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7. Abstract <p>This documents the results of the measurement of sludge depths in the 105-KW Sandfilter Backwash Pit (SFBWP) and provides the calculated sludge volume. The measurements of sludge depth were made in the pit and the transfer channel and an estimate made for the amount of material on structures and surfaces in the SFBWP. The total volume of sludge was determined to be 3.75 m³ (132.2 ft³).</p>		
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105-KW SANDFILTER BACKWASH PIT
SLUDGE VOLUME CALCULATION

E. N. Dodd, Jr.

February 10, 1995

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ABSTRACT

The volume of sludge contained in the 100-KW Sandfilter Backwash Pit (SFBWP) was calculated from depth measurements of the sludge, pit dimension measurements and analysis of video tape recordings taken by an underwater camera. The term "sludge" as used in this report is any combination of sand, sediment, or corrosion products visible in the SFBWP area. This work was performed to determine baseline volume for use in determination of quantities of uranium and plutonium deposited in the pit from sandfilter backwashes.

The SFBWP has three areas where sludge is deposited: (1) the main pit floor, (2) the transfer channel floor, and (3) the surfaces and structures in the SFBWP. The depths of sludge and the uniformity of deposition varies significantly between these three areas. As a result, each of the areas was evaluated separately. The total volume of sludge determined was 3.75 m^3 (132.2 ft^3).

The most significant depth of sludge was on the floor of the main pit. This sludge showed wide variations in depths ranging from a maximum of almost 75 cm (29.5") to a low of about 30 cm (11.5"). The main pit area is 6.06 m^2 (65.2 ft^2). Sludge volumes in the main pit were determined by establishing a 3X4 grid in the pit and taking at least one sludge depth measurement in each grid location. These depth measurements were then used to calculate a volume for each grid location and the sum of the grid volumes gave the pit sludge volume. In addition to the calculation done on a grid location summation, a computer calculation of the volume was performed. This calculation was an integration of the surface plot determined based on the sludge depth measurements and their actual location in the pit. Results of the hand calculation gave a sludge volume of 3.16 m^3 (111.7 ft^3) and the computer calculation gave a volume of 3.18 m^3 (112.3 ft^3).

The transfer channel is located 1.5 m (5 ft) above the floor of the main pit and has an area of 2.11 m^2 (22.7 ft^2). The sludge deposited on the floor of the transfer channel was relatively uniform in depth and averaged about 22.4 cm (8.8 in). A 2X3 grid was established in the transfer channel and depth measurements taken in each of the grid locations. As in the case of the main pit, the volume calculations were performed both by hand and by computer the results of the hand calculation gave a volume of 0.48 m^3 (16.8 ft^3) and the computer calculation resulted in a volume of 0.46 m^3 (16.2 ft^3).

The volume of sludge on the structures and supports in the KW SFBWP was estimated based on review of the underwater camera video recordings and comparison with the similar video recordings from the KE SFBWP. The review of the video tapes showed the structures and supports to be similar in regard to sludge deposition. Based on this review, an estimate of volume was made and then an additional 10% was added to provide engineering conservatism. The resulting estimated sludge volume on structures and supports was 0.105 m^3 (3.7 ft^3).

1.0 INTRODUCTION

The volume of sludge contained in the 100-KW Sandfilter Backwash Pit (SFBWP), designated on basin drawings as the North Loadout Pit (NLOP), was calculated from measurements of the sludge depth, pit dimension measurements and review of video tapes of the sludge taken with an underwater camera. This work was performed to more adequately establish the total quantity of material in the SFBWP prior to further sandfilter backwashes. The volume data will be utilized with results of sludge sample analyses to better determine the SFBWP uranium and plutonium content.

1.1 General Description of SFBWP and Sludge

The 100-KW SFBWP is a concrete pool adjoining the KW Fuel Storage Basin. The pit itself measures approximately 216 cm (85 inches) wide by 282 cm (111 inches) long and has a transfer channel of about 96.5 cm (38 inches) wide by 231 cm (91 inches) long connecting it to the main basin. There is a barrier between the basin and the transfer channel although the top does form a weir to allow water to overflow into the main basin. The bottom of the transfer channel is approximately 6.3 m (20'9") below the basin grating and the pit is about 1.5 m (5') deeper at 7.8 m (25'9"). The as measured dimensions are as indicated on Figure 1. The pit is used to collect the discharge from the backwash of the 100-KW fuel storage pool sandfilter.

Sludge from backwashing the KW sandfilter has accumulated in the SFBWP. The amount of sludge is greatest in the pit itself with lesser accumulation in the transfer channel. Both locations are relatively clear of other structures and material and thus do not have significant surfaces for additional sludge accumulation. Review of the video tapes of the sludge depth measurements indicate some minor sludge accumulation on the vertical wall surfaces.

Observation of the sludge itself in the video tapes shows the surface of the sludge to be a type of material that is not readily resuspended if disturbed. Upon insertion of the measuring rod into the sludge the material frequently exhibited gelatinous type shifting and settling. In the pit itself, each penetration of the sludge resulted in the release of gas bubbles from the material. As the measurement rod was removed from the sludge, a cloud of very dark silt type material was brought up with the rod. This material remained resuspended in the area of the sludge penetration and did not quickly resettle which generally reduced visibility in the immediate area of the measurement location.

Figure 1

1.2 Responsible Organization

The sludge depth measurements contained in this report were obtained by Surveillance Systems Engineering (SSE) personnel. Video tape recordings utilizing an underwater camera were also made of the SFBWP by SSE personnel during the depth measurement process.

Computer generated three dimensional visualizations of the measurements and the computer integrated sludge volume analysis were performed by Nuclear Fuel Evaluations personnel, Nuclear Engineering.

Analyses of the depth measurement data and the video tapes as well as final total sludge volume calculations were performed by Technical Safety personnel, K Basin Engineering.

1.3 Analyzed Parameters

Sludge depth measurements were taken in the pit based on a 3X4 grid. In the transfer channel, the measurements were taken in relation to a 2X3 grid. The layout of the grid and specific grid locations were as shown in Figure 2. Although the area is relatively clear of obstructions, obtaining measurements in the center of each grid was not always possible or desirable. This was primarily due to the irregularity of the sludge surface. The depth measurement locations were generally selected to provide the best site for overall depth determination. Multiple measurements were made in several grid locations to either provide data for statistical analysis or to better define the observed variation in sludge depth within the grid location.

A total of 25 depth measurements were made in the backwash pit and a total of 11 measurements taken in the transfer channel. The method used to obtain the measurements is described in detail in Section 2.1. The depth measurement raw data is shown in Tables 1 and 2.

Determination of sludge accumulation on the structures and surfaces of the SFBWP was made through review of the video tapes. The degree of sludge adherence to the items was estimated from viewing the surfaces and structures in relation to the measured sludge depths in the pit.

K WEST BACKWASH PIT MEASUREMENT SCHEMATIC

1.4 Dates of Performance

Sludge depth measurements in the 100-KW SFBWP were taken during the period September 23 through November 15, 1994. The volume of sludge determined is that in the pit following the September 8, 1994 sandfilter backwash. Future backwashes of the sandfilter will alter the contents of the pit from those determined in this report.

Graphical representations of the sludge content and topology of the KW SFBWP are contained in Section 2.3.

Table 1. Backwash Pit Measurements

Grid Location	Top(cm)	Bottom(cm)	Sludge Depth(cm)	Grid Designation
A1	3'4½" (102.9)	1'5½" (44.5)	1'11" (58.4)	A1-1
A3	3'8" (111.8)	1'5¾" (45.1)	2'2¼" (66.7)	A3-1
	3'6" (106.7)	1'5¾" (45.1)	2'0¼" (61.6)	A3-2
A5	3'10½" (118.1)	1'5" (43.1)	2'5½" (74.9)	A5-1
B1	3'0" (91.4)	1'4¼" (41.3)	1'7¾" (50.2)	B1-1
	3'4¾" (103.5)	1'3½" (39.4)	2'1¼" (64.1)	B1-2
	3'5¾" (104.5)	1'4¾" (42.2)	2'0½" (62.2)	B1-3
	3'0¾" (93.0)	1'4¾" (42.2)	1'8" (50.8)	B1-4
	3'4¾" (103.5)	1'4¼" (41.3)	2'0½" (62.2)	B1-5
B3	3'2" (96.5)	1'4" (40.6)	1'10" (55.9)	B3-1
	3'2" (96.5)	1'4¼" (41.3)	1' 9¾" (55.2)	B3-2
B5	3'4¾" (103.8)	1'3¾" (38.4)	2'1¾" (65.4)	B5-1
C1	2'11" (88.9)	1'5½" (43.5)	1'5½" (45.4)	C1-1
	2'9¾" (85.7)	1'5½" (43.5)	1'4¾" (42.2)	C1-2
	3'0¾" (93.0)	1'4¾" (41.6)	1'8¼" (51.4)	C1-3
	2'8¼" (81.9)	1'5¼" (43.8)	1'3" (38.1)	C1-4
C3	2'4½" (71.4)	1'4¾" (42.5)	0'11¾" (28.9)	C3-1
	2'5½" (74.9)	1'4½" (41.9)	1'1" (33.0)	C3-2
C5	3'1" (94.0)	1'4¾" (42.5)	1'8¼" (51.4)	C5-1
	3'1½" (95.6)	1'5¾" (45.1)	1'7¾" (50.5)	C5-2
D1	2'9¾" (85.4)	1'4" (40.6)	1'5½" (44.8)	D1-1
D3	2'6¾" (78.4)	1'4¾" (42.5)	1'2½" (35.9)	D3-1
	2'7¾" (80.6)	1'4" (40.6)	1'3¾" (40.0)	D3-2
	2'8½" (81.6)	1'4¾" (42.2)	1'3½" (39.4)	D3-3
D5	2'9" (83.8)	1'5¼" (43.8)	1'3¾" (40.0)	D5-1

Table 2. Transfer Channel Measurements

The bottom of the Transfer Channel is five feet above the bottom of the Backwash Pit. The measurements as made do not reflect this difference.				
Grid Location	Top (cm)	Bottom (cm)	Sludge Depth (cm)	Grid Designation
Chute Doorway	2'10 $\frac{1}{4}$ " (87.0)	2'5 $\frac{3}{4}$ " (75.6)	0'4 $\frac{1}{2}$ " (11.4)	H2-1
	3'2 $\frac{1}{8}$ " (96.8)	2'6 $\frac{1}{2}$ " (77.5)	0'7 $\frac{5}{8}$ " (19.4)	H4-1
E2	2'0 $\frac{3}{8}$ " (61.9)	1'3" (38.1)	0'9 $\frac{3}{8}$ " (23.8)	E2-1
E4	2'0 $\frac{1}{8}$ " (61.3)	1'3 $\frac{5}{16}$ " (38.9)	0'8 $\frac{13}{16}$ " (22.4)	E4-1
F2	2'1 $\frac{1}{2}$ " (64.8)	1'3 $\frac{1}{2}$ " (39.4)	0'10" (25.4)	F2-1
F4	2'0 $\frac{1}{2}$ " (62.2)	1'3 $\frac{3}{8}$ " (39.1)	0'9 $\frac{1}{8}$ " (23.2)	F4-1
	1'11 $\frac{3}{8}$ " (59.4)	1'3 $\frac{1}{8}$ " (38.4)	0'8 $\frac{1}{4}$ " (21.0)	F4-2
G2	2'3 $\frac{3}{4}$ " (70.5)	1'7 $\frac{1}{2}$ " (49.5)	0'8 $\frac{1}{4}$ " (21.0)	G2-1
	2'7 $\frac{1}{4}$ " (79.4)	1'10 $\frac{1}{8}$ " (56.2)	0'9 $\frac{1}{8}$ " (23.2)	G2-2
	2'6 $\frac{1}{4}$ " (76.8)	1'11" (58.4)	0'7 $\frac{1}{4}$ " (18.4)	G2-3
G4	2'5" (73.7)	1'8" (50.8)	0'9" (22.9)	G4-1

2.0 ANALYTICAL METHODS

The majority of sludge deposited in the 100-KW SFBWP is on the floor of the pit itself with a lesser amount on the floor of the transfer channel. The pit sludge accumulation shows wide variations in depths ranging from a maximum of almost 75 cm (29.5") to a low of about 30 cm (11.5"). The sludge in the transfer channel shows a fairly uniform depth averaging 22.4 cm (8.8"). The amount of sludge adhering to the walls of the SFBWP and structures within it was estimated based on review of the video tapes of the pit. The amounts of material that were observed on the walls and structures was relatively small and did not significantly influence the volume total.

2.1 Sludge Depth Measurements

All grid locations were accessible for direct measurement of sludge depths. However, observation of the video showed some grids with significant variance in sludge depth. The following process was used to determine sludge depths in the main pit and transfer channel.

1. Each grid location in the pit and transfer channel was measured by carefully inserting a scaled rod into the sludge. A fixed zero reference line was established above the water and basin grating. The underwater video camera was then used to determine sludge contact and to control rod insertion into the sludge. Additional details regarding the measurement techniques are contained in Reference 4.2.
2. The video tapes were reviewed and slope variances between adjacent measurement points were estimated. These estimates were especially important in the overall determination of main pit sludge volume content.
3. Additional measurements were made in grids where data was needed for statistical analysis and where initial measurements showed relatively large variances in depths of sludge. The results of all sludge depth measurements are shown in Tables 1 and 2.

A total of 25 depth measurements were made in the main pit sludge and 11 measurements were made of the transfer channel sludge depth. The measurements taken were such that an attempt to include the lowest point in the observed depression was made. There were not specific measurements made to define the full extent of the depression. As a result, the measurements taken represent a conservative measure of the depth of sludge in grids B1, B3, C1 and C3.

2.2 Structures and Supports

As previously noted, the 100-KW SFBWP is relatively clear of underwater structures and supports. This meant that relatively small amounts of sludge needed to be added besides that included in the depth measurements, to account for the material on the walls and other structures within the SFBWP. The following method was used to determine the volume of sludge on structures and supports:

1. The video tapes of the depth measurements made in the pit and transfer channel were reviewed. Particular attention was paid to the observable sludge on the vertical walls of the pit and transfer channel and on any observable horizontal or sloped surfaces in the pit and channel. No attempt was made to quantify the amount at this time.
2. The video tapes of the depth measurements in the 100-KE SFBWP were reviewed with particular emphasis on the observable levels of sludge on the structures and supports.
3. Based on the above noted comparisons, the relative amounts of material on the KW structures and supports was estimated. An additional 10% was added to this estimate to account for possible errors in estimates and to provide for engineering conservatism.

2.3 Graphical Representations

The measurement data obtained from the pit and transfer channel were provided to Nuclear Fuel Evaluations of Nuclear Engineering for preparation of graphical representations of the sludge. The results of the graphical representation development are presented in the following charts.

Chart 1: K West Backwash & Transfer Pit Top of Sludge Reference Measurement

This chart presents a three dimensional representation of the measurements made as the bottom edge of the measurement rod touched the top of the sludge surface. These measurements represent the location of the top of the sludge surface relative to the reference line established above the basin grating. The resulting three dimensional representation shows the large variation in the surface that was observed in the video tapes.

**Chart 2: K West Backwash & Transfer Pit Bottom of Sludge
(Floor) Reference Measurement**

This chart provides a three dimensional representation of the bottom of the backwash pit and transfer channel as determined by measurement with the rod. The data represented here is the lowest point measured when the rod penetrated the sludge. Notice that the bottom of the transfer channel shows significant variation in depth at both ends.

Chart 3: K West Backwash & Transfer Pit Sludge Depth

This chart provides a three dimensional representation of the differences between the measurements depicted in Charts 1 and 2. The data presented is a representation of the actual sludge depth as measured. Notice that the depth in the pit is widely variable while that in the transfer channel is relatively uniform.

K WEST BACKWASH & TRANSFER PIT TOP OF SLUDGE REFERENCE MEASUREMENT

K WEST BACKWASH & TRANSFER PIT

BOTTOM OF SLUDGE (FLOOR) REFERENCE MEASUREMENT

Chart 2

K WEST BACKWASH & TRANSFER PIT SLUDGE DEPTH

3.0 DESCRIPTION OF RESULTS

The volume of sludge in the 100-KW SFBWP was calculated from sludge depth measurements, pit dimension measurements and analysis of video tape recordings taken with an underwater camera. The SFBWP has three general areas where sludge is deposited: (1) the main pit floor, (2) the transfer channel floor, and (3) the structures and surfaces of the SFBWP. Each of these areas demonstrated different depths of sludge deposits. Additionally, the sludge surfaces of the areas showed significant differences with the pit having the greatest variability in depth and the transfer channel the least. The sludge volume determination was performed by individually calculating the volume of sludge in each of the areas and then summing them. The volume calculations for the pit and for the transfer channel were performed both by hand and by computer code. In the hand calculations, the method utilized average sludge depths in each of the grid locations times the area of the specific grid site. In the case of the computer calculation, the average sludge depth was calculated for the pit and transfer channel from a fitted surface and then applied to their respective total areas.

The results of the hand calculation for the pit and transfer channel sludge volumes were:

Main Pit	3.16 m ³	(111.7 ft ³)
Transfer Channel	0.48 m ³	(16.8 ft ³)
Total Volume	3.64 m ³	(128.5 ft ³)

The results of the computer code integration calculation for pit and transfer channel sludge volumes were:

Main Pit	3.18 m ³	(112.3 ft ³)
Transfer Channel	0.46 m ³	(16.2 ft ³)
Total Volume	3.64 m ³	(128.5 ft ³)

The volume of sludge on the surfaces and structures was estimated based on comparison with that determined for the 100-KE SFBWP. Review of the video tapes of surfaces and structures in both pits showed that the surfaces were similar in regards to deposit of sludge. The major difference was the lack of major structures in the KW pit. The sludge volume calculated for the 100-KE SFBWP was reduced by the amount of material on the structures that are not found in the 100-KW pit. The remainder was used as the basic volume. The final volume of sludge on surfaces and structures used in the overall total SFBWP sludge volume had an additional 10% added to provide engineering conservatism. The resulting calculated sludge volume for surfaces and structures was 0.105 m³ (3.7 ft³).

The total 100-KW SFBWP sludge volume calculated was 3.75 m³ (132.2 ft³).

4.0 REFERENCES

- 4.1 WHC-SD-WM-TI-606, "105-KE SFBWP Sludge Volume Calculation," December 22, 1993.
- 4.2 WHC-SD-WM-PROC-014 REV 0, "KW Basin Sandfilter Backwash Pit Sludge Measurement/Video," September 1, 1994.
- 4.3 Internal Memo, WHC, S. L. Hecht to E. N. Dodd, Jr., "K West Backwash Pit Sludge Depth Data: Visualization and Analysis," dated October 24, 1994.