{,}421\ ppm$$

or 6.4%. Again, this assumes that all of the K in the sample is in the KCl.

If we add the concentrations of NaCl and KCl together we get a total salt concentration of 17.85%. For sample #1, the concentration of salts is higher than the 10% limit for dangerous waste. Additional data has been generated through analysis of the aluminum dross to determine if it is a dangerous waste.

6.0 ANALYSIS OF ALUMINUM DROSS

The aluminum dross has been tested by numerous parties for various reasons. Much of the focus for chemical testing has revolved around determining the chemical composition of the dross for waste classification purposes. Additional testing has been conducted to determine if the dross can be recycled into a useful product. The results from all of the testing are summarized in this report.

6.1 Dross Testing

6.1.1 Chempro Investigation

Chempro, Inc. conducted aluminum dross testing beginning on August 9, 1988. Samples of dross were collected from boreholes, test pits, and backhoe excavations (Figure 3).

Four boreholes were drilled in Pile A with an air rotary drill equipped with an eight inch bit. Samples were taken on a continuous basis from the discharge cyclone over each five foot interval. They were collected and stored in coated canvas sample bags. Bore holes DBH 1 and DBH 2 both encountered very hard material near the bottom of the pile.

Test pits were dug in Piles A, E and the dross pit. The depth of the test pits was about eight feet. Samples were collected by scraping the backhoe bucket up the pit wall. This procedure collected a continuous sample representative of eight vertical feet. A random sample was then taken from the bucket and put in a canvas sample bag.

Most of the piles were sampled by cutting a hole or trench in the side of the pile with a backhoe and exposing 2 to 4 feet of fresh material below the weathered surface. This material was sampled by hand in a continuous channel from the top of the exposure to the bottom. In smaller piles, a bulk load of fresh material was scooped up with the loader bucket and a random sample was collected from the bucket.

Upon completion of field work, the samples were taken to Chempro's Tacoma plant where they were composited prior to laboratory analysis. A composite was made of each bore hole by taking equal amounts of material from the five foot interval samples and placing it on a rubber mat. The material was then rolled in the mat to achieve thorough mixing. When mixed, 180 to 250 grams of the composited material was transferred to glass sample jars and capped. Excess material was placed in a separate sample bag. The same procedure was used for the test pit and backhoe samples where more than one sample was collected from a single pile.

The net result was 25 samples, eight of which were from Pile A. The remainder were one each from Piles B through Q and the dross pit. In addition, sample material from the bore holes, test pits and backhoe excavations in Pile A was composited into another sample (No. 26).

Sample 1-26 were analyzed by Chempro (Table 1). The dross samples were prepared by weighing 10 grams of sample material into a clean beaker and adding 50 ml of deionized water. The samples were heated to near boiling for four hours, filtered and diluted with 100 ml of deionized water. The water samples were analyzed for fluoride, chloride, nitrite, nitrate, phosphate, and sulfate by EPA Method 300, ion chromatography, at the Chempro Laboratory.

The dross samples analyzed by Chempro contained chloride at concentrations ranging from 56 ppm to 57,000 ppm with an average of 13,634 ppm. The samples contained fluoride at concentrations ranging from 44 ppm to 6,400 ppm with an average of 1,351 ppm.

Samples 1-4, 7, 11-15, 18-24, and 26 were analyzed by TrecLen Laboratory (Table 2). For each dross sample, the material was pulverized to -150 mesh using a disc pulverizer; then 10 grams was weighed into a clean beaker with 50 ml of deionized water. The sample/water mixture was heated to near boiling for 2 hours, cooled, filtered and diluted to 100 ml with deionized water. Association of Official Analytical Chemists (AOAC) Method 18.030 was used by TrecLen to analyze for chloride and EPA Method 340.2 was used to analyze for fluoride. Flame emission was used to analyze for sodium and potassium.

The dross samples analyzed by TrecLen contained chloride at concentrations ranging from 275 ppm to 104,000 ppm with an average of 28,193 ppm. The samples contained fluoride at concentrations ranging from 1.85 ppm to 375 ppm with an average of 184 ppm.

The discrepancies in Cl^- and F^- concentrations between the two laboratories are attributed to sample inhomogeneity, and differing sample preparation and analytical methods (Appendix C). The aluminum dross material is inherently inhomogeneous resulting from the aluminum recovery process. The dross is a by-product from secondary aluminum smelting and is poorly mixed resulting in variable concentrations of elements within the dross particles.

The sample preparation methods are a major factor for the discrepancies between the Chempro and TrecLen results. TrecLen pulverized their samples while Chempro did not. Pulverizing the samples dramatically increases the surface area of the samples and thus the solubility of the salts. It also breaks down any encapsulation of the salts that resulted from the smelting process. According to John Trechter of TrecLen Labs, the pulverization was performed to maximize the levels of Cl^- and F^- detected in the dross samples. In addition, deionized water was used by TrecLen in the analyses. Deionized water has a stronger affinity for Cl^- and F^- than rain or groundwater. Therefore, these results are not representative of the leachability of the salts from the dross at the site.

Two samples of dross were taken from the southwest end of the pit and composited for analysis (sample No. 25, Figure 3). One of the samples was taken from a test pit and the other from the nearby west pit wall. Together, the samples represent a continuous sample of the low salt dross over a vertical extent of sixteen feet.

In addition to being analyzed for fluoride, chloride, nitrite, nitrate, phosphate, and sulfate (Table 1), sample No. 25 was submitted to AmTest Laboratories in Redmond, WA for metals analysis (Table 3). Furthermore, to determine the actual free aluminum metal content, an x-ray diffraction analysis (XRD) was done by Scan Tech, Inc. of Bellevue, WA.

The XRD analysis, verified by x-ray dispersive spectroscopy (EDS), determined that the dross sample contained over 45% aluminum. However, only 5.6% was aluminum metal, the remainder was identified as Al_2O_3 and three forms of hydrated aluminum oxide. Other metallic oxides found in the sample included Fe_3O_4, ZnO, and MgO. Copper oxide was not detected and it is assumed that the copper found by chemical analysis is alloyed with the aluminum.

The amount of aluminum metal in the "low salt" dross is too low to be recovered by off-site recycling operators. R.A. Barnes, Inc. located in Dallesport, WA reportedly has treated similar material but it had a minimum of 30% metal. Imperial West Chemicals Inc., located in Spokane has taken small amounts of the dross for use in manufacturing industrial alum for the cement industry.

6.1.2 EMR/Tamars Investigation

EMR and Tamars Engineering collected five samples of the aluminum dross on September 10, 1992 (Figure 4). These samples were collected with a hand-held auger. The auger was used to drill down to approximately eight feet below the weathered surface of the piles. A discrete dross sample was collected at that depth using a decontaminated bucket auger and placed into plastic sampling bags. Soil samples were collected from Piles A, D, E , P and from the pit. These samples were analyzed for metals by the toxic characteristic leachate procedure (TCLP) (Table 4). No metals were detected in the TCLP leachate above regulatory levels.

6.2 Dross and Dross Leachate Testing

EMR/Tamars approached Ash Grove Cement in an effort to recycle the aluminum dross as a constituent of cement. Ash Grove analyzed samples of the dross for compatibility with their cement making process. The analytical results indicated that the dross was too high in alkali elements, particularly sodium (Na) and potassium (K), possibly in the form of salts, to be compatible with their process. A potential solution to this problem was to wash the dross to remove the salts, thus reducing the amount of sodium and potassium. A testing program was initiated to determine if the Na and K could be washed out of the dross.

6.2.1 Ash Grove Testing

Samples of the dross were sent to Ash Grove where they were subjected to numerous washing and testing procedures on December 5, 1991. Five samples were analyzed after washings that consisted of repeated agitation and stirring:

- Sample 100 was the dross sample as-is
- Sample 100-2A was tested after 2 hot water soaks and washes
- Sample 100-3A was tested after 1 boiling water wash
- Sample 101-100 was tested after sieve and 3 washings
- Sample 101-200 was tested after sieve and 3 washings

The samples were analyzed by x-ray diffraction. The results indicated that sodium was reduced by 7.8%, 11.9% and 3.3% in samples 100-2A, 100-3A and 101-200 respectively (Table 5). Sodium increased by 3.9% in sample 101-100. Potassium decreased by 27.5%, 23.19%, 42.93% and 40.22% in samples 100-2A, 100-3A, 101-100 and 101-200 respectively. These results indicate that sodium and potassium were not significantly removed from the dross samples by the washing procedures.

6.2.2 Cominco Exploration Testing

Additional washed dross tests were performed by Cominco Exploration Research. A composite of Pile A and of a Pit Sample were washed 5 times and tested after each wash. Potassium in the Pile A composite decreased by 1.3 % after all of the washings and sodium increased by 1.2% over the unwashed sample (Table 6). Both potassium and sodium increased in the Pit composite sample. Again, the washing tests indicate that sodium and potassium were not removed in any significant amount from the dross samples.

6.2.3 H.P. Jacobi Testing

One additional test series was conducted on dross samples to determine if the sodium and potassium could be washed out of the dross. A composite of Pile A and a Pit composite were subjected to the following procedures:

SAMPLE A (PILE A):

Test #1: 100 grams of sample in the "as is" condition mixed with 200 ml of cold tap water. Manually agitated for 10 mins. Subsequently filtered in a Buchner funnel and the solids dried ahead of assay. The filtrate was given a quick run on the ICP for Na only.

Test #2: A 50 gram sample was dried in the drying ovens overnight ahead of pulverization. Dry weight was 37.95 grams, which was used for the test. That gives Pile "A" a moisture content of 24%. The sample was pulverized for 2 minutes, mixed with 100 ml of cold tap water and agitated with a magnetic stirrer for 5 minutes. Both filtrate and filter cake were handled the same as sample #1.

Test #3: 37 grams of dry material was placed into 100ml of tap water and heated to 90 degrees C for about 5 minutes but allowed to stand and cool off before filtration. Smell of ammonia was quite evident.

Test #4: Test #3 repeated but only at 58 - 60 degrees C for 10 minutes. Handled as above. No ammonia smell this time.

Test #5: 37.5 grams pulverized as above, mixed with 500 ml of cold water acidified with 5 ml of 93% sulfuric acid.

SAMPLE B (PIT):

Test #6: 100 grams dry, unpulverized sample leached in 200 ml of cold tap water for 10 minutes. Filtered and the filtrate and cake handled as before.

Test #7: 50 grams of dry material pulverized in the same ring-mill for 1 minute. Mixed with 100 ml of cold tap water and leached under magnetic stirrer agitation for 10 minutes. Treated as before.

Test #8: Same as test #7 but water heated to 65 - 68 degrees C.

Test #9: 50 grams of material unpulverized, leached for 10 minutes in cold sulfuric acid solution of 5 ml Acid in 500 ml tap water, pH was 1.4. Treated as others.

STANDARD

Test #10: Standard as-is sample.

The test results for the Pile A sample (Table 7) indicate that not enough of the alkalis could be removed from the dross to be acceptable to Ash Grove for their cement process. However, these tests were somewhat better at removing sodium from the Pile A sample than the previous tests with a maximum 44% reduction in Na_2O, probably due to the pulverizing process. Potassium was reduced by a maximum of 56% from the Pile A sample. Sodium and potassium were reduced by a maximum of 12% and 13% from the Pit sample respectively. These results indicate that at least 50% of the sodium and potassium are bound in stable mineralogical forms, possibly as silicates.

6.3 Leachability Testing

The previous washed dross sample analyses indicated that low levels of the sodium and potassium could be washed from the dross samples. This implies that much of the sodium and potassium in the dross is not in the form of salts, because salts are soluble in water and would have been washed out of the dross (leached) and that the salts that are there have been encapsulated in the dross material. In order to understand more clearly what elements will leach from the dross, a 60 year leach simulation was performed on dross samples.

Three samples were submitted to the 60 year leach test:

- #1 ½ composite dross sample and ½ sand
- #2 100% composite dross sample with coarse fractions
- #3 100% composite dross sample soaked for 24 hours

Each dross sample was put in a bucket with holes and placed in a 5 gallon bucket containing rinse water (a volume 7 times the volume of dross). The dross samples were then totally submerged for 15 minutes in their rinse waters. The buckets were removed slowly from their rinse waters and allowed to drain for 15 minutes before submerging again for another 15 minutes. The rinse waters were not changed and no fresh water was added. The submerging and hanging-to-drain process was followed 60 times for each sample. Samples of the rinse water were collected from #1, #2 and #3 after the procedure and were submitted for analysis.

The rinse water sample results indicate that low levels of sodium and potassium leached from the dross samples. Samples #1, #2 and #3 contained 236 ppm, 422 ppm and 405 ppm sodium and 129 ppm, 277 ppm and 253 ppm respectively (Table 8).

In addition to the 60 year leach test, a dross sample was washed in a cement mixer by the following process:

- Four liters of water were added with a 10 lb. composite dross sample in a cement mixer and tumbled for ½ hour. The wash water was drawn off and the suspended solids were allowed to settle out. A sample of the cleared water was collected.
- Added 4 more liters of fresh water to the dross. The dross/water mixture was tumbled for a second ½ hour. The wash water was drawn off and the suspended solids were allowed to settle out. A sample of the cleared water was collected.
- Added 4 more liters of fresh water to the dross. The dross/water mixture was tumbled for a third ½ hour. The wash water was drawn off and the suspended solids were allowed to settle out. A sample of the cleared water was collected.

All three cleared water samples were combined and submitted for analysis. The sample contained 242 ppm sodium and 205 ppm potassium (Table 8). Again, much higher concentrations would be expected if the salts were leaching out of the dross. For example, in the test described above, 10 lbs. of dross were mixed with a total of 12 liters of water. If the dross contained 10% leachable NaCl, then 1 lb. of salt would have dissolved in the 12 liters of water. This would have resulted in a concentration of 37,799 ppm (mg/l) of NaCl or 14,850 ppm of Na dissolved in the water, but only 242 ppm of Na were detected. The equivalent concentration of NaCl for 242 ppm Na is 0.16% in the dross, well below the 10% "book-designation" level.

6.4 Bioassay Testing

On October 17, 1995, EMR again visited the site and collected discrete dross samples from four of the piles and from the dross pit. A total of 15 samples were collected: seven from Pile A, two from Pile D, three from Pile E and 1 from previously unnamed Pile R (Figure 5). Two of the sample were from the pit. The samples were collected from depths ranging from 8 to 12 feet below the weathered surface of the dross piles utilizing a hand-held bucket auger.

All 15 samples were submitted for fish bioassay testing and three of the samples were submitted for rat bioassay testing according to the Washington State Dangerous Waste regulations to Bio Research, Inc. The mortality rate for both the fish and rat bioassay tests was zero-- none of the fish or rats died. According to the dangerous waste regulations (WAC 173-303-100), bioassay testing takes precedence over all other classification methods. The dross is not a Washington State Dangerous waste.

The zero mortality rate for the fish and rat bioassay test is another indication that any salts in the dross are tightly encapsulated in the dross matrix. If the salts were leachable, a higher mortality rate would be expected.

7.0 GROUNDWATER ANALYSIS

The aluminum dross piles lie above the "Hillyard Trough", a major branch of the Spokane-Rathdrum Aquifer. In 1987, Morrison Knudsen (MKE) installed two monitor wells in the area to measure the degree and extent of groundwater contamination due to leaching from the dross piles.

Monitor well BN-2 was installed just west of pile A (Figure 2) and well BN-5 is 1517 feet to the north northwest. Both well borings are 200 feet deep. The well was drilled to a total depth of 200 feet bgs with an 8-inch Odex bit and steel casing, and the monitoring well installed. The 8-inch steel casing was pulled during well construction. Static water levels, measured in September, 1987 indicated that the groundwater table is about 178 feet bgs at an elevation of 1874 feet.

BN-5 is located north of the site. The 8-inch Odex bit and casing were used to drill to a depth of 148 feet bgs. The casing separated at that depth, preventing further use of the 8-inch casing. BN-5 was finished with a 6-inch Odex bit and steel casing to a total depth of 200 feet bgs. The monitoring well was installed and the 6-inch casing pulled. The 8-inch steel casing had separated at the bottom 10-foot joint, leaving steel casing from a depth of 138 to 148 feet bgs.

All monitoring wells were constructed of flush threaded 4-inch ID Schedule 40 PVC with 15 feet of PVC well screen (0.020 slot). The well screens were located with approximately 10 feet of screen below the static water line and 5 feet of screen above. The wells were sand packed from the bottom of the bore hole to a minimum of 5 feet above the well screen. A bentonite seal of approximately 10 feet was installed above the sand pack. Cement grout was then placed in the bore hole to the ground surface to prevent water from seeping down the outside of the casing.

The completed monitoring wells were developed to enhance well production by increasing the porosity and permeability of the natural formation in the vicinity of the well. Development was also utilized to remove any fine grained material remaining in the well after drilling, casing, and packing emplacement. Development procedures consisted of air-lifting the water from the wells until the water was free of sand and silt. Air-lifting was accomplished using an air compressor coupled to steel drill rods reaching to a depth slightly above the bottom of the well. Prior to initial well development and after each subsequent use, all down-hole equipment was steam-cleaned to avoid cross-contamination between well locations.

7.1 Groundwater Sampling

MKE collected a groundwater sample from monitoring wells BN-2 and BN-5 in 1987. The fluoride concentration in BN-2 was found to be 1.2 ppm, which is well below the Spokane area drinking water standard.

On August 10, 1988 the two wells were pumped and sampled by Ponderosa Drilling and Development, Inc. of Spokane. Static water levels were measured prior to pumping. The wells were pumped for three to five minutes at 15 gpm to purge the well of four to five casing volumes of water prior to sampling. Samples were collected and taken to Chempro's laboratory in Seattle for analysis.

The laboratory analyses indicate that groundwater from well BN-2 beneath the dross pile area was contaminated with over three times the primary Maximum Contaminant Levels (MCL) set by the state for fluoride and nitrate (Table 9). Chloride concentrations were 4.6 times the state secondary (non health related) MCL standards. The fluoride level was over ten times that reported by MKE in 1987. All three compounds were detected at concentrations an order of magnitude higher than in water from well BN-5.

EMR sampled water from BN-2 again on October 18, 1995. Prior to sampling, the well was re-developed by surging and bailing. Approximately five well volumes were removed from the well. The water in the well was allowed to equilibrate for one hour. A sample was collected with a clean Teflon bailer. The sample was submitted to North Creek Analytical in Bothell, Washington for analysis.

The sample did not contain detectable concentrations of fluoride, nitrite or phosphate (Table 9). Sulfate was detected at 26 ppm, below the MCL of 250 ppm. The sample contained 1,400 ppm chloride and 23 ppm nitrate, above the MCLs of 250 ppm and 10 ppm respectively.

The results from the groundwater sampling might not be representative of the actual groundwater conditions under the site. The location and construction of monitoring well BN-2 could result in anomalously high concentrations of chloride and nitrates in the groundwater samples. This well was drilled in close proximity to the largest dross pile and pulling the steel casing during drilling could have allowed dross material from the surface to enter the well boring.

7.2 Aquifer Characteristics

According to the MKE report, five well locations in the Hillyard area were selected to evaluate the groundwater flow direction and gradient. Monitoring well surface elevations for BN-1, BN-2, BN-3, BN-4, and BN-5 were surveyed from a brass cap (#283) located at the northeast corner of the intersection of Market Street and Wellesley Avenue. This bench mark had an elevation of 2048.72 feet. Water level elevations were determined by measuring the distance between the top of the well casing and the static water level in the monitoring wells. This distance was subtracted from the elevations determined for the top of the well casing.

Water levels were compared with those reported by Golder Associates in October, 1985. MKE's January 1988 water table data show elevations approximately 20 feet higher than those reported by Golder Associates. This difference could be due to a seasonal or annual variation in the static water level. The groundwater flow direction indicated by MKE and Golder Associates is north to northwest. The gradient indicated by MKE's data is approximately 7 feet per mile while Golder Associates reported a gradient of 10 feet per mile at the southern Hillyard area, increasing to 20 feet per mile at the northern end. MKE's 1988 report cites Golder Associates for an estimated groundwater velocity of 40 feet per day in the Hillyard area.

8.0 INTERPRETATION AND CONCLUSIONS

The Ecology hazard ranking of 2 for this site was based on the following issues:

- The aluminum dross had been book designated as a Washington Dangerous Waste based on the <u>estimated</u> amount of salts (NaCl and KCL) in the dross.
- The dross sits above a sole source aquifer.

This section reviews these issues in light of the data presented earlier in this document.

8.1 Dangerous Waste Classification

As discussed earlier in this report, the procedure for dangerous waste designation has four steps or tests. The first test is to check the waste against a list of discarded chemical products. The second is to check the waste against a list of dangerous waste sources. The third test is to check the waste for dangerous waste characteristics. The fourth, and final, test is to check the waste for toxicity. These steps must be performed in order. If the waste fails any test, it is designated a dangerous waste. These are the results for the aluminum dross:

1. The aluminum dross is not a, and does not contain any, listed discarded chemical products.
2. The aluminum dross is not a listed dangerous waste source.
3. The aluminum dross does not exhibit any dangerous waste characteristics.

4. The aluminum dross does contain an estimated equivalent concentration of NaCl and KCl in excess of 10%. This would "book designate" the waste a state-only Category D Toxic Dangerous Waste.

Steps one through three are straight forward and undisputed. The result for step four, however, is inaccurate. The dross should not be "book designated" a toxic dangerous waste because the fish and rat bioassay tests had zero mortality rates and the calculated equivalent concentrations for NaCl and KCl are too high.

The dross testing described earlier in this report indicates that the sample preparation method has an effect on the sample results. Pulverizing the samples prior to analysis results in higher concentrations of Na and K. This results from the increased surface area of the sample and from breaking the dross matrix which is encapsulating any NaCl and KCl. Pulverized samples are not representative of the actual dross on the site and cannot be used to estimate accurately the amount or leachability of the salts.

The aluminum dross at the Hillyard site is not a Washington Dangerous Waste. If the equivalent concentrations for salt were re-calculated, adjusting for the amount of Na and K bound in stable mineralogical forms, none of the equivalent concentrations would be above 10%. In addition, and more importantly, the fish and rat bioassay tests conducted on the dross resulted on zero mortality. According to the Dangerous Waste Regulations, the bioassay tests take precedence over other classification methods.

8.2 Sole Source Aquifer

The site is located above the Spokane-Rathdrum sole source aquifer. Monitoring of groundwater from an on-site well (BN-2) indicated that there are elevated concentrations (above the MCLs) of chloride and nitrate, and possibly fluoride, in the groundwater under the site. Another well (BN-5), located 1,517 feet down gradient from the site, did not contain the elevated levels of chloride and nitrate. This data is not surprising given the hydraulic conductivity of the Spokane-Rathdrum aquifer. Under the groundwater velocity of 40 feet/day that is estimated for this area, any salts, nitrates or fluorides that happened to leach through 178 feet of soil to the aquifer would rapidly disperse to below the MCL concentrations.

Since there is not as much salt in the dross as previously estimated and the salts are bound in the dross matrix material, the threat to the sole source aquifer is somewhat overstated. The impact to the sole source aquifer, if any, by salt leaching from the dross has not been accurately determined. Additional testing of the water from the SRA will be necessary to determine any impact to the aquifer.