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SUMMARY STATUS OF K BASINS SLUDGE CHARACTERIZATION

R. B. Baker

January 1995

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SUMMARY STATUS OF K BASINS SLUDGE CHARACTERIZATION

INTRODUCTION AND SUMMARY

A number of activities are underway as part of the Spent Nuclear Fuels Project (SNFP) related to the processing and disposing of sludge in the 105-K Basins (K Basins). Efforts to rigorously define data requirements for these activities are being made using the Data Quality Objectives (DQO) process. Summaries of current sludge characterization data are required to both help support this DQO process and to allow continued progress with on-going engineering activities (e.g., evaluations of disposal alternatives). This document provides the status of K Basins sludge characterization data currently available to the Nuclear Fuel Evaluations group. This group is tasked by the SNFP to help develop and maintain the characterization baseline for the K Basins. The specific objectives of this document are to:

1. Provide a current summary (and set of references) of sludge characterization data for use by SNFP initiatives, to avoid unnecessary duplication of effort and to support on-going initiatives.
2. Submit these data to an open forum for review and comment, and identify additional sources of significant data that may be available.
3. Provide a summary of current data to use as part of the basis to develop requirements for additional sludge characterization data through the DQO process.
4. Provide an overview of the intended activities that will be used to develop and maintain the sludge characterization baseline.

It is intended to periodically revise this document as additional data are developed, maintaining a general or top level sludge characterization baseline through this means. The reader would be given what is judged as the most pertinent data of general interest and then directed to expert sources (e.g., reports, data bases, staff, etc.) for supporting detailed characterization data.

Figure 1 indicates the general work breakdown for the sludge characterization activities being pursued by the Nuclear Fuel Evaluations group. The sections of this document provide status on the primary topics noted in Figure 1 (numbering of document sections correspond to figure). The emphasis is to provide as much useful data and data sources as possible.

Appendix A provides a background overview of the K Basins system and fuel storage system. The intent is to provide a consistent set of overviews and cross-references (e.g., names used for basin pits) to allow easy interpretation of the information provided in this document that is drawn from

many sources. Appendix A also includes recent characterization results for K East Basin fuel based on a video survey and evaluation of fuel condition--these may be found to relate to sludge quantity or composition.

Basin "sludge" or "sediment" is particulate matter that for the most part has settled to the bottom of the basins, pits, and spent fuel storage canisters. It is generally found to consist of particulate material composed of solid atmospheric pollutants (e.g., insects, dust, sand, etc.), storage canister corrosion products (particularly from those constructed of aluminum), sloughed-off basin structural materials (e.g., concrete grit from walls, rust from storage racks, etc.), fuel element reaction products (e.g., cladding corrosion products, uranium oxide, insoluble fission products, corrosion products, fuel, etc.), and miscellaneous materials accumulated during the operations of the basins (hand tools, nuts, bolts, etc.).

Figure 2 provides a general summary of the sludges in the K Basins. Most characterization data in this document are related to K East Basin pits and floors because of the larger volume of sludge found there and the higher likelihood of the material containing fuel related matter. This follows primarily because of (1) the open fuel canister system used allowing more fuel and fission product materials to freely mix into the floor sludge, (2) more older model fuel canisters being used, fabricated with more corrosion prone materials, and (3) the basin construction itself that did not include sealing of the concrete walls as was used in K West Basin.

Reference 1 provided a limited preliminary summary of historic sludge data. Some of these data are repeated here both for wider distribution and to provide several revisions resulting from continued analyses. In addition the present document includes recent final sludge depth measurements from K East Basin, revised sludge volume calculations, and chemical analyses. Also included here are further results of reviews of historic Hanford documents that have been collected to help assure that significant conclusions of past efforts with K Basin sludge characterization are not overlooked.

1.0 DATA REQUIREMENTS

The DQO methodology is being completed for sludge characterization activities to fully define those requirements that must be met to respond to needs of the SNFP. The process is scheduled for initial completion in February 1995. Specific input is being obtained from those activities which have a vested interest in the final sludge recovery and disposal process including:

- Characteristics required to choose and develop sludge recovery processes and packaging alternatives. These are being defined by the Westinghouse Hanford Company (WHC) Equipment Engineering group, with assistance of subcontractors including British Nuclear Fuels Laboratories (BNFL).
- Characteristics required to develop sludge simulants. These are being defined by WHC with the assistance of BNFL and Pacific Northwest Laboratory (PNL) staff. The simulants will be used by WHC to verify viable sludge recovery and packaging methods, Reference 2.
- Characteristics required to develop and choose final (e.g., long term) disposal options.
- Characteristics required where sludges could impact the selection of viable alternatives for processing and disposal of the stored spent fuel.

In addition, the DQO process will consider related SNFP global needs including any characterization interface needs identified in the project's overall systems engineering Functions and Requirements, and any unique characterization concerns posed by interfaces with the Defense Nuclear Facilities Safety Board (DNFSB). The final deliverable of this DQO process will be a report defining the specific objectives of the sludge characterization program, including the type and confidence levels required of the data to meet SNFP needs.

2.0 PROCESSING SUPPORT

The ultimate product of this sludge characterization effort is to develop a definitive data baseline that will support the mechanics of sludge retrieval and processing, safety and regulatory needs for processing, and any archive data needs for the final disposal repository for the sludge. This baseline will be the compilation of data from the past characterization efforts, plus the data resulting from the additional requirements for sampling and characterization analyses.

Currently disposal of K Basins sludge is in the stage of developing, recommending, and selecting processing alternatives (i.e., "Path Forward"). Also, as noted previously, there is an interface between the selection of processing alternatives for the stored spent fuel elements and selection of alternatives for at least a portion of the sludges (e.g., sludge in spent fuel storage canisters and the ITA fuel processing option, Reference 3). Potentially very basic questions about the disposal of sludges still may be posed (e.g., its classification as "fuel" or "waste"). All these can impact the ultimate scope of the characterization effort and must be addressed as part of the final DQO process.

Using the objectives defined by the DQO process a characterization plan will be developed to provide those data not available. The plan will include the sampling plan, requirements for analyses, schedule, and reporting requirements. As historic background for this effort a characterization plan for basin sludge written in 1989, Reference 4, for N Basins was reviewed. This addressed the data required to recover, classify, and dispose of N Basin sludges (which are related to K Basins sludges) using a Mobile Sediment Processing (MSP) unit that was being developed at that time. A summary of this plan is provided in Appendix B for reference.

In the interim period while the sludge characterization DQO process is being completed, there remains an on-going need for evaluating and optimizing potential process alternatives. As noted, the most valid information available to the Nuclear Fuel Evaluations group from past K Basins sludge characterization work are included in this current document.

3.0 PAST CHARACTERIZATION

Over the past 6 months J. D. Watrous and K. W. Fischer have worked with other Hanford staff (e.g., B. B. Emory, M. A. Meier, etc.) to obtain as many historic documents and references as possible on K Basins sludge characterization. This effort is being maintained by the author and other staff to include any recently released documents. The primary references collected are listed in two bibliographies provided in Appendix C. The first bibliography provides a listing of significant formal documents associated with K Basins sludge (or sediment) characterization, sampling, processing, disposal, or related topics. The second bibliography lists related references that are less formal including internal memos, DSI's, analyses, and correspondence.

Most references in the bibliographies directly relate to K East Basin because of its larger quantity of sludge. The references show that over the years K Basins, and other Hanford production facilities, have had several periods of increased interest in handling basin sludges and sediments. In addition to the direct references to K Basins, several references are also included that address N Reactor Basins sludges--there are both program and technical relationships between these sludges and their potential processing. In addition, the bibliographies include several references addressing potential related areas of interest at spent fuel storage basins located at other DOE sites, and potentially related sampling technologies from the Hanford Tanks Waste Retrieval System (TWRS).

It is intended that bibliographies in Appendix C be used as a resource for those working on sludge related initiatives for the SNFP to quickly locate historic background. It is planned in the future to briefly annotate those references in bibliographies of general interest.

The primary source of the most valid characterization data is believed to be in the recent (circa 1993) formally documented sample data. This is summarized in the following section.

3.1 GENERAL CHARACTERIZATION DATA FROM FORMALLY DOCUMENTED ANALYSES

J. D. Watrous has analyzed the most recent information from formal reports, References 7 and 8, for the K East Basin sludges and summarized it in a series of tables. These are included here:

- Table 1 provides a general overview of sludge properties.
- Table 2 provides a summary of the sludge characterization from the indicated reference for the Weasel pit, main basin, and Sandfilter Backwash pit. This includes radiation dose rates, density, particle size and selected chemistry.
- Table 3 summarizes additional data taken from the Sandfilter Backwash pit sludge.

- Table 4 provides overview data and calculations for specific areas of the K East Basin, and the corresponding estimates of content and volume of the sludge.
- Table 5 provides a summary of sludge volumes in each of the bays. Assumes a continuous layer of sludge; does not account for volume of sludge displaced by in-place canisters sitting on floor.
- Table 6 provides detail on specific volumes and estimates of uncertainties.

Additional detail on these data are discussed in the corresponding sections of this document including sludge volumes (Section 4.0), distributions of particle sizes (Section 7.0) and chemical analyses (Section 6.0). The source references noted include full details in each case.

It should be noted the chemical data shown in these tables are based on chemical analyses that used methods that did not dissolve silica (e.g., sand); this material likely composed the bulk of the undissolved residue. Also organic carbon (e.g., insects, etc.) was not analyzed; this material may be part of the unidentified material in the mass balance.

3.2 GENERAL CHARACTERIZATION DATA FROM INFORMALLY DOCUMENTED ANALYSES

Appendix C Bibliography 2 includes various informal documents on K Basins sludges. Note too, that Appendix C Bibliography 1, on formal reports, also includes listings of any internal documents included in the formal reports. The informal reports so noted as attachments are not repeated in Bibliography 2.

Review and collection of these informal references are continuing. Many of the older (e.g., 1974 to 1985) references in this set deal with details of specific sample analyses without giving details of location and analysis methods used. Review is being made to confirm which if any are unique and applicable enough to be pursued further. Additional reconstruction would be needed to use such data. The value of this appears minimal as a good review of all viable samples on K East Basin sludge was made in 1988, Reference 9. This review indicated the apparent useful data, as well as that which was uncertain. This review, Reference 9, is further discussed in later sections of the current document.

More recent (e.g., 1992 to present) informal references included in Bibliography 2 document sludge characterization samples taken as part of the operation of K Basins and sludge depth measurement analyses. These data, if significant, are discussed in later sections in combination with other results.

4.0 VOLUME, LOCATION, AND GENERAL CHARACTER OF SLUDGE

A series of measurements of the depth of sludge in the K East Basin (main basin, pits, and canisters) was recently completed by Surveillance Systems Engineering and K Basin Engineering staff (R. H. Webb, R. C. Cecil, and T. A. Meling), Reference 5, the K East Sandfilter Backwash pit, Reference 8, and the K West Sandfilter Backwash (North Loadout) pit, Reference 6. This activity provides two important forms of data:

- Physical measurements of current sludge location and depths. These, in-turn, allow more accurate estimates of total sludge volumes than previously made by less refined estimation methods.
- Video tapes documenting the measurements provide corresponding visual evidence of the qualitative physical character of the sludge in the various locations in the K East Basin and the K West Sandfilter Backwash pit.

These recent efforts provide the best overview of the current general physical condition of the sludge.

Future analyses will review the recent sludge depth characterization data from K East Basin (discussed in the following section and shown in Figure 5) versus both the location of different types of fuel storage canisters and condition of fuel elements in these canisters (discussed in Appendix A, shown in Figures A5 and A6). There could be correlations between these because of the different corrosion behavior of the canister types adding to the sludge (e.g., Mark 0 canisters made of aluminum being much more corroded); as well as the potential for breached fuel elements in canisters adding to floor sludge (e.g., Mark 0 canisters have barrels with holes and slots to allow internal sludge to potentially move to floor). Both these correlations (or lack of correlation) will help clarify the sources and character of sludge throughout the basin and potential further characterization needed.

The review of historic documents, Appendix C, provided no additional significant past data on sludge depths at the K Basins. The review did, however, note the development of a sludge depth probe in 1989, that was designed to provide meter readout of the sludge depths--this relied on a linear array of photo electric emitters and photo sensitive transistors that responded to the sludge blocking the sensors up to the level of its depth (see Reference 4). The method used to measure the sludge depth in the recent work employed a steel ruler or scale and a video camera.

4.1 PHYSICAL MEASUREMENT OF SLUDGE DEPTH IN K EAST BASIN

The recent physical measures of sludge depth were made, Reference 5, using a stainless steel scale, 18 in. (45.7 cm) long, that was inserted into the sludge, and then the graduated markings on the scale were read using a

high resolution underwater video camera. Both the scale and the camera were lowered into the basin on individual stainless steel rods. Depth measurements were made in:

- Over 230 positions on the floor in the three bays of the basin
- Eleven positions in the basin remote pits
- Seventeen in empty or near empty fuel storage canisters.

Figure 3 indicates the general location the depth measurements were taken in the basin. The raw data were analyzed by T. A. Meling, are documented in Reference 5, and included in Appendix D.

As part of this analysis S. L. Hecht, Nuclear Fuel Evaluations, analyzed the main basin sludge depth data using the TECPLOT software on the SUN work stations. The data were fit with a mathematic surface and the volume of material calculated. This provides not only good estimates of the sludge volume but provides aids to visualize the sludge distribution in the basin. Table 5 provides the sludge volume calculations. Figure 4 indicates the locations and value of the sampling done in Bay 1 of the basin and the surface fit. Figure 5 provides a three dimensional graphic representation of the sludge throughout the basin, these were made in both gray level and color graphics.

The mathematic fits of sludge depth measurements in the main basin using a uniform surface provide a good general visualization tool. The actual basin fuel storage system, however, is more complicated as noted in Reference 5 and shown in Appendix A. Needing to be accounted for is the fact the fuel storage canisters (1,065 empty and 3,666 fueled) sit directly on the basin floor, each taking up about 0.73 ft^2 (6.7 cm^2) of basin floor area. Assuming there is no significant sludge under the canisters; a reduction of calculated sludge volume results, bringing the total sludge on the basin floor down from about $1,310 \text{ ft}^3$ (36.7 m^3) to about 764.5 ft^3 (21.7 m^3). Effects of canister storage racks and potential debris on the floor are assumed to be negligible.

Within the fuel storage canisters the depth of sludge has not been characterized except in empty or near empty barrels. Appendix D provides the a list of measurements taken. Not characterized are the depths of sludge in canisters containing full loads of spent fuel assemblies. To make a total basin sludge volume estimate assumptions of sludge depths were made:

- In canister barrels with fuel, but without breached cladding, a sludge depth of 0.5 in. (1.3 cm) was assumed (based on depth measurements in empty canisters and the lack of corrosion noted on the cladding of non-breached fuel elements in video surveys of K Basin fuel)
- In canister barrels containing fuel elements with breached cladding a depth of 4 in. (10.16 cm) was used (assuming corresponding increase in sludge volume from fuel, etc.)
- In empty canister barrels a depth of 0.2 in. (0.5 cm) was used (based on averages of measured sludge).

The total sludge volume in the (1,065 + 3,666) canisters was then calculated, excluding space inside the canister barrels already taken up by fuel elements. The estimated volume of sludge in all the storage canisters was 783 ft³ (21.9 m³).

Finally the volumes of sludge in the associated K East Basin pits were calculated from either direct measurement of depths or implied from nearest depth measurements, Reference 5. While the majority of depths in the K East Basin are less than 2.75 in. (7.0 cm), the deepest accumulation measured was next to the screen separating the Weasel pit from the main basin, here the depth was approximated to be 39 in. (99 cm). The volumes estimated for all the pits are noted in Table 5. The total estimated quantity of sludge in the pits being 795 ft³ (22.5 m³).

The overall total of sludge in the K East Basin was estimated to be 1,837 ft³ (52.0 m³). J. D. Watrous has estimated a conservative uncertainty factors [based on measurement uncertainties, potential impact of assumptions (e.g., no sludge under canisters, etc.), estimates in fuel canister depths, etc.] that could be present in these results to provide a range of bounding sludge volumes. Table 6 provides these estimates showing the total K East sludge volume to be up to 2,382 ft³ (67 m³). It is noted that all the values for volume given here are for the sludge in its current "settled" state without removal of any water. The volumes of sludge estimated here varies from the initial values provided in Reference 1 because the current document accounts for sludge volume displaced by the volume of the fuel canisters sitting on the floor and revised estimates of sludge volume in the storage canisters. The volumes of sludge in this document vary from those in Reference 5 primarily because the inclusion of an estimate of sludge volume in the Segregation pit.

Visualization of plots were also made by S. L. Hecht for the K East Basin Sandfilter Backwash pit. An example of these is shown in Figure 6, taken from Reference 10. This shows the general location and variation of depth of the sludge material both in the pit and the transfer channel.

4.2 PHYSICAL MEASUREMENT OF SLUDGE DEPTH IN K WEST BASIN

Measurements of sludge depth were made recently of the K West Basin Sandfilter Backwash pit and Transfer Channel. This was done by R. H. Webb, R. C. Cecil, and E. N. Dodd in a manner similar to that described in the previous section for K East Basin with the exception that a reference line above the basin grating was used; and the top and bottom (e.g., floor) of the sludge measured using reference marks on the pole supporting the steel scale. Thus, in this case the scale was used simply as a probe. The method used in the K East Basin was not employed because a clear side view of the markings on the scale with the video camera was not possible because of the restricted physical space in pit and the depth of the sludge. An advantage of this method was the data on the surface profile of the floor, which in this case showed the floor not to be totally flat in several instances (or that there is compacted sludge or some other hard material).

S. L. Hecht developed, Reference 6, visualization plots and calculated by integration the corresponding volume of sludge found. Figures 7, 8, and 9 show the top, bottom and depth of the sludge. The volume of sludge was calculated to be 129 ft³ (3.6 m³). Additional analyses are being made to account for sludge that may be present on structures and pipes in the pit. The large depression in the sludge near the center of the pit was the result of using a water lance in an attempt to mix or homogenize the layers of sludge material prior to taking samples for chemical analyses.

Emphasis on establishing sludge volumes has been concentrated on K East because of the much larger volume and higher concentrations of fuel material in the sludge. No other definitive sludge depth or volume measurements were found to date for the K West areas. Similar estimates of sludge volumes in the fuel storage canisters could be made as was done for the K East Basin. It anticipated this would result in about the same volumes of sludge since the amount of fuel and canisters is about the same. An added unknown is the actual breached fuel count, since the canisters all have lids in K West. In general the volume of sludge on the basin floor has been observed to be minimal but depths have not been characterized. Responding to inquiries by the author, T. J. Ruane also noted that besides the Sandfilter Backwash pit there is significant sludge in the K West South Loadout pit (due to decapping canisters prior to shipment to PUREX) and the Tech View pit (from changing filter cartridges).

4.3 QUALITATIVE PHYSICAL CHARACTER OF SLUDGE

In addition to taking direct depth measurement data, all the video tapes of the recent sludge measurements in K East Basin were initially reviewed by the Nuclear Fuel Evaluations group to identify qualitative behavior of the sludge material. Brief highlight tapes were made from the main tapes providing examples of behaviors observed when the material was disturbed by measuring the depths. These tapes are available to view as are the full length tapes, Appendix E. In the main basin the sludge was observed in many instances have a thin, lighter colored crust which contained lower layers of flocculent brown material. A series of still photographs were made from scenes on these tapes. Examples of these are included here:

- Figure 10 shows the 18 in. (45.7 cm) long scale being inserted in the sludge near a basin wall where the depth is about 3.0 in. (7.6 cm).
- Figure 11 shows the scale being inserted and withdrawn from a deep accumulation of sludge in the Weasel pit and the corresponding cloud formed.
- Figure 12 illustrates the probe of an empty Mark 0 fuel canister barrel containing about 0.8 in. (2 cm) of sludge (this is the deepest sludge measured in a barrel).
- Figure 13 illustrates probing a Mark 0 canister with five fuel assemblies and the bottom of an empty Mark 0 canister barrel—showing so little sludge the holes in the bottom of the barrel are visible.

Detailed reviews of the video tapes of the depth measurements are in progress with the objective to document qualities to assist in visualizing the sludge character as related to clouding/settling, variability of apparent composition, containment when disturbed, correlation of depth with location (e.g., dependency on local canister types, failed elements, etc), and other qualities that could assist in processing and disposal.

Brief reviews of the video tapes from the recent depth measurements made in the K West Sandfilter Backwash pit indicated generally similar behavior to sludge in K East; in many instances being represented by a thin crust with underlining flocculent material. The top crust material settles fairly rapidly, while the underlining finer material tends to settle slowly (e.g., it was observed that after a day of probing, the general clarity of the water was noticeably reduced versus the excellent clarity of the water first thing in the work day). Differences noted included the flocculent sludge material in K West appeared much darker, almost black; the material appeared to tend to clump more; and it was observed there was often a significant number of bubbles released from the sludge as the probe was inserted in the material. The source of the gas bubbles has not been identified, a possible source is the injection of gas during water lancing.

Copies of video tapes of sludge depth measurements made in 1993 at the K East Sandfilter Backwash pit, References 6 and 8, were recently obtained from R. C. Cecil and will be reviewed in the near future for additional potential data. Summaries of observations made by the staff at the time of the measurements are described in Reference 8.

5.0 SLUDGE SAMPLING INITIATIVES

The degree and type of characterization the K Basin sludges will require vary with the alternatives chosen for their ultimate processing and disposal. The focus of the requirements for this characterization is being coordinated through the on-going DQO process discussed in Section 1.0. Though the specific requirements are not fully established it is clear that all currently envisioned alternatives for the disposal of the sludge require some level of additional sampling and characterization of sludge materials. A particular need is the characterization of the sludge in the fuel storage canisters, since there is little significant data on its current volume or composition. This sludge is also of concern as it may influence the alternatives considered for the processing the stored spent fuel.

Efforts are currently underway to provide early additional sludge sampling capability and characterization to support decision making, and to minimize the time between making decisions and beginning meaningful work on processing. Past experience in sampling basin sludges is being used wherever possible. Two initiatives are currently under way.

5.1 CO-OPERATIVE USE OF PERIODIC OPERATIONS SAMPLING

Currently sludge samples are taken, as a part of operation of the basins, from the Sandfilter Backwash pits and the Sandfilter on a quarterly basis, and from the main basins annually. M. A. Green, Operations Analysis and Waste Handling group, is currently responsible for taking these samples and maintaining files of past memos and results from chemical analyses. Basically the sampling has been aimed at calculating the plutonium, uranium, and radiological source terms. A 250 ml sample is typically taken with an activity of less than 100 mR. M. A. Green has provided the Nuclear Fuel Evaluations group with a collection of results from recent analyses and a copy of the "letter of instruction" to the laboratory that is used for sample analysis requirements (see Bibliography 2, Appendix B).

It is planned that once SNFP requirements for sludge characterization are defined, wherever possible these operation samples will be used cooperatively; first to serve their primary basin operations objective, and second to obtain as much relevant auxiliary analyses data as possible to support sludge characterization needs.

5.2 SPECIALIZED SLUDGE SAMPLER EQUIPMENT

The need for characterization of sludges in the fuel storage canisters has led to an effort to develop a sludge sampling device that can be used to reach into fuel storage canister barrels even when they contain a full complement of seven fuel assemblies. This device is being developed for the Nuclear Fuel Evaluations group with the lead assistance of staff from the

Engineering/Environmental Demonstration Laboratory group (B. B. Emory, P. J. MacFarlan, and K. A. Larkin). Currently a number of viable conceptual designs have been devised, partially based on past sampling experience. Key parameters (e.g., sample size, laboratories, etc.) are being fixed while maintaining the device as adaptable as possible to evolving characterization needs. This equipment will also be applicable to collecting samples from regions of the basins and pits. Since the basin floors and pits are likely to contain sludge with less fuel material, simpler equipment designs for sampling these areas are also being considered (e.g., equipment used in recent safety evaluations, Reference 15) where appropriate.

Additional sampling initiatives will be initiated based on the needs defined by the DQO process.

6.0 CHEMICAL ANALYSES

Chemical characterization of the K Basin sludges are necessary to support decisions and pursuing the phases of processing the sludge. This is critical to successful safe handling and efficient storage of the material. General areas that may be identified from the DQO process that will require characterization include general composition, radionuclides concentrations, potential presence of hazardous inorganic elements, and perhaps total organic carbon.

J. D. Watrous has reviewed available significant chemical analyses of samples recently taken from K East. Analytical averages of sludge chemistry are provided in Table 7. Averages of radionuclides are listed in Table 8. Individual typical analyses are provided in Appendix F.

Tables 9 and 10 provide recent analyses from Reference 7 ("Meier"), these were performed in the most complete manner of any set of analyses. General comparisons were also made of these recent analyses to two other primary sources (these are summarized in Appendix E). The first is from a compilation, Reference 4 ("Old"), of results for analyses up through 1988. The second is results found in the quarterly and annual samples taken for basin operation, see Section 4.0 and Reference 11 ("Quarterly").

In general, the analytical chemistry results of the three sets of data support one another. In the Weasel pit analyses, the Meier data showed low uranium values whereas in the basin analyses the Old data was high, and in the Sandfilter Backwash pit the Quarterly results were very high and the Old data was variable. Otherwise the Quarterly results were high for aluminum and iron in the Sandfilter Backwash pit. There were relatively consistent variations in alpha and europium (154 and 155) values among the three sets of radionuclide analyses. The Meier results were always low and the Old analyses were always high with the Quarterly data in between. Otherwise, there was no systematic variation in the radionuclide analyses.

As noted previously the chemical analyses discussed here deal with dissolved portions of the sludge. The non-dissolved residue ranged from 25% to greater than 90%, see Table 3. The chemical analyses methods used did not dissolve silica (e.g., sand) in order to avoid problems analyzing certain other materials of interest (e.g., Pu). It is likely the undissolved residue was composed mostly of silicon related compounds, References 7 and 15. Also organic carbon (e.g., insects, etc.) was not analyzed and it is expected this material is part of the missing mass balance in some cases, see Table 2.

It may be of interest as a historic note that the author of Reference 9 concluded that; even with the addition of inert material, the K East Basin floor sediment would result in a waste that could only be classified as transuranic (TRU) waste; and the need for it to be classified a mixed (dangerous) waste would require further characterization (including for the two inorganic elements cadmium and chromium).

7.0 PHYSICAL CHARACTERISTICS

Physical characteristics of the sludge bear directly on the methods of recovery, movement, concentration, and packaging of the material. Parameters identified in initial DQO efforts include:

- Particle size distribution
- Mean particle density
- Particle shape distribution
- Sludge viscosity
- Radiation source levels.

Past characterization analyses have provided data in some of these areas. Tables 1 through 4 include summaries of general results based on the most recent efforts.

Because of recent interest, the following section discusses measurements related to sludge particle size. Once the DQO is complete, corresponding reviews will be made of past characterization information for the parameters of primary interest and additional characterization efforts will be implemented where needed. Currently PNL staff have provided an initial list of specific physical characteristics needed for their development of K Basin sludge simulants, Reference 2. This list includes some of the parameters noted previously. Additional work to define parameters is being performed by BNFL, under contracts to WHC.

7.1 PARTICLE SIZE OF SLUDGE IN K EAST

Recent sludge characterization efforts in K East, Reference 7, included measurement of particle size distributions summarized in Tables 2 and 3. Appendix G includes a set of typical results indicating particle size as a function of both number and volume. Note the distributions are truncated below the diameter of 0.5 μm , because of the measurement method used.

Current interest has been on simulants of the sludge (for pumping, packaging, etc.) and concerns about times for the disturbed sludge to settle. Both of these are partially related to the size distribution of the particles that compose it. As background for this area standard particle behavior for both of these data were obtained from handbooks, Reference 12, and compared to particle size ranges found in sludge samples.

- Figure 14 compares the K East Basin sludge versus selected typical particle sizes.
- Figure 15 indicates the use of an initial simulant composed of three materials (e.g., fly ash, sand, and gravel) compared to the ranges of particle size of the sludge.

- Figure 16 illustrates typical settling times for standard particles (i.e., spheres with specific gravity of 2.0) in water. This can be used as a "rule of thumb" for estimating magnitudes of settling times based on particle size. The shape and density of the particles, number of particles in the water, and any turbulence of the water will naturally influence the settling times for the actual sludge material involved.

Some related general observations on K East main basin and pit sludges noted by Dick Denise, Reference 13, are that it appears pumpable as long as the water velocities are on the order of 5 ft (1.5 m) per second; and that based on pumping sludge from the Segregation pit to the Weasel pit most of this type sludge settles out of the water within 8 hours and fully settles out of the water in 24 hours.

7.2 SLUDGE RADIATION LEVELS

Tables 1 and 2 give some general recent results of radiation levels in the pit and basin sludges in K East.

One historic observation of interest was found in Reference 14. This indicates the potential levels possible from sludges taken from the fuel canisters, Weasel pit, and Segregation pit. Here sampling of sludges in the Segregation pit was made using a pump with a 0.375 in. (0.953 cm) inside diameter tube. One sample recovered had a "small piece" of uranium in it, along with a balance of mostly uranium sludge. This single piece measured in "excess of 5 R per hour at 2 in." (5.08 cm). This is the highest radiation level sludge material found in documented sources to-date and could have implications to handling various sludges.

8.0 BASELINE AND COMMUNICATIONS

An overall objective of the K Basin sludge characterization effort is to complete, maintain and communicate the data baseline supporting the SNFP initiatives. The activities identified by the Nuclear Fuel Evaluations group that are directly linked to the sludge data baseline include:

- Documentation of supporting characteristics and their basis for use
- Maintaining files of documents, references and video tapes supporting the basis of sludge characteristics
- Revising the baseline as data are developed and monitoring the quality assurance levels needed
- Maintaining cognizance of the general characterization data and responding to inquiries with data sources or referrals
- Closing out the baseline, once the sludge disposal is complete, will include archiving: (1) required data for the disposal site and (2) unique and potentially beneficial characterization data to the DOE Office of Science and Technology (OSTI) consistent with DOE orders.

The development of the sludge characterization data baseline will be an evolving effort. Consistent with this, any omissions or errors in data noted in this document should be brought to the attention of the author. Also any data areas that should be considered in the sludge characterization DQO process, but do not appear to be part of the current scope should be brought to the attention of B. J. Makenas or the author.

9.0 ACKNOWLEDGEMENTS

The topic of sludge and sediment in the K Basins has evolved over a period of many years, and includes many operational and technical areas. The author gratefully acknowledges the continued support of the technical staff noted throughout this document including; Mr. R. H. Webb, Mr. R. C. Cecil, Mr. T. A. Meling, Mr. S. L. Hecht, Ms. M. A. Green, Mr. B. B. Emory, and Mr. T. A. Ruane. The author also wishes to especially thank Mr. J. D. Watrous for his assistance and mentoring in the areas of sludge chemistry, historic documents, and reviewing of this document. The professional assistance of Ms. J. M. Nelson in providing wordprocessing and graphics; and Ms. G. R. Baird for clerical support is also gratefully acknowledged.

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Table 1. Typical Characteristics of K East Sludge.

	Range or Type
<ul style="list-style-type: none"> Particle size distribution <ul style="list-style-type: none"> - Median of volume distribution (μ) - 90% of volume (μ) 	32 to 44 4 to 120
<ul style="list-style-type: none"> Settling times (second) 	Not determined
<ul style="list-style-type: none"> Particle shape 	Not determined
<ul style="list-style-type: none"> Density <ul style="list-style-type: none"> - Settled-with water (g/ml) - Particle density-dried (g/ml) 	1.13 to 1.54 3.0 to 3.3
<ul style="list-style-type: none"> Percent solids 	17.5 to 52.6
<ul style="list-style-type: none"> Percent nondissolvable solids* 	25 to 94
<ul style="list-style-type: none"> Chemical composition of dissolvable portions 	Fe>U>Al>Ca>Si>Cr>Zn>Mg
<ul style="list-style-type: none"> Fissile content <ul style="list-style-type: none"> - U (%) - Pu 	3.5 to 10.9 (~1/400 of U) (?)
<ul style="list-style-type: none"> Radiation level (mR/hr/g of B/γ) 	3.3 to 11.4

*Methods used did not dissolve silica (e.g., sand), this material likely composed bulk of undissolved material, References 7 and 15.

Table 2. Summary of K East Basin Sludge Characterization.

ITEM	WEASEL PIT-WEST		WEASEL PIT-EAST		BASIN		SANDFILTER BACKWASH PIT	
	WHC	PNL	WHC	PNL	WHC	PNL	WHC	PNL
RADIATION DOSE RATES Full Sample (mR/hr) Window Open Window Closed Specimen (mR/hr/g) B/ γ γ Specimen (μ Ci/g) α β γ (Approximate) Pu ^{239,240}	5000 - 16.2 289 6.83	 3.32 0.25 61.1 402 206	3500 500 10.3 254 4.24	 11.44 0.88 94.8 719 310	1000 100 17.0 155 5.87	 3.74/4.47 0.37/0.39 50.4 471 344	400 100 5.2 46 2.35	
FISSILE CONTENT (%) U Pu	10.9 (0.03)	9.59 0.034	4.0 (0.01)	12.48 0.032	3.5 (0.009)		0.97 (0.002)	
SLUDGE DENSITY (g/ml) Settled Centrifuged Particle Density	1.53 1.65 3.26		1.54 1.67 3.02		1.13 1.22 3.00		1.11 1.23 ?	
SLUDGE PROPERTIES Solids (w/o of Sludge) Solid Concentration (g/ml) Mass Balance (w/o of Dried Sludge)	49.94 0.764 66.5		52.64 0.811 43.2		17.52 0.198 23.7		10.30 0.114 6.02	
PARTICLE SIZES (μ m) Number Dist-Median Number Dist-Mean Volume Dist-Median Volume Dist-Mean	1.26 2.04 31.71 36.46	0.95 1.24 12.82 13.34	1.12 1.62 42.63 46.31	0.92 1.22 20.47 21.92	0.97 2.03 44.13 48.29	0.96 1.32 17.78 16.97	1.09 1.57 21.13 31.27	
SELECTED CHEM (%) Al Fe Zr	2.4 28.5 0.02	15.6/13.5 18.4/12.5 0.09	1.2 20.0 0.008	15.8/14.1 7.7/ 8.9 0.09	2.1 7.4 0.015	8.3 12.5	0.4 1.4 0.002	

Data from M. A. Meier's "Analysis of 105 KE Basin Sludge Samples," 12110-PCL93-069, and other documentation.

Table 2. Summary K East Basin Sludge Characterization. (cont.)

RADIATION DOSE RATES

Full Sample (mR/hr) - Measured on wet sludge at 2 in.
Specimen (mR/hr-g) - Measured on 206-284 g samples at unknown distance
Specimen ($\mu\text{Ci/g}$) - Measured on dried sludge

FISSILE CONTENT (%)

U (% of Dry Solids) - Measured based on dry solids
Pu content in parentheses are based on U/Pu ratio of 400/1

SLUDGE DENSITY (g/ml)

Settled - Wet sludge density after settling
Centrifuged - Wet sludge density after 1/2 hr centrifuging
Particle Density - Calculated density of the dry particles

SLUDGE PROPERTIES

Solids (w/o of Sludge) - Fraction of solids in sludge (Remainder is water)
Solids Concentration (g/ml) - Settled Density times Solids fraction
Mass Balance (w/o of Dried Sludge) - Chemical compounds plus residue as fraction of dried solids

PARTICLE SIZES (μm) - Sludge particles dispersed in their own water

Number Distribution - Median - Half of particles are larger (and smaller)
Number Distribution - Mean - Average size of all particles (Always larger than Median)
Volume Distribution - Median - Half of volume/mass above this size (and below)
Volume Distribution - Mean - Average volume/mass of all particles (Always larger than Median)
Most particles are $<2 \mu\text{m}$ diameter; Over half of volume is in particles $>20/40 \mu\text{m}$ depending on measuring lab

SELECTED CHEMISTRY (%)

Comparative values for aluminum, iron, and zirconium from WHC and PNL based on dried sludge

Table 3. Summary K East Sandfilter Backwash Pit Characterization.

TITLE SAMPLES >>	TRANSFER CHANNEL EAST TO WEST 5/ 6/ 7/ 8	PIT SOUTH-EAST TO WEST 3/ 12/ 9	PIT NORTH-EAST TO WEST 4/ 11/ 10	PIT RESEARCH SAMPLE UPPER/LOWER
RADIATION DOSE RATES Specimen ($\mu\text{Ci/g}$) α β $\text{Pu}^{239,240}$	62.3/ 8.2/ 4.8/ 6.3 525 / 75 / 54 / 59 45.7/ 5.0/ 3.0/ 7.3	12.6/ 2.3/ 4.4 63/ 35/ 98 7.5/ 2.2/ 3.0	5.7/ 8.1/ 3.0 39/ 125/ 57 3.5/ 5.8/ 2.2	52.7/ 4.9 313/ 41 33.7/ 4.0
FISSILE CONTENT U (% of Dry Solids) U (mg/ml) WHC Laser U (mg/ml) PNL Laser U (mg/ml) ICP/MS Pu ($\mu\text{g/ml}$) AEA	14.6/ 2.4/ 1.3/ 1.5 7.2/ 6.1/ 6.2/ 6.0 7.9/ 6.8/ 6.2/ 6.0 7.5/ 6.9/ 6.2/ 6.3 24.2/14.6/44.6/16.8	3.7/ 1.3/ 3.2 4.6/ 4.6/ 4.6/ 7.0 4.9/ 4.8/ 5.9 9.0/11.6/10.3	1.1/ 5.2/ 1.7 5.3/ 6.3/ 9.2/ 6.0 6.8/ 8.6/ 6.2 18.0/17.2/11.4	13.2/ 3.2 6.4/ 6.5 6.0/ 6.4 19.6/16.2
SLUDGE PROPERTIES Density(Settled)(g/ml) Mud (v/o of Sludge) Particle Density(g/ml) Solids (w/o of Sludge) Solids Concentration (g/ml) Non-Dissolved Residue (w/o Dried Sludge) Mass Balance (w/o of Dried Sludge)	1.08/1.21/1.41/1.31 100/ 57/ 90/ 97 3.53/3.22/2.86/2.75 4.5/20.7/34.4/31.1 .049/.251/.484/.406 25.4/47.8/75.5/86.6 80.3/87.7/94.1/96.4	1.08/ 1.48/ 1.18 93/ 69/ 77 2.88/ 2.56/ 2.64 11.4/ 40.1/ 26.0 0.123/0.594/0.308 72.2/ 94.1/ 87.2 94.6/100.0/101.9	1.30/ 1.25/ 1.23 72/ 95/ 72 2.76/ 2.71/ 2.59 37.1/ 23.0/ 38.7 0.483/0.288/0.479 84.3/ 80.5/ 90.6 96.7/ 99.9/ 100.5	1.06/ 1.37 97/ 88 3.22/ 2.64 5.3/ 28.4 0.056/0.386 39.0/ 87.3 85.1/ 99.0
PARTICLE SIZE (μm) Optical Scan - Residue	50-150/ 400-900/ 1-50,300-700/100-700	50-700/400-700/ 400-700	400-900/400-700 400-700	25-400/300-700
SELECTED CHEM (mg/ml) Al - WHC Al - PNL Fe - WHC Fe - PNL	3.3/ 3.0/ 5.1/ 4.7 3.2/ 3.2/ 5.4/ 5.2 7.1/58.2/47.1/13.2 7.6/57.1/46.4/15.5	3.2/ 4.0/ 4.2 3.1/ 3.8/ 4.0 8.9/ 6.8/ 9.3 8.3/ 1.3/ 2.3	5.4/ 5.2/ 4.5 5.0/ 4.8/ 4.4 21.1/11.9/11.4 20.7/ 3.5/ 2.7	3.6/ 3.6 3.6/ 3.7 6.6/10.7 2.5/ 3.9

Data obtained from R. D. Warner's "Safety Evaluation of the Plutonium and Uranium Content of the 105-K East Sandfilter Backwash Pit," WHC-SD-TM-TA-152, and associated references. 8/10/94

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Table 3. Summary K East Sandfilter Backwash Pit Characterization. (cont.)

SAMPLE LOCATIONS

RADIATION DOSE RATES

Radiation level based on dry solids

FISSILE CONTENT

U (% of Dry Solids) - Measured based on dry solids

U (mg/ml) - Measured on dry solids but calculated for wet sludge as settled

Pu ($\mu\text{g/ml}$) - Measured on dry solids but calculated for wet sludge as settled

SLUDGE PROPERTIES

Density (Settled) (g/ml) - Wet sludge density after settling

Mud (v/o of Sludge) - Upper layer of settled sludge (Lower layer is mostly sand)

Particle Density (g/ml) - Calculated density of the dry particles

Solids (w/o of Sludge) - Fraction of solids in sludge (Remainder is water)

Solids Concentration (g/ml) - Density times Solids fraction

Non-Dissolved Residue (w/o Dried Sludge) - Fraction (mostly sand) of solids remaining undissolved for analysis

Mass Balance (w/o of Dried Sludge) - Chemical compounds plus residue as fraction of dried solids

PARTICLE SIZE

Optical scan of non-dissolved residue - mostly sand

SELECTED CHEMISTRY

Comparative values for aluminum and iron from WHC and PNL based on wet sludge as settled

Table 4. Summary of Sludge Volumes and Content in K East.

Location	Sludge Vol (ft ³)	No. Drums	Mass (Mg)	Plutonium (g)	Uranium (kg)	α Content (Ci)	β Content (Ci)
Tech View Pit	15.23	2	0.66	88	31	16	142
Weasel Pit	418.77	57	18.20	2,410	863	426	3,884
North Loadout Pit	221.59	30	6.96	17	7	4	33
South Loadout Pit	38.35	5	1.67	221	79	39	356
Dummy Elevator Pit	48.50	7	2.11	279	100	49	450
Segregation Pit	52.75	7	2.29	304	109	54	489
Basin Floor	764.50	104	24.46	375	150	144	1,341
Canisters--Empty	13.84	2	0.44	7	3	3	24
Canisters--Full, Good	28.67	4	0.92	14	6	5	50
Canisters--Full, Breach	234.48	32	10.19	1,349	483	238	2,175
TOTALS	1,836.67 (52.01 m ³)	250	67.91 (74.86 tons)	5,064	1,830	978	8,944

NOTE: Mass, Pu and U contents, and α and β contents for Tech View Pit, Weasel Pit, South Loadout Pit, Segregation Pit, and "Canisters--Full, Breach;" are based on characteristics of sludge in the Weasel Pit. Similarly, the Basin Floor characteristics are also used for "Canisters--Empty" and "Canisters--Full, Good."

Table 5. K East Basin Sludge Volume Estimate by Bay.
(Fuel storage canisters not accounted for)

Location	Volume m ³ (ft ³)
Bay 1	13.9 (490.9)
Bay 2	12.6 (445.0)
Bay 3	11.1 (392.0)
Total	37.6 (1327.9)

Table 6. Sludge Volumes for K East and Estimated Uncertainties.

Location	Average Depth (in.)	Area (ft ²)	Volume (ft ³)	Positive Uncertainty	Negative Uncertainty	Minimum Volume (ft ³)	Maximum Volume (ft ³)
Tech View-North Chan	0.97	49.35	3.99	50%	50%	1.99	5.98
Tech View-South Chan	0.21	49.35	0.86	50%	50%	0.43	1.30
Tech View Pit	0.88	141.50	10.38	50%	50%	5.19	15.57
Weasel Pit Channel	12.00	53.79	53.79	20%	20%	43.03	64.55
Weasel Pit	39.00	112.30	364.98	20%	20%	291.98	437.97
North Loadout Pit	33.00	66.53	182.96	20%	50%	91.48	219.55
North Loadout Chan	20.00	23.18	38.63	20%	20%	30.91	46.36
South Loadout Pit	5.25	64.70	28.31	50%	50%	14.15	42.46
South Loadout Chan	5.25	22.95	10.04	50%	50%	5.02	15.06
Dummy Elevator Pit	6.00	97.00	48.50	50%	50%	24.25	72.75
Segregation Pit	2.00	316.50	52.75	50%	50%	26.38	79.13
Basin Floor	1.90	4,828.39	764.50	20%	20%	611.60	917.39
Canisters-Empty	0.22	754.70	13.84	20%	20%	11.07	16.60
Canisters-Full, Good	0.50	688.19	28.67	70%	70%	8.60	48.75
Canisters-Full, Breech	4.00	703.44	234.48	70%	70%	70.34	398.62
TOTALS (ft ³)			1,836.67			1,236.42	2,382.03
TOTALS (m ³)			52.01			35.01	67.45

Table 7. Averages of Chemical Analyses on Sludge Taken from Various K East Basin Locations. (micro g/g)

	Weasel Pit	Main Basin	Sandfilter Backwash Pit
Al	40,300	15,678	24,844
As	44	17	30
Ba	611	73	85
Be	4	25	16
Ca	5,130	1,430	1,218
Cd	77	107	71
Co	22	9	21
Cr	773	202	239
Cu	286	223	558
Fe	214,000	51,639	49,328
K	161	50	138
Li	3	11	5
Mg	1,204	270	515
Mn	318	473	441
Mo	37	15	12
Na	6,111	100	157
Nd	131	67	398
Ni	284	70	65
P	415	191	628
Pb	487	195	344
S	324	214	788
Sb	217	88	273
Si	7,180	2,190	537
Sm	473	225	744
Sr	89	21	28
Ti	177	39	81
Tl	144	100	438
V	370	165	549
Zn	1,396	522	495
Zr	534	102	153
U	158,480	51,703	6,419

Table 8. Averages of Radionuclide Analyses on Sludge Taken from Various K East Basin Locations. (micro Ci/g)

	Weasel Pit	Main Basin	Sandfilter Backwash Pit
Total Alpha	73.86	45.48	52.99
Total Beta	812.88	817.73	350.23
²³⁴ U	0.137	0.00234	
²³⁵ U	0.0131	0.000493	
²³⁸ Pu	8.11	2.51	8.01
²³⁹ Pu, ²⁴⁰ Pu	29.01	14.83	28.51
²⁴¹ Pu	59.02	27.63	19.43
²⁴¹ Am	22.22	24.21	15.99
²⁴¹ Am GEA	6.48	4.17	11.18
⁶⁰ Co	10.32	2.97	4.12
⁹⁰ Sr	44.78	44.66	21.89
¹³⁷ Cs	85.56	46.18	28.22
¹⁵⁴ Eu	9.51	4.39	4.05
¹⁵⁵ Eu	8.78	2.95	3.18
³ H	0.0127	0.00423	0.0781

Table 9. Selected Chemical Analyses on Sludge Taken from Various K East Basin Locations (from Meier, Reference 7). (micro g/g)

	Weasel Pit West SMP 01	Weasel Pit East SMP 02	Main Basin SMP 03	Sandfilter Backwash Pit SMP 04	Average
Al	24,300	12,300	20,800	4,410	15,453
As	41	46	17	3	27
Ba	116	67	54	35	68
Be	4	3	25	6	10
Ca	4,380	2,460	693	766	2,075
Cd	96	58	59	62	69
Co	30	14	9	4	14
Cr	1,180	671	238	48	534
Cu	369	202	213	125	227
Fe	285,000	200,000	73,500	14,300	143,200
K	200	121	50	104	119
Li	4	2	1	2	2
Mg	1,070	611	300	242	556
Mn	363	240	156	323	271
Mo	46	28	15	2	23
Na	150	84	44	64	86
Nd	187	75	67		110
Ni	114	72	40	23	62
P	502	327	191	166	297
Pb	618	356	195	58	307
S	344	303	214	235	274
Sb	318	115	88	32	138
Si	1,430	1,410	1,990	470	1,325
Sm	665	280	225	58	307
Sr	45	22	11	9	22
Ti	174	108	45	28	89
Tl	217	70	100	35	106
V	527	212	165	48	238
Zn	1,250	737	353	201	635
Zr	222	81	148	21	118
U	109,000	40,400	35,000	9,670	48,518

Table 10. Selected Radionuclide Analyses on Sludge Taken from Various K East Basin Locations (from Meier, Reference 7). (micro Ci/g)

	Weasel Pit West SMP 01	Weasel Pit East SMP 02	Main Basin SMP 03	Sandfilter Backwash Pit SMP 04	Average
Total Alpha	16.20	10.30	17.00	5.19	12.17
Total Beta	289.00	254.00	155.00	46.00	186.00
²³⁹ Pu ²⁴⁰ Pu	6.83	4.24	5.87	2.35	4.82
²⁴¹ Am	7.44	46.10	68.80	5.07	31.85
²⁴¹ Am GEA	8.05	4.90	8.13	2.03	5.78
⁶⁰ Co	1.41	0.95	1.63	0.59	1.15
¹³⁷ Cs	42.80	47.50	41.50	13.10	36.23
¹⁵⁴ Eu	1.56	0.93	1.66	0.37	1.13
¹⁵⁵ Eu	0.93	0.48	0.97	0.27	0.66
⁹⁰ Sr	88.10	30.00	74.80	7.01	49.98
³ H			0.00	0.00	

Figure 1. Work Breakdown for K Basins Sludge Characterization.

Figure 1. Work Breakdown for K Basins Sludge Characterization.

Overview Status of K Basins Sludge

Figure 2. Overview of K Basins Sludge.

Figure 3. K East Fuel Storage Basin Layout and Sludge Depth Sampling Locations. (South-to-North Axis Ranges "01" to "76," the East-to-West Axis Ranges "01" to "67")

105-KE FUEL STORAGE BASIN LAYOUT

• - Location of Sludge Depth Measurement

Figure 4. Data Points and Surface Fit of Sludge in K East Bay 1.
(Locations relate to Figure 3)

Figure 5. Surface Fit of Data from Three Bays of K East Main Basin.
(Locations relate to Figure 3)

Figure 6. Surface Fit of Sludge Depth Data
in K East Sandfilter Backwash Pit.

Figure 7. Surface Fit of Sludge Depth Data
in K West Sandfilter Backwash Pit.

K WEST BACKWASH & TRANSFER PIT TOP OF SLUDGE REFERENCE MEASUREMENT

Figure 8. Surface Fit of Top Surface of Sludge
in K West Sandfilter Backwash Pit.

Figure 9. K West Sandfilter Backwash Pit Sludge Bottom (Floor) Surface.

Figure 10. Scale Being Inserted in Sludge Near Wall in K East Basin.

Figure 11. Scale Being Inserted in Large Accumulation of Sludge in K East Weasel Pit and Resulting Cloud Upon Withdrawal.

Figure 12. Measurement of Sludge in Bottom of Mark 0
Storage Canister Barrel in K East.

Figure 13. Appearance of Sludge at Bottom of Storage Canister Barrel Containing Five Fuel Assemblies, and at Bottom of an Empty Mark 0 Canister--Showing Wire Mesh Covered Holes on Bottom of Barrel.

Figure 14. Comparison of K East Sludge to Standard Particle Sizes of Various Materials.

*Atterberg or International Std. Classification System Adopted
by International Society of Soil Science since 1934
** C.E. Lapple, Stanford Res. Inst. Jour., Vol. 5, pg 94, 1961.

Figure 15. Comparison of K East Basin Sludge, Standard Particle Sizes and Selected Initial Simulant Materials.

*Alterberg or International Std. Classification System Adopted by International Society of Soil Science since 1934

**C. E. Lapple, Stanford Res. Inst. Jour., Vol. 5, pg 94, 1961.

Figure 16. Estimate of Gravitational Settling for K East Basin Sludge.

*for spheres, specific gravity 2.0, in 25°C water.
** C.E. Lapple, Stanford Res. Inst. Jour., Vol. 5, pg 94, 1961.

A P P E N D I X A

GENERAL OVERVIEW OF K BASINS STORAGE SYSTEM

APPENDIX A

GENERAL OVERVIEW OF K BASINS STORAGE SYSTEM

The intent of this appendix is to provide

- A brief summary to orient the reader not generally familiar with the K Basins system to its parameters related to concerns on sludges
- A summary of general dimensions and nomenclature used in the document
- Results from the recent video survey of the fuel storage canisters and fuel condition in K East Basin (canister and fuel condition may have general implications to interpreting the character of the sludge).

The K Basins system is summarized in detail in Reference A1. A summary of selected parameters for the K East fuel system is provided in Table A1. The storage canisters each have two barrels. The storage canisters sit directly on the basin floor. A series of racks assure the canisters remain upright. A schematic of the this layout is shown in Figure A1. Sludge is located on the basin floor, in the auxiliary basin pits, and in the fuel canisters. Each canister barrel can contain up to seven fuel assemblies, each fuel assembly being composed of an "inner" and "outer" fuel element. (Note: In some documents the "assembly" is referred to as a "fuel element assembly" or "element." In this document the combined elements are referred to as an "assembly.")

Figures A2 and A3 show examples of the fuel canisters in K East Basin. Here there are no lids on the canister barrels and in some cases empty canisters are laying on top of the in-use canisters. There are at least three general types of canisters; Mark 0, Mark I, and Mark II. The Mark 0 canister barrels have both slots in the sides and holes in the bottom, as can be seen in Figure A3 on the upper right. The other canister designs do not have these features. The canister barrels with slots and holes allow free movement of the sludge in the barrel to the basin floor and water when the canister is moved. The Mark 0 and some Mark I canisters have aluminum barrels; these typically now have large nodules of white corrosion products visible on them (this material is at times deposited in the sludge). The other canister barrels are made of stainless steels and typically have a fairly clean surface appearance.

In K West Basin all the canister barrels are closed; having no slots or holes in barrel and initially sealed lids. Figure A4 shows examples of canisters and racks in K West Basin. The canisters are all the newer Mark I and Mark II canisters.

The storage canisters contain from zero to fourteen spent fuel assemblies. These can range in condition from no apparent degradation to degradation to the point pieces of cladding and fuel are all that is evident. A video survey of the K East Basin fuels was recently completed, References A2

and A3. Figure A5 shows a visualization graphic indicating the location of the various types of fuel canisters observed (note this figure does not show all the canisters since some were hidden from view of the camera survey). Figure A6 shows for these canisters the results of the survey indicating the assessed fuel condition in general for each canister. The data represented on both these figures will be used in the future to assess potential dependencies of the local sludge volume and character in the K East Basin (e.g., data on fuel element condition will be compared to data such as that shown in Figure 6 in the main text).

Figure A7 provides a general overview of the basins indicating general names and dimensions are used in this document. Dimensions were taken from Reference A4. The walls of the K West Basin have been coated with a sealer, the walls in K East Basin have not. The latter could contribute to material accumulating into the sludge, Reference A1. As indicated in Figure 2, K West Basin has markedly less sludge than K East Basin.

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- A3. Memo, A. L. Pitner to R. P. Omberg, "Illustrations From K East Basin Fuel Survey," December 14, 1994.
- A4. A. D. Alwardt, "100 K East/K West Basin Water Surface Area Calculation," Draft, WHC-SD-NR-ANAL-004, Rev. 1, October 1994.

Table A1. Selected Parameters for K East Basin Fuel
and Storage System Related to Sludge.

1. Basin floor areas see Figure A7
2. K East Basin storage rack grid layout: Figure 5 in main text
(Note: There are 76 rows and 67 columns, except for columns 2 and 66 which only have 38 rows. Also there are 8 rack positions that are half size in these 2 columns so these cannot be used for normal canisters.)
3. Total number of canisters in K East: 4,731

Empty	1,065
Fueled: Containing unbreached fuel elements (estimate 50%)	1,833
Fueled: Containing breached fuel elements	1,833
4. Typical Mark II fuel canister:
 - Two barrels per canister
 - Maximum capacity: Seven fuel assemblies per barrel, each assembly composed of an "inner" element and an "outer" element
 - Barrel dimensions
(at basin floor level, reference drawing H2-42792)

OD	8.19 in. (20.80 cm)
ID	8.06 in. (20.47 cm)
Height of barrel	28.00 in. (71.12 cm)
5. Total number of fuel assemblies in K East, Reference A1: 50,683
[If all barrels were full (7 assemblies) there would be 51,324 assemblies]
6. Typical Mark IV fuel assemblies (reference drawing H1-39775)
 - Inner element

OD	1.2765 in. (3.24 cm)
ID	0.4825 in. (1.24 cm)
 - Outer element

OD	2.4225 in. (6.1532 cm)
ID	1.7035 in. (4.3269 cm)
Length	26.1 in. (66.29 cm)

Figure A1. Schematic of Sludge Locations in K East Basin.

Figure A2. Overview of Storage Canisters and Racks in K East.

Figure A3. Overview of Canisters in K East with Empty Canisters Laying Over In-Use Canisters (Note in upper right of photograph the Mark 0 Canister with holes in bottom and corrosion products on surface of barrels).

Figure A4. Overview of Canisters (with lids) and Racks in K West Basin.

Figure A5. K East Basin Visual Survey Results: Canister Types.

Figure A6. K East Basin Visual Survey Results: Fuel Condition in Canisters.

Figure A7. Schematic of K East Basin Overview.

Schematic of K East Basin Overview

Alternate Names Used

- * Sandfilter Backwash Pit.
- ** Transfer Pit.

A P P E N D I X B

SUMMARY OF 1989 SLUDGE SAMPLING AND CHARACTERIZATION PLAN FOR N BASINS

Taken from: V. B. Subrahmanyam, "Basin Sediments Sampling
Characterization Plan," WHC-SD-CP-TP-048, Rev. 0, April 1989.

SUMMARY OF 1989 VINTAGE BASIN SEDIMENT SAMPLING AND CHARACTERIZATION PLAN

R. B. Baker
November 4, 1994

Source: WHC-SD-CP-TP-048 (4/29/89)

Title: "Basin Sediment: Sampling and Characterization Plan"

Summary: Reviews proposed statistical sampling and characterization of sediment in the N Reactor facility water filled areas. The brownish flocculent sediment is the result of fuel processing, basin operation and environment (i.e., insects, dust, etc.). This report is related to WHC-SD-CP-TI-142 ("K East Fuel Storage Sediment Processing: Assessment of and Characterization Needs for Disposal," February 8, 1989). It provides the physical parameters, analytical measurements, and special analyses believed at the time to be necessary for characterization of basin bottom sediments. Sampling, measurement techniques, equipment needs and documentation are discussed. While aimed at N Basins the inference is application to K East Basin also. Intent was to support development of the Mobile Sediment Processing (MSP) unit and final waste disposal. The MSP system used the addition of inert particulate (e.g., gypsum Al_2O_3) to act as a inert extractor in the systems' centrifuge. (The WHC-SD-CP-TI-142 report notes for K Basin the sediment must be classified TRU, even with the addition of inert extractor, and that the need to further classify it "mixed (dangerous) waste" requires further measurement of concentrations of cadmium and chromium.)

Summary of Plan

1. Location of sediment sampling and depth measurements

- Minimum number of samples for parameter and confidence level
 - For a basin they concluded 24 random locations/four subsets of six each for sequential analyses, stopping sequence if not warranted
 - Assumes aliquots of 250 ml
 - Assumes homogenizing locally by agitation

2. Collection and preservation of specimens

- "Collected and analyzed to meet requirements of RCRA"
- Used a thief sampler method adapted from ASTM
- Sampling meets or exceeds EPA ("Test Methods for the Evaluation of Solid, Physical/Chemical Methods") and WAC ("Dangerous Waste Regulations") methods of sampling

- Used peristaltic pump with 0.5 inch diameter stainless steel pickup tube with portion of Teflon or plastic tube in between
- Sample will be collected into plastic containers, and capped with minimum headspace
- Size of sample will be 250 ml at minimum

3. Physical measurements

- Sediment depth
 - Objective: Accurate calculation of volume
 - Depth probe with meter readout was developed and documented
- Specific gravity in suspended condition (wet)
 - Objective: Estimate volume and mass of sediment to be processed
 - Direct measurement of volume and mass using material allowed to settle for 24 hours or more
- Specific gravity of centrifuged sediment (dry)
 - Objective: Estimate volume and mass to establish transuranic (TRU) nature of processed sediment
 - Centrifuge to >800 g's
- Volume percent solids in suspended sediment
 - Objective: Estimate volume and mass for processing
 - Settle for 24 hours and centrifuge
 - Confirm with mass balance using wet and dry specific gravities

4. Chemical measurements

- Preparation: centrifuge and dry
- Radionuclides Concentration of Dry Sediment
 - Objective: Estimate TRU activity levels
 - Small known quantity (about 100 mg) of solids on 47-mm diameter filter paper (vacuum filtration, drying, known volume of suspended sediment dispersed uniformly in known volume of deionized water).

- Use gamma energy analyses (GEA) to identify specific activity of gamma emitting activation products, fission fragments and TRU isotopes.
- Dissolved aliquot of dry sediment counted for gross alpha and beta activity per unit mass
- Uranium content will be determined if necessary
- Typical elements of concern shown in Table B1
- Hazardous inorganic elements in dry sediment
 - Objective: Estimate type of waste
 - Inductively coupled plasma (ICP) of dissolved aliquots.
 - Typical elements of concern shown in Table B2
- Total organic carbon (TOC) of dry sediment
 - Objective: Suggested because of the reported presence of insect remains, would allow explanation of component of total mass balance of material. Not expected to impact disposal decisions, unless it is a major portion of the sediment.
 - Use aliquots of dry sediment use Dohrman method or its equivalent

5. Special analyses

- Radionuclides and inorganic ions in aqueous phase
 - Objective: If determined to be "waste" leachability of inorganic elements.
 - Analyses of preserved (acidified) filtrate from removal of solids should be similar to EP-Toxicity (EP-Tox) test and Toxicity Characteristic Leaching Procedure (TCLP) except for higher pH conditions in basin versus tests at pH=5.
 - Use GEA for gamma emitters and ICP for inorganic
- PCB analyses
 - Objective: Confirm "waste" type where contaminants of polychlorinated biphenyls (PCBs) from hydraulic fluid may have mixed with water and found its way to sediments.
 - Separated solid sediment and the filtrate should be analyzed for the presence

Table B1. Important Radionuclides of Disposable Mixed Waste.
(From WHC-SD-CP-TI-135, 10/11/88)

A. Activation and Fission Products

Tritium
Carbon-14
Nickel-59
Cobalt-60
Nickel-63
Selenium-79
Strontium-90
Niobium-94
Technetium-99
Iodine-129
Cesium-137

B. Transuranic Waste Elements*

Neptunium-237
Uranium-238
Plutonium-239/240
Plutonium-241**
Americium-241

*TRU waste nuclide, as defined by DOE Order 5840.2, is a transuranic isotope ($Z > 92$) that decays by alpha particle emission with a half life > 20 years.

**This nuclide is not a true TRU waste nuclide, but decays to a TRU waste nuclide (Americium-241).

Table B2. Hazardous Elements and Anions of Importance
in Disposed Mixed Waste. (From WHC-SD-CP-TI-135, 10/11/88)

A. Elements

Arsenic
Barium
Cadmium
Chromium
Lead
Mercury
Selenium
Silver

B. Anions

Fluoride
Nitrate (as NO_3^-)
Nitrite (as NO_2^-)

6. Procedures

- Only physical measurement, sampling and sample preparations unique; the balance of equipment and procedures are standard methods.
- It is emphasized that RCRA sampling and analyses demands strict QA/QC, sampling team personnel should be trained

A P P E N D I X C

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WHC-SD-NR-TRP-021, Rev. 0 D.B. Bechtold (EDT600470)	Report of Laboratory Test Plan for Analysis of KE Basin Backwash Pit Samples	March 28, 1994 S-4	Excerpt from WHC-SD-WM-DP-056, 222-S Analytical Laboratory, K East Filter Backwash Pit, December 3, 1993 Excerpt from WHC-SD-WM-DP-057, 105-K East Basin Sand Filter Backwash Pit (SFBWP) Transfer Channel Narrative Excerpt from WHC-SD-WM-DP-062, Sand Filter Backwash Pit (SFBWP) Second Campaign Narrative DSI, Dave Bechtold to J.K. Watts, Please Perform the Following Procedure on Equipment Blank Sand, 11/19/93 Ron Sanders to C.L. Bennett, XRF Analysis of Residue Samples (KE-84B, -84C, and -84D) from Acid Digestion Process at WHC 222-s Laboratory Using the KEVEX 0810A Subsystem, 2/17/94 B.E. Hey to D.B. Bechtold, Results of Polarized Light Microscopy Analysis on Acid Digest Residues from the K East Basin, 1/18/94

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WHC-SD-WM-TA-152, Rev. 0 R.D. Warner (EDT603558)	Safety Evaluation of the Plutonium and Uranium Content of the K East Basin Sandfilter Backwash Pit	March 31, 1994 S-5	J.E. Truax to J.E. Mecca, Resolution Plan for 100-K East Basin Sandfilter Backwash Pit (SFBWP) Safety Limit Violation, 8/12/93 J.E. Mecca to President DOE, WHC Resolution Plan for 100-K East Basin Sandfilter Backwash Pit (SFBWP) Safety Limit Violation, 8/12/93 D.L. Edwards to C.L. Bennett, 105-K East Sample Collection Dry Run, 9/16/93 D.L. Edwards to C.L. Bennett, Sampling Summary for 105-K East, 9/23/93 D.L. Edwards to C.L. Bennett, Sampling Summary for 105-K East Round 2, 11/11/93 C.L. Bennett to Distribution, Data Quality Objectives-Final Report, 12/20/93 Larry Greenwood to C.L. Bennett, 105-K East NLOP Analysis for Sample Group 3 for Project ED4182, 2/25/94 D.B. Bechtold to C.L. Bennett, Sludge Calculations for KE Backwash Pit Series S3062- Samples, 12/29/93 E.J. Wyse to Larry Greenwood, 105-K East Narrative, 2/10/94 James Bramson to Larry Greenwood, ICP/MS Analysis of 105-K East Basin Samples, 1/11/94 Ron Sanders to C.L. Bennett, XRF Analysis of Residue Samples (KE-84B, -84C, and -84D) from Acid Digestion Process at WHC 222-s Laboratory Using the KEVEX 0810A Subsystem, 2/17/94 Larry Greenwood to C.L. Bennett, 105-K East NLOP Analyses for Project ED4182, 12/14/93 T.L. Welsh to C.L. Bennett, Statistical Analysis of 105-K East Basin Backwash Pit Sample Data, 3/9/94

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Number/Author	Title	Date/Log	Memos and Documents Included
WHC-SD-EN-EV-028 Revision 0 Loc V. Nguyen (EDT141676)	GENII Population and Maximum Individual Dose Consequence Calculations for the N Reactor Basin Sludge	May 20, 1994	Milton Shultz to J.C. VanKeuren, 1/26/94
WHC-SD-CP-TI-175, Rev. 2 -DRAFT- K.H. Bergsman	Hanford Irradiated Fuel Inventory Baseline	June 14, 1994 S-3	
WHC-SD-SNF-TI-002, Rev. 0 -DRAFT-	Hanford Site Existing Irradiated Fuel Storage Facilities Baseline	June 29, 1994 S-2	
WHC-SD-WM-PLN-083 Rev. 0 M.J. Vitulli (EDT603561)	Waste Certification Plan for 100-K Basins	July 8, 1994	
WHC-SD-SNF-TI-003 Rev. 0 C.C. Pitkoff (EDT606308)	Tech. Bases for IB/CX for 105-K East Basin Spent Nuclear Fuel/Sludge Pilot Run	August 5, 1994	
WHC-SD-SNF-TI-004, Rev. 0 T.L. Welsh (EDT600492)	Statistical Evaluation of the Data Obtained from the K East Basin Sandfilter Backwash Pit Samples	September 16, 1994 S-7	
8E110-PCL94-084 D.B. Bechtold	Particle Size Distributions of Fly Ash Sample	September 29, 1994 S-6	
WHC-EP-0830 Rev. 0, Volume I J.C. Fulton	Hanford Spent Nuclear Fuel Project Recommended Path Forward	October 1994	
WHC-SD-NR-ANAL-004, Rev. 1 -DRAFT- From Dave Watrous	100 K East/K West Basin Water Surface Area Calculation	October 17, 1994	

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WHC-SD-SNF-PMP-002 Rev. 0 L.M. McWethy (EDT600505)	Project Management Plan 105-K East Basin Sludge Retrieval and Packaging	November 7, 1994	
WHC Correspondence No. 9550053 J.C. Fulton to R.A. Holten (RL)	K Basin Sludge Classification Recommendation	January 6, 1995	

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Rockwell International W.K. Kratzer from D.M. French	105-K East Backwash Pit Sample Results	January 12, 1984	
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Battelle John Adams from C.W. Thomas/ V.W. Thomas	Gamma and radiochemical analyses for the six samples of basin sludge	February 16, 1984	
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Addressee/Author	Title	Date/Log	Comments/Memos Included
United Nuclear Industries J.A. Adams from A.E. DeMers	105-B/C, D/DR Sludge Characterization	February 24, 1984	
Battelle John Adams from C.W. Thomas/ V.W. Thomas	Gamma and radiochemical analyses for six sludge samples	March 12, 1984	
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United Nuclear Industries G.L. Smith from A.P. Larrick	K East Basin Filter Backwash Sludge	August 29, 1985	Summary of sampling at seven different locations five different heights each
United Nuclear Industries G.L. Smith from R.L. Moffitt	K East Sandfilter Loadout Pit Pu Limits	September 17, 1985	

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Addressee/Author	Title	Date/Log	Comments/Memos Included
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United Nuclear Industries	K East Sludge Testing History Sandfilter Backwash Pit		Summary Memos October 18, 1978 through August 13, 1985
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FAX	Sample Analyses Around K East Basin	August 1989	
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WHC S.A. Slinn from T.D. Jarecki	K East Storage Basin Water Surface Area Calculations	March 3, 1993	

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Addressee/Author	Title	Date/Log	Comments/Memos Included
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WHC M.A. Meier, C.L. Bennett from Bruch Hey (12110-PCL93-058)	Results of Thermal Gravimetric Analysis on K East Basin Sludges and Supernatant Liquids	July 14, 1993	
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WHC A.J. Colburn from R.P. Denise (DSI)	Air and Water Concentrations at K East During Sludge Pumping	February 17, 1994	
WHC C.L. Bennett from L.D. Alwardt (94LDA.001)	Updated Calculation of Uranium and Plutonium in the 105-K East Sandfilter as of March 30, 1993	March 14, 1994	
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WHC E.N. Dodd from S.L. Hecht	K West Backwash Pit Sludge Depth Data: Visualization and Analysis	October 24, 1994	
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WHC C.A. Thompson from M. A. Green (OAWH-074-94)	105-K East Quarterly Sandfilter Sand Sample Results	November 10, 1994	
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Scientific Ecology Group, Inc. S.A. Brisbin from J.G. Wagner	Surrogate Sludge Floc Testing	November 28, 1994	
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Addressee/Author	Title	Date/Log	Comments/Memos Included
WHC R.P. Omberg from A.L Pitner and S.L. Hecht	Illustrations from K East Basin Fuel Survey	December 14, 1994	

Annotation of Selected Formal References from Bibliography 1

WHC-SD-CP-TI-135 -- 10/11/88

Hanford Production Reactor Fuel Storage Basin Sediment Characterization and Processing for Disposal

Concludes solid waste generated by isolation of N Reactor fuel storage basin sediment using the mobile sediment processing system (MSP) can be classified as non-hazardous, non-transonic (non-TRU) radioactive waste. Includes estimates of activation products ($\mu\text{Ci/g}$). The MSP uses a addition of gypsum to enhance the centrifuging process. Reviews N Basin sludge sampling 1987 versus 1983 and 1980. The packaging, transferring and final disposal decision logic is reviewed with concerns.

WHC-SD-CP-TI-142 -- 2/8/89

K East Fuel Storage Sediment Processing: Assessment of and Characterization Needs for Disposal

Summary report providing information compilation and evaluation of available (as of 2/88) sampling methods used and the results of analyses of the K East fuel storage basin sediment (sludge). Along with fuel related materials the sediment was found to have cadmium and chromium in some samples. Sediment isolated is concluded as needing to be classified as TRU waste based on data available. Noted is the need to obtain additional data (leachability of cadmium and chrome) to clarify if the final waste form is to be classified as mixed (dangerous) waste. Characterization needs are reviewed including need for 24 samples from each area using a "thief sampler method" using materials that conform to RCRA protocol is require obtain aliquot of basin sediment.

WHC-SD-CP-TP-048 -- 4/29/89

Basin Sediment: Sampling and Characterization Plan

A statistical sampling and characterization sediment in the N Reactor facility water filled areas related to fuel processing, basin operation and environment (i.e., insects, etc.). Related to WHC-SD-CP-TI-142 to in providing the physical parameters, analytical measurements, and special analyses necessary to characterization in basin bottom sediments are reviewed. Sampling, measurement techniques, equipment needs and documentation are discussed. While aimed at N Basins the inference is application to K East Basin also. Intent was support planning for the Mobile Sediment Processing unit and final waste disposal (also see Appendix B).

A P P E N D I X D

SLUDGE DEPTH MEASUREMENTS FROM K EAST BASIN

(From Reference 5, Locations are Shown in Figure 3
of Main Text, Depths are in Units of Inches.)

DEPTH	LOCATION			
BAY 1				
0.875	102		** Inside canister infers	
1	104		an empty canister unless	
4	122		otherwise noted	
4	124			
5	129		** Between Canisters infers	
4.75	131		measurement cubicle	
2.375	133		contained a canister -	
3	147		measurement was taken	
2.75	150		adjacent to can	
3.25	150			
7.625	163			
5.625	168			
1.75	172			
2	176			
2	204			
3	206			
3.5	213			
3.125	214			
7.875	215			
1.875	218			
1.5	219			
1.5	220			
1.875	222			
2.875	225			
7.5	232			
0.75	302			
2	324	Between Canisters		
2	326	Between Canisters		
1.25	332			
0.625	336			
4.25	471	Between Canisters		
3.625	476			
1	504			
1	506	Between Canisters		
2.125	570			
0	603	Inside Canister		
0.5	701			
1.125	731			
0.75	1006			
1.75	1176			
0.375	1201			
1.75	1321			
1.125	1322			
1.5	1324			

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DEPTH	LOCATION			
1.75	1328			
1.5	1354			
2.25	1375			
1.5	1422			
1.125	1424			
1.125	1455			
0.125	1743	Inside Canister		
2.375	1831	Between canisters		
3	1868			
2.5	1870			
1.75	1872			
1.25	1901			
1.375	1904			
2	1906			
1	1909			
1.375	1911			
4.75	2076			
2.125	2201			
1.625	2202			
5.125	2205			
3.625	2225			
3.25	2228			
3.125	2231			
3	2234			
3.125	2269			
2.5	2272			
5.75	2276			
BAY 2				
3.875	2302			
1.875	2305			
3.75	2316			
3.25	2331			
4.25	2345	East of 2345		
2	2345	Between Canisters		
4	2352			
1.75	2352			
3.375	2358			
0.5	2359	Between Canisters		
2.5	2371	East of 2371		
1.875	2371	Between Canisters		
2.25	2375			
3.625	2376			
0.25	2501			
0.5	2511			

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DEPTH	LOCATION			
1	2515			
0.75	2575	Inside Canister		
0.5	2575			
1.375	2576			
1.5	2609			
1.625	2614			
1.375	2620			
1.375	2626			
3.125	2676			
0.875	2717			
1.75	2725			
0.75	2728			
0	2747	Inside Canister		
0	2748	Inside cansiter		
1.875	2769			
0.5	2771			
0.125	2901			
1.125	2904			
0.625	2927			
1	2935			
0.5	2939			
0	2947	Inside Canister		
0	2951	Inside Canister		
0.125	3002			
2.375	3007			
0.125	3037	Inside Canister		
0	3047	Inside Cansiter		
1	3101			
1.75	3205			
2.25	3213			
2.5	3214			
0	3521	Inside Canister		
2.875	3558			
4	3567			
1.375	3571			
2.25	3573			
2.75	3603			
2.5	3610			
1	3675			
1	3712			
1.5	3739			
1.5	3744			
1	3804			
0.375	3806			
2.25	3814			

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DEPTH	LOCATION			
1.625	3816			
1.125	4003			
0.875	4006			
0.875	4008			
2.375	4011			
1.25	4012			
1.875	4014			
2.375	4016			
1.625	4101			
1.125	4103			
2.875	4149			
2.25	4155			
1.375	4163			
1.25	4172			
0.375	4201			
0.375	4203			
1.25	4205			
1.375	4301			
0.875	4303			
0.25	4311			
0.875	4401			
0.25	4404			
0.625	4405			
1.875	4407			
0.375	4412			
1	4415			
2.25	4501			
2.625	4503			
2.5	4505			
1.25	4507			
1.5	4513			
1.5	4516			
3.5	4524			
3.875	4535			
2.625	4545			
3.125	4555			
3.5	4567			
0.75	4571			
3.25	4572			
BAY 3				
2.75	4601			
3.375	4606			
0.625	4606	Between Canisters		
3	4612			

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DEPTH	LOCATION			
0.5	6014			
0.375	6015			
0.625	6017			
0.875	6018			
1	6026			
1.25	6032			
0.875	6033			
1.375	6045	Between Canisters		
2.5	6055	Between Canisters		
7.5	6070			
0.625	6073	Inside Canister		
1.375	6170			
0.625	6201			
2.375	6268			
1.75	6273			
3.5	6376			
0.875	6433			
0.25	6439			
0.625	6450			
0.75	6459			
2.75	6475			
	6500			
0.75	6602			
4.75	6609			
5	6610			
6.25	6611			
4.25	6627			
0.75	6704			
1.125	6761			
0.875	6775			
0.5	6776			
DEPTH	LOCATION			
TECH VIEW SOUTH CHANNEL				
0.25		NORTH WALL NEAR DOOR		
0.25		MIDWAY BETWEEN DOORS, NORTH WALL		
0.125		MIDWAY BETWEEN DOORS, SOUTH WALL		
TECH VIEW NORTH CHANNEL				
0.6875		EAST DOORWAY		
1.25		MIDWAY BETWEEN DOORS, SOUTH WALL		
TECH VIEW LARGE BAY				
0.875		SOUTH END OF BAY, NEAR SOUTH DOOR		

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DEPTH	LOCATION		
3.375	4612	Between Canisters	
2	4617	East of 4617	
2.625	4617	Between Canisters	
0.625	4627	In Canister w/5 elements	
4.625	4629	East of 4629	
2.75	4629	Between Canisters	
0.375	4638	In Empty Canister	
2	4640	Between Canisters	
4.25	4641		
4	4650		
2.625	4650	Between Canisters	
3.625	4660		
2	4660		
1.375	4668	Between Canisters	
4.375	4670		
1.25	4709		
0.5	4767	In Empty Canister	
1.25	4801		
1.25	5010	Between Canisters	
2.5	5027	Between Canisters	
1.125	5045	Between Canisters	
3.125	5055	Between Canisters	
3	5065	Between Canisters	
1.75	5076		
1	5101	Between Canisters	
0.625	5254		
0.5	5256		
0.375	5261	Between Canisters	
1.25	5271	Between Canisters	
0.875	5501		
3	5576		
0.25	5604		
0.375	5604		
1.375	5617		
0.75	5619		
1	5653		
0.375	5655	Inside Canister	
3	5656	Between Canisters	
0.375	5657	Inside Canister	
2.375	5664	Between Canisters	
0	5665	Inside Canister	
3	5669		
0.5	5801		
2	5970		
0.625	6005		

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. A P P E N D I X E

VIDEO TAPE INVENTORY AND EXAMPLE DATA OBSERVATION SHEET

Nuclear Fuel Evaluations Video Tape Inventory

Tape Log Number	Title (Description)	Date	Author	Length (minutes)	Number of Copies (includes original if NFE Author)			
					3/4 in. 8	Mini 8	VHS	S-VHS
1	K East Fuel Inspection Highlight Video (highlights of early K East video)	6/1/94	B.J. Makenas	05:00	1	2	4	--
2	Highlight Video 100-K East Fuel From Center and West Bay (highlights of K East sludge depth; fuel views and one sludge measurement)		B.J. Makenas	04:35	1	--	--	--
3	100-K East Fuel Inspection Highlight Video for the DNFSB (condensation of tapes Log Numbers 1 and 2)	7/11/94	B.J. Makenas	02:15	1	--	4	--
4	(1981 B&W K East fuel)							
5	Highlights of 105-K East Sludge Depth Measurements	9/1/94	R.B. Baker	03:30	--	--	5	--
6.1 to 6.5	105-K East Sludge Depth Measurement (5 tapes: sludge measurement raw data)	6/29/94	R. Cecil	Varies	--	--	4	1
7.1 to 7.25	105-K East Fuel Canister Exam (25 tapes: top views of all fueled canisters--video survey)	7/15/94	R. Cecil	Varies up to 2:00:00	--	--	2	1
8	Highlights of 105-K East Fuel and Sludge Depth Measurements (basin pan, good/bad fuel, sludge)	9/21/94	A.L. Pitner, R.B. Baker	03:22	--	--	5	--
9	Directors' Highlights of K East Fuel and Sludge Depth Measurements (examples of worst fuel and worst sludge for WHC directors)	9/21/94	A.L. Pitner, R.B. Baker	01:15	--	--	3	--
10.1 to 10.3	100-K West Backwash Pit Sludge Depth Measurements (3 tapes: pit overview and measurement)	9/23/94	R. Cecil	Varies	--	--	1	--
11.1 to 11.17	105-K East Backwash Pit Sludge Depth Measurements	10/19/93	Varies	Varies	--	--	1	
12	105-K East Under Water Debris Exam	8/22/94	R. Cecil		--	--	1	--
13	Detail Video Survey of 105-K East Discharge Chute	10/28/94	R. Cecil		--	--	1	--

Example K East Basin Sludge Depth Measurements Video Tapes

Tape 6.5

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Evaluators R.B. Baker

Date 10/28/94

Pit or Basin Location (Lattice XXYY)	Starting Location on Tape (Minutes)	Depth Measured by Team (inches)	Type Location	Surrounding				Sludge Character			Comments
				Canisters		Pins		Appearance	Crust	Clouding	
				Type	Con't	No.	Con't				
E4601	1:21	2 3/4	BNW	1A IS	1 0	0 7	— 1	1, 2	2	0	Channel end, Debris
E4606	2:07	3 3/8	BNW	IS	0	7	0	1	1?	1	Rusted rack
4606	2:43	5/8	BBC	IS	1	13 1	1 2	0	0	0	Difficult to observe
4709	3:29	1 1/4	BOR	1A	2	3	1	1, 2	1	White Particles	Rusted rack.
4810	4:42	—	?	IS	0	6 1	1 2	1	1	1	Breached fuel elements
E4612	4:52	3.0	BNW	1A —	2 —	5A 2E	1 1	1	1	1	
4612	5:19	3 3/8	BBC	1A 1A	2 2	14 14	1 1	1	1	0	Some white particles in sludge
4617	5:54	2 5/8	BBC	1A 1A	2 2	14? 14?	1? 1?	1	1	0	ID disks over barrels
?	7:29	?	eB	1A	2	5	1	5	Very Thin	0	Into Canister barrel, loose nodules
4629	9:44	2 3/4	BBC	1A? 1A	2 2	3/2 14	2/1 ID Disk	1	1?	0	Cloud off rack.
4641	12:11	4 1/4	BNW	?	—	14	—	dark particles	1	1	Cracked Crust cloud as ruler removed

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Key for Sludge Tape Characterization Table

Category	Symbol	Comment
Type:	(1) BOR (2) BBC (3) BNW (4) CB (5) P	Basin - Open Rack Basin - Between Canisters Basin - Next to Wall Canister Barrel Pit
Surrounding or Barrel: Canister Type	(1) 1 A (2) 1 S (3) 2 S	Mark 0 or Mark I Aluminum Mark 0 or Mark I Stainless Steel Mark II Stainless Steel
Canister Condition	0 1 2 3 4	No Corrosion Some Corrosion Moderate Corrosion (white nodules) Heavy Corrosion Severe Corrosion
Pin Condition	0 1 2 3	Clean and intact Some corrosion Minor rupture/minor fuel exposure Major rupture and major fuel exposure
Sludge Character: Appearance	2 5 1 4 3 0	Uniform smooth surface Agglomerate Light grey surface, brown substrate Broken uneven settled powder Flat granular grey/brown surface Other
Crust	0 1 2 3 4	None Thin Moderate and broken after measure Heavy and chunks apparent after measure Caky
Clouding	0 1 2 3 4	None Flocculent settles quickly (<30 second) Flocculent settles slowly (<1 minute) Flocculent settles very slowly (<2 minute) Clouding did not clear no measure

A P P E N D I X F

TYPICAL CHEMICAL ANALYSES OF K BASIN SLUDGE

Table F1. Comparison of Recent (Meier) and Past Chemical Analyses on Sludge in K East Weasel Pit (WP) and Segregation Pit (Seg Pit). (micro g/g)

	WP-West, Meier SMP 01 ^{F1} (Dry)	WP-East, Meier SMP 02 ^{F1} (Dry)	Seg Pit 7/11/86 ^{F2} (Dry)	Seg Pit 5/28/85 ^{F2} (Dry)	Seg Pit 7/11/86 ^{F2} (Dry)	Averages
Al	24,300	12,300	84,300			40,300
As	41	46				44
Ba	116	67	1,650			611
Be	4	3				4
Ca	4,380	2,460	8,550			5,130
Cd	96	58				77
Co	30	14				22
Cr	1,180	671	467			773
Cu	369	202				286
Fe	285,000	200,000	157,000			214,000
K	200	121				161
Li	4	2				3
Mg	1,070	611	1,930			1,204
Mn	363	240	350			318
Mo	46	28				37
Na	150	84	18,100			6,111
Nd	187	75				131
Ni	114	72	667			284
P	502	327				415
Pb	618	356				487
S	344	303				324
Sb	318	115				217
Si	1,430	1,410	18,700			7,180
Sm	665	280				473
Sr	45	22	200			89
Ti	174	108	250			177
Tl	217	70				144
V	527	212				370
Zn	1,250	737	2,200			1,396
Zr	222	81	1,300			534
U	109,000	40,400	165,000	185,000	293,000	158,480

Table F2. Comparison of Recent (Meier) and Past Chemical Analyses on Sludge in K East Basin Floor. (micro g/g)

	Meier, SMP 03 ^{F1} (Dry)	12/92 ^{F3} (Wet)	12/92 ^{F3} (Dry)	5/28/85 ^{F2} (Dry)	8/10/85 ^{F2} (Wet)	Averages
Al	20,800				10,555	15,678
As	17					17
Ba	54				92	73
Be	25					25
Ca	693				2,167	1,430
Cd	59				156	107
Co	9					9
Cr	238				167	202
Cu	213				233	223
Fe	73,500				29,778	51,639
K	50					50
Li	1				21	11
Mg	300				239	270
Mn	156				789	473
Mo	15					15
Na	44				156	100
Nd	67					67
Ni	40				100	70
P	191				100	191
Pb	195					195
S	214					214
Sb	88					88
Si	1,990				2,389	2,190
Sm	225					225
Sr	11				32	21
Ti	45				32	39
Tl	100					100
V	165					165
Zn	353				691	522
Zr	148				55	102
U	35,000	7,650	41,700	105,000	69,167	51,703

Table F3. Comparison of Recent (Meier) and Past Chemical Analyses on Sludge in K East Basin Sandfilter Backwash Pit. (micro g/g)

	Meier, SMP 04 ^{F1} (Dry)	5/28/85 ^{F2} (Dry)	1/12/93 ^{F3}	3/30/93 ^{F3} (Wet)	Welsh, Pit ^{F4} (Wet)	Welsh, Channel ^{F4} (Wet)	Averages
Al	4,410			85,999	4,818		24,844
As	3			58			30
Ba	35			187	66		85
Be	6			46	4.1	6.7	16
Ca	766			3,610	423	71	1,218
Cd	62			157	33	33	71
Co	4			39			21
Cr	48			754	78	77	239
Cu	125			1,830	178		558
Fe	14,300			141,000	10,480		49,328
K	104			171			138
Li	2			7			5
Mg	242			1,030	486	301	515
Mn	323			1,050	197	192	441
Mo	2			22			12
Na	64			116	227	172	157
Nd				398			398
Ni	23			107			65
P	166			1,090			628
Pb	58			1,210	54	55	344
S	235			1,340			788
Sb	32			514			273
Si	470				532	609	537
Sm	58			1,430			744
Sr	9			48			28
Ti	28			134			81
Tl	35			840			438
V	48			1,050			549
Zn	201			1,450	126		495
Zr	21			285			153
U	9,670	131,000	13,400	257,000	5,963	6,604	6,419

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Table F4. Comparison of Recent (Meier) and Past Radionuclide Analyses on Sludge in K East Basin Weasel Pit (WP) and Segregation Pit (Seg Pit). (micro Ci/g)

	WP-West, Meier SMP 01 ^{F1} (Dry)	WP-East, Meier SMP 02 ^{F1} (Dry)	Seg Pit 5/28/85 ^{F2} (Dry)	Seg Pit 7/11/86 ^{F2} (Dry)	8/24/89 ^{F3} (Wet)	8/24/89 ^{F3} (Wet)	Averages
Total Alpha	16.20	10.30	143.07	125.88			73.86
Total Beta	289.00	254.00	2,708.50				812.88
²³⁴ U				0.40	0.00495	0.00318	0.14
²³⁵ U				0.04	0.000875	0.000561	0.01
²³⁸ Pu			11.97	19.60	0.72	0.15	8.11
²³⁹ Pu ²⁴⁰ Pu	6.83	4.24	82.89	75.10	4.06	0.94	29.01
²⁴¹ Pu					101.17	16.87	59.02
²⁴¹ Am	7.44	46.10	30.85	34.63	2.79	11.54	22.22
²⁴¹ Am GEA	8.05	4.90					6.48
⁶⁰ Co	1.41	0.95	21.07	36.68	1.31	0.49	10.32
⁹⁰ Sr	88.10	30.00			33.82	27.19	44.78
¹³⁷ Cs	42.80	47.50	150.15	167.10	90.95	14.87	85.56
¹⁵⁴ Eu	1.56	0.93	17.04	18.50			9.51
¹⁵⁵ Eu	0.93	0.48	16.21	17.52			8.78
³ H					0.0222	0.00311	0.01

Table F5. Comparison of Recent (Meier) and Past Radionuclide Analyses on Sludge in K East Basin Floor. (micro Ci/g)

	Meier, SMP 03 ^{F1} (Dry)	12/92 ^{F3} (Wet)	12/92 ^{F3} (Dry)	8/24/89 ^{F3} (Wet)	7/11/86 ^{F3} (Dry)	5/28/85 ^{F2} (Dry)	Averages
Total Alpha	17.00	45.40	48.10			71.40	45.48
Total Beta	155.00					1,480.46	817.73
²³⁴ U					0.00284		0.00284
²³⁵ U					0.000493		0.000493
²³⁸ Pu		4.08	3.59	0.13	0.17	4.61	2.51
²³⁹ Pu ²⁴⁰ Pu	5.87	25.50	22.70	0.69	1.10	33.12	14.83
²⁴¹ Pu				23.2	32.10		27.63
²⁴¹ Am	68.80	16.10		0.39		11.56	24.21
²⁴¹ Am GEA	8.13	0.21					4.17
⁶⁰ Co	1.63	1.65		0.11	0.00376	11.46	2.97
⁹⁰ Sr	74.80	33.60	80.90	14.78	19.20		44.66
¹³⁷ Cs	41.50	93.20	72.20	6.60	8.23	55.32	46.18
¹⁵⁴ Eu	1.66	3.30		18.50		8.21	4.39
¹⁵⁵ Eu	0.97	2.11				5.77	2.95
³ H				0.00423			0.00423

Table F6. Comparison of Recent and Past Radionuclide Analyses on Sludge
in K East Basin Sandfilter Backwash Pit. (micro Ci/g)

	Meier, SMP 04 ^{F1} (Dry)	8/29/89 ^{F3} (Wet)	5/28/85 ^{F3} (Dry)	1/12/93 ^{F3}	3/30/93 ^{F3} (Wet)	Welsh, Pit ^{F4} (Wet)	Welsh, Channel ^{F4} (Wet)	Averages
Total Alpha	5.19		82.10	82.50	144.00	1.67	2.50	52.99
Total Beta	46.00		1,302.67			28.59	23.65	350.23
²³⁴ U								
²³⁵ U								
²³⁸ Pu			8.49	8.31	7.22			8.01
²³⁹ Pu ²⁴⁰ Pu	2.35	0.88	49.80	46.10	43.40			28.51
²⁴¹ Pu		19.43						19.43
²⁴¹ Am	5.07	0.50	18.20	36.50	49.40	0.98	1.29	15.99
²⁴¹ Am GEA	2.03			40.40		0.97	1.34	11.18
⁶⁰ Co	0.59	0.18	17.77	5.75		0.21	0.22	4.12
⁹⁰ Sr	7.01	1.62		70.80	8.12			21.89
¹³⁷ Cs	13.10	2.11	68.01	95.90	0.30	10.00	8.09	28.22
¹⁵⁴ Eu	0.37		11.44	7.95		0.20	0.27	4.05
¹⁵⁵ Eu	0.27		10.77	4.62		0.11	0.15	3.18
³ H	0.00	0.15						0.08

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- F1. D. B. Bechtold and M. A. Meier, "Analyses of 105-K East Basin Sludge Samples," WHC-12110-PCL93-069, July 27, 1993.
- F2. V. B. Subrahmanyam, K East Fuel Storage Basin Sediment Processing: "Assessment of and Characterization Needs for Disposal," WHC-SD-CP-TI-142, Rev. 0, February 8, 1989.
- F3. DSI, M. A. Green to R. B. Baker, "Summary Collection of Chemical Analyses from Quarterly Pit and Annual K Basin Sampling," October 1994.
- F4. T. L. Welsh, "Statistical Evaluation of the Data Obtained from the K East Basin Sandfilter Backwash Pit Samples," WHC-SD-SNF-TI-004, Rev. 0, September 16, 1994.

A P P E N D I X G

EXAMPLES OF PARTICLE SIZE DISTRIBUTIONS OF K EAST BASIN SLUDGE

(From Reference 7 in Main Text)

Center Basin

DATE : 07/07/1993 : ACQ. RANGE : 0.5-150 : COUNTS : 609576
 TIME : 14:12 : ACQ. MODE : SAMPLE : S.N.F. : 1.00
 CONFIG. : 1 (0.7 S1) : ACQ. TIME : 2246 SEC : S.D.U. : 11228
 CELL TYPE : SLIDE : SAMPLE SIZE : MAN. SUM : CONCENTR.: 5.5E+06 #/ml
 SAMPLE TYPE : REGULAR : REQ. CONF. : None : SOLIDS : MAN. SUM

PROBABILITY NUMBER DISTRIBUTION

Name: R3805 S873D S883283 SLUDGE IN S872A SUM
 5.5E+06 #/ml(188.8%)
 Mode at 0.75 μ m
 Median : 0.97 μ m
 Mean(nl): 2.83 μ m
 S.D.(nl): 3.50 μ m
 Conf(nl): 188.88 %

7/C << SCALE RANGE (μ m): ADJUSTED >>

100% - 20% $\leftarrow$ arbitrary units

Center Basin

DATE : 07/07/1993 : ACQ. RANGE : 0.5-150 : COUNTS : 609576
 TIME : 14:12 : ACQ. MODE : SAMPLE : S.N.F. : 1.00
 CONFIG. : 1 (0.7 S1) : ACQ. TIME : 2246 SEC : S.D.U. : 11229
 CELL TYPE : SLIDE : SAMPLE SIZE : MAN. SUM : CONCENTR.: 5.5E+05 #/ml
 SAMPLE TYPE : REGULAR : REQ. CONF. : None : SOLIDS : MAN. SUM

PROBABILITY VOLUME DISTRIBUTION

Name: R3885 S873D S382203 SLUDGE IN S872A SUM

1.3E-83 cc/ml(100.8%)

Mean(nv): 7.64µm

Mode at 45.76 µm

S.D.(nv): 6.61µm

Median : 44.13µm

Mean(om): 40.29µm

S.D.(om): 29.62µm

Conf(om): 100.80 %

<< SCALE RANGE (µm): ADJUSTED >>

100% - 20% *arbitrary units*
 98.8%
 88.8%
 78.8%
 68.8%
 58.8%
 48.8%
 38.8%
 28.8%
 18.8%
 8.8%

DATE	: 07/07/1993	ACQ. RANGE	: 0.5=150	COUNTS	: 2722029
TIME	: 15:25	ACQ. MODE	: SAMPLE	S.N.F.	: 1.00
CONFIG.	: 1 (0.7 S1)	ACQ. TIME	: 436 SEC	S.D.U.	: 10797
CELL TYPE	: SLIDE	SAMPLE SIZE	: MAN. SUM	CONCENTR.	: 4.1E+07 #/ml
SAMPLE TYPE	: REGULAR	REQ. CONF.	: None	SOLIDS	: MAN. SUM

PROBABILITY NUMBER DISTRIBUTION

Name: R3900 SD75F S303201 SLUDGE IN SD75A SUM

4.1E+07 #/ml(100.0%)

Mode at 0.75 μ m

<< SCALE RANGE (μ m): ADJUSTED >>

Median : 1.26 μ m

Mean(nl): 2.04 μ m

S.D.(nl): 2.33 μ m

Conf(nl):100.00 %

West Measel Pit

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West Weasel Pit

DATE : 07/07/1993 : ACC. RANGE : 0.5-150 : COUNTS : 2722029
TIME : 15:25 : ACC. MODE : SAMPLE : S.N.F. : 1.00
CONFIG. : 1 (0.7 SI) : ACC. TIME : 436 SEC : S.D.U. : 10767
CELL TYPE : SLIDE : SAMPLE SIZE : MAN. SUM : CONCENTR.: 4.1E+07 #/ml
SAMPLE TYPE : REGULAR : REQ. CONF. : None : SOLIDS : MAN. SUM

PROBABILITY VOLUME DISTRIBUTION

Name: R3908 S875F S383281 SLUDGE IN S875A SUM
3.8E-03 cc/ml(100.0%) Median : 31.71µm
Mean(nv): 5.19µm
Mean(vn): 36.46µm
Mode at 45.76 µm S.D.(nv): 3.92µm
S.D.(vn): 27.30µm
Conf(vn): 100.88 %

<< SCALE RANGE (µm): ADJUSTED >>

100% 20% arbitrary unit

98.0%
88.0%
78.0%
68.0%
58.0%
48.0%
38.0%
28.0%
18.0%
8.0%

DATE	: 06/07/1993	ACQ. RANGE	: 0.5-150	COUNTS	: 505931
TIME	: 15:36	ACQ. MODE	: SAMPLE	S.N.F.	: 0.99
CONFIG.	: 1 (0.7 S1)	ACQ. TIME	: 1428 SEC	S.D.U.	: 9224
CELL TYPE	: SLIDE	SAMPLE SIZE	: MAN. SUM	CONCENTR.	: 9.8E+06 #/ml
SAMPLE TYPE	: REGULAR	REQ. CONF.	: None	SOLIDS	: MAN. SUM

PROBABILITY NUMBER DISTRIBUTION

Name: R3947 SB70B S383204 SLUDGE IN SB69A SUM

9.8E+06 #/ml (188.8%)

Mode at 8.75 μ m

7/C << SCALE RANGE (μ m): ADJUSTED >>

Median : 1.89 μ m

Mean(nl): 1.57 μ m

S.D.(nl): 1.58 μ m

Conf(nl): 108.88 %

Sandfilter Backwash Pit

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TE	: 06/07/1993	ACQ. RANGE	: 0.5-150	COUNTS	: 505931
ME	: 15:36	ACQ. MODE	: SAMPLE	S.N.F.	: 0.99
NFIG.	: 1 (0.7 S1)	ACQ. TIME	: 1428 SEC	S.D.U.	: 8224
LL TYPE	: SLIDE	SAMPLE SIZE	: MAN. SUM	CONCENTR.	: 9.8E+06 #/ml
MPLE TYPE	: REGULAR	REQ. CONF.	: None	SOLIDS	: MAN. SUM

PROBABILITY VOLUME DISTRIBUTION

Sample: R3047 SB70B S303204 SLUDGE IN SD69A SUM
 Concentration: 3E-04 cc/ml (100.0%)
 Median: 21.13µm
 Mean(nv): 3.53µm
 Mean(vn): 31.27µm
 S.D. at 73.61 µm
 S.D.(nv): 2.46µm
 S.D.(vn): 25.54µm
 << SCALE RANGE (µm): ADJUSTED >>
 Conf(vn): 100.00 %

Sandfilter Backwash Pit

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