

**MAINE YANKEE
FINAL STATUS SURVEY RELEASE RECORD
FR-0400 FOREBAY
SURVEY UNIT 8**

Prepared By:	<u><i>Dale Randall</i></u> FSS Engineer – Signature <u>Dale Randall</u> Printed Name	Date: <u>11-11-04</u>
Reviewed By:	<u><i>[Signature]</i></u> FSS Specialist – Signature <u>George Pillsbury</u> Printed Name	Date: <u>11/11/04</u>
Reviewed By:	<u><i>[Signature]</i></u> Independent Review – Signature <u>W. S. Cooper</u> Printed Name	Date: <u>11/16/04</u>
Approved By:	<u><i>[Signature]</i></u> Superintendent, FSS – Signature <u>George Pillsbury</u> Printed Name	Date: <u>11/18/04</u>
Approved By:	<u><i>[Signature]</i></u> FSS, MOP – Signature <u>JAMES R. BROWN</u> Printed Name	Date: <u>12/23/04</u>

**MAINE YANKEE
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A. SURVEY UNIT DESCRIPTION

Survey Unit 8 is located within Survey Area FR-0400, the Forebay. The Forebay is located south of the radiologically Restricted Area of the site at coordinates 407,000 N and 623,700 E (see map FR 0400 SITE, Attachment 1). The Forebay is a large, rock-lined basin in which condenser cooling water collected prior to its release through the diffuser system out to the ocean. During plant operation, the Forebay/Diffuser System was the licensed discharge path for liquid, radiological effluent. After plant shutdown, stop logs were set in place at the Forebay end of the diffuser to isolate the Forebay in order to prevent the release of Forebay sediment into the river during remediation activities.

Two earthen dikes make up the north-south running walls of the Forebay with concrete walls at the extreme north and south ends to support the circulating water and diffuser pipes. The dike walls form a V at the southern end of the Forebay (adjacent to Foxbird Island). The diffuser discharge pipes originate at the notch of the V. A concrete dam, or weir, runs in the east west direction at the northern end of the Forebay and creates a small, water-filled area called the sealpit. The sealpit maintained a water seal over the circulating water pipes to prevent loss of flow with tidal fluctuations.

Survey Unit 8 consists of the interior of the east dike of the Forebay. This is inclusive of a rip-rap layer, sediment and ledge. The area is bounded on its southern extent by the discharge canal, and by the weir to the north. The area includes both above water and submerged portions from the top to bottom (toe) of the slope. The Survey Unit has a total surface area of approximately 1,525 m².

B. SURVEY UNIT DESIGN INFORMATION

The Forebay received the liquid radioactive discharges from the plant. It was known to have been contaminated to levels in excess of the release limits and extensive remediation activities including underwater dredging, underwater vacuuming, and dry surface vacuuming were performed. Given the high probability of residual contamination, the Forebay was classified as Class 1.

Revision 3 of the Maine Yankee License Termination Plan (LTP)¹ states that the Forebay dose from residual radioactivity "is so insignificant and the probability so low that an individual would be able to successfully place a viable well within the Forebay, survey measurements of the Forebay surfaces including rip-rap will be limited". As a result, the survey design for the Forebay is a reasonable approach to demonstrate compliance with the release criteria while not necessarily meeting all of the requirements for a "MARSSIM" survey.

¹ LTP, Revision 3 refers to the LTP submitted in October 2002 (Reference 1) as amended by the MY's addenda of November 2002 (Reference 2). LTP, Revision 3 was approved by the NRC in February 2003 (Reference 3).

The survey unit design parameters are shown in Table 1. The values shown in this table reflect those used for the design and implementation of the survey. Changes to several key parameters (i.e., DCGL and AF) occurred after the survey was complete. These changes were used to evaluate the data, are discussed in Sections G and H, and shown in Table 2-2.

Given a relative shift of 1.6, a minimum number of 17 direct samples were required per the Sign Test. The survey design was based on twenty samples. Twenty-one actually fell within the survey unit. Each sample measurement location was determined using a random start point and a square grid. These locations are presented on survey maps FR 0400-8, FR 0400-8a, and FR 0400-8b (Attachment 1). Direct measurements located above the waterline consisted of soil samples analyzed with laboratory gamma spectroscopy instrumentation. Measurements located below the waterline were obtained with *in situ* gamma spectroscopy (ISOCS).

In situ gamma spectroscopy was used to conduct 100% scan of the area. The survey unit design used the ISOCS portable high purity germanium detector system to perform both underwater and above-water scans. The submerged individual scan grids were 4 m². Grids above water and below the “bathtub ring” were 12 m². Grids above the “bathtub ring” were 28 m². The “bathtub ring” was the area of high water in the Forebay during plant operation. The ISOCS detector was positioned with the aid of a prefabricated track and trolley system for measurements below water. Above water measurements were located utilizing a pre-established grid system. This scan survey ensured there were no areas exceeding the design DCGL_{EMC} limit. The survey instruments used, their MDC values, and investigation levels are provided in Attachment 2.

TABLE 1
SURVEY UNIT DESIGN PARAMETERS

Survey Unit	Design Criteria	Basis
Area	1,525 m ²	
Number of Direct Measurements Required	17 (20 used)	Based on an LBGR of 3.5 pCi/g Co-60, a sigma ² of 2.18 pCi/g Co-60, and a relative shift of 1.6. Type I = Type II = 0.05
Sample Area	76.3 m ²	1,525 m ² / 20
Sample Grid Spacing ³	8.5 m	(76.3) ^{1/2}
Area Factor (AF)	10	
Scan Survey Area	1,525 m ²	~ 100%
Background	N/A	<i>In situ</i> gamma spectroscopy used
Scan Investigation Level	See Table 2-2	Less than DCGL _{EMC}
DCGL	7.0 pCi/g Co-60	Forebay Technical Basis Document (Reference 4)
DCGL _{EMC}	70.0 pCi/g Co-60	Area Factor x DCGL

² Sigma was determined using post remediation survey results.

³ A sample spacing of 8.5 m was used in the final design. This is conservative and generated 21 Direct Points when the grid was laid out on the SU maps.

C. SURVEY RESULTS

As designed, 21 direct measurements were obtained. Eighteen measurements consisted of soil samples. Three measurements were obtained *in situ* with the ISOCS detector. The direct measurement data are presented in Table 2 below. All sample measurement results were less than the DCGL.

The scan process was performed in accordance with FSS requirements using *in situ* gamma spectroscopy. To achieve approximately 100% scan coverage, 185 ISOCS measurements were obtained. The process identified no locations in excess of the investigation level; therefore, no investigations were required.

TABLE 2
DIRECT MEASUREMENTS

Sample Number	Cs-137 (pCi/g)	Co-60 (pCi/g)	Unitized Value of Unity Rule
FR0400081S001SS	2.28E-01 ± 2.88E-02	2.74E-01 ± 2.44E-02	7.35E-03
FR0400081S002SS	1.46E-01 ± 3.15E-02	1.65E+00 ± 8.40E-02	3.53E-02
FR0400081S003SS	3.03E-01 ± 3.57E-02	1.34E+00 ± 6.59E-02	3.01E-02
FR0400081S004SS	3.17E-01 ± 3.84E-02	3.37E+00 ± 1.53E-01	7.25E-02
FR0400081S005SS	< MDA	5.51E-02 ± 1.78E-02	1.15E-03
FR0400081S006SS	1.28E-01 ± 2.02E-02	4.66E-02 ± 1.23E-02	1.89E-03
FR0400081S007SS	2.33E-01 ± 3.05E-02	1.47E-01 ± 2.10E-02	4.73E-03
FR0400081S008SS	1.43E-01 ± 2.75E-02	< 7.59E-02	2.61E-03
FR0400081S009SS	< MDA	< 3.03E-02	6.31E-04
FR0400081S010SS	1.28E-01 ± 2.48E-02	3.20E-01 ± 2.91E-02	7.58E-03
FR0400081S011SS	1.34E-01 ± 2.41E-02	5.57E-01 ± 3.60E-02	1.26E-02
FR0400081S012SS	2.28E-01 ± 3.24E-02	1.47E+00 ± 7.51E-02	3.23E-02
FR0400081S013SS	2.02E-01 ± 4.09E-02	3.91E-01 ± 4.15E-02	9.60E-03
FR0400081S014SS	1.08E-01 ± 2.68E-02	< 4.93E-02	1.80E-03
FR0400081S015SS	2.33E-01 ± 4.99E-02	1.12E+00 ± 8.36E-02	2.50E-02
FR0400081S016SS	3.74E-01 ± 5.78E-02	1.65E+00 ± 9.99E-02	3.70E-02
FR0400081S017SS	3.22E-01 ± 3.24E-02	1.47E-01 ± 1.89E-02	5.39E-03
FR0400081S018SS	1.30E-01 ± 2.35E-02	7.28E-02 ± 2.51E-02	2.45E-03
FR0400081R019IG	< MDA	< 2.28E+00	4.75E-02
FR0400081R020IG	< MDA	< 4.98E+00	1.04E-01
FR0400081R021IG	< MDA	< 4.08E+00	8.49E-02
Mean	1.60E-01	1.15E+00	2.50E-02
Median	1.43E-01	3.91E-01	9.60E-03
Standard Deviation	1.17E-01	1.45E+00	2.99E-02
Range	0.00E-00 – 3.74E-01	3.03E-02 – 4.98E+00	6.31E-04 – 1.04E-01

- NOTES**
1. All values in bold are positive detection values.
 2. "<" indicates MDA value for non-detect Co-60 results.
 3. "< MDA" indicates non-detect for Cs-137 results. Refer to Section E for additional discussion.
 4. The unitized values were adjusted to account for the contamination depth used in the excavation scenario (60 cm). Refer to Section E for additional discussion.

D. SURVEY UNIT INVESTIGATIONS PERFORMED AND RESULTS

No measurements exceeded the investigation level. Therefore, no investigations were required.

E. SURVEY UNIT DATA ASSESSMENT

The Forebay dike soil DCGL was developed assuming that a 2-foot (24") band of soil contamination at the DCGL exists underneath the rip-rap in the Forebay dikes. This 2-foot assumption was arbitrarily made based upon a minimum amount of data. In order to determine the actual extent of contamination within this band of soil, Maine Yankee performed extensive characterization using samples obtained from incline core bores beneath the rip-rap. The samples were obtained as close to the rip-rap as possible. Overall, the Forebay dike soil boring campaign showed that the radiological contamination had not penetrated into the Forebay dikes beyond the rip-rap to any substantial depth (likely less than several inches).

ISOCS measurements of the Forebay dike soil through the rip-rap were geometrically configured such that the entire photon spectra was attributed to a contaminated soil band of 6 inches. Thus, this activity, attributed to a 6-inch band, should be divided by a factor of four in order to appropriately compare the results to a DCGL which was developed assuming a 24-inch band of contaminated soil. This adjustment, also applicable to ISOCS measurements above the rip-rap and soil samples obtained at depths of 0" to 6", is justified since the Forebay dike core boring campaign demonstrated that the contamination had not penetrated into the Forebay dike beyond the rip-rap to any significant extent. Therefore, the results for FR-0400 Survey Unit 8 were evaluated as discussed above.

An analysis of the direct sample measurement results, including the mean, median, standard deviation, and sample result range, are provided in Table 2. Positively detected values are bolded in the table. Since Co-60 is the primary radionuclide of concern, non-detect values were assumed to be present at the MDA. Non-detect values for Cs-137 were assumed not to be present.

The sampling results yielded fourteen measurements which detected both Co-60 and Cs-137, two measurements with only Cs-137, one measurement with only Co-60, and four samples with no plant-derived activity detected. The right hand column in Table 2 is the DCGL unity column. The survey unit mean value in this column indicates that the direct measurements were at 2.5% of the DCGL limit. No direct measurements exceeded the unitized DCGL. The sigma for the direct measurements was also evaluated and determined to be less than the design sigma. This indicates that a sufficient number of samples were taken.

No scan (ISOCS) locations exceeded the investigation level and, therefore, no investigations were performed.

For illustrative purposes, as indicated in LTP Section 5.9.3, a simplified general retrospective dose estimate can be calculated from the average residual contamination level. By subtracting the established mean fallout Cs-137 background value of 0.19 pCi/g (Reference 5) for disturbed soil from the survey unit mean ($0.19 \text{ pCi/g}/4 = 0.05 \text{ pCi/g}$) yields a negative value which is equivalent to 0.0 mrem/y. Since there is no background value for Co-60, the annual dose contribution from this radionuclide is 0.2 mrem/y ($= 1.15 \text{ pCi/g}/4 \times 1/12 \text{ pCi/g} \times 9 \text{ mrem/y}$). However, for the purposes of demonstrating compliance with the radiological criteria for license termination and the enhanced State criteria, background activity is not subtracted from the sample analysis activity values.

F. ADDITIONAL DATA EVALUATION

Attachment 4 provides additional data evaluation associated with this Survey Unit, including relevant statistical information. Based on survey unit direct measurement data, this attachment provides the Sign Test Summary, Quantile Plot, Histogram, and Retrospective Power Curve.

1. The Sign Test Summary provides an overall summary of design input and resulting calculated values used to determine the required number (N) of direct measurements (per LTP Section 5.4.2). The Sign Test Summary is a separate statistical analysis that also calculates the mean, median, and standard deviation of the direct measurements.

The critical value and the result of the Sign Test are provided in the Sign Test Summary table, as well as a listing of the key release criteria. As is shown in the table, all of the key release criteria were clearly satisfied for the FSS of this survey unit.

2. The Quantile Plot was generated from direct measurement data listed in Table 2. The data set and plot are consistent with expectations for a Class 1 survey unit. All of the measurements are well below the DCGL of 12.01 pCi/g Co-60 and 34.76 pCi/g Cs-137.
3. A Histogram Plot was also developed based on the direct measurement values. This plot shows that the direct data were essentially a skewed distribution with no outliers.
4. A Retrospective Power Curve was constructed, based on FSS results. The curve shows that this survey unit having a mean residual activity at a small fraction of the DCGL has a high probability (“power”) of meeting the release criteria. Thus, it can be concluded that the direct measurement data support rejection of the null hypothesis, providing high confidence that the survey unit satisfied the release criteria and that the data quality objectives were met.

G. CHANGES IN INITIAL SURVEY UNIT ASSUMPTIONS ON THE EXTENT OF RESIDUAL ACTIVITY

The dose model originally assumed 24 inches of contaminated soil behind the rip-rap on the dike walls. Based on data from the core boring campaign, the depth was 2 inches or less. The ISOCS results were divided by 4 to adjust the depth to 6 inches. In addition, the entire 10 mrem/y was assumed because there were no other contributing sources.

H. LTP CHANGES SUBSEQUENT TO SURVEY UNIT FSS

The FSS of Survey Unit 8 was designed and performed using the criteria of the approved Forebay Technical Basis Document (Reference 4) and LTP Revision 3 Addenda (Reference 1 and 2). Subsequent LTP changes have been evaluated and have no impact on the design, conduct, or assessment of the final status survey of this Survey Unit.

However, during final data evaluation, Survey Unit 7 (FR-0400) had issues related to the EMC Unity Rule criteria. As a result, the Forebay soil excavation scenario was modified to increase the Forebay soil DCGL to a value which was equivalent to the entire 10 mrem/y (9 actually used) limit allowed for soil outside the Restricted Area. This change raised the DCGLs for the Co-60 and Cs-137 to 12.01 pCi/g and 34.76 pCi/g respectively. These changes are documented Reference 6.

I. CONCLUSION

The FSS of this survey unit was designed based on the LTP designation as a Class 1 area. The survey design parameters are presented in Table 1. The required number of direct measurements was determined for the Sign Test in accordance with the LTP. As presented in Table 2, all direct measurements were less than the DCGL of 12.01 pCi/g Co-60 and 34.76 pCi/g Cs-137.

A Sign Test Summary analysis demonstrated that the Sign Test criteria were satisfied. The direct measurement sigma was determined to be less than that used for design, thus indicating that a sufficient number of samples was taken.

The Retrospective Power Curve shown in Attachment 4 confirmed that sufficient samples were taken to support rejection of the null hypothesis, providing high confidence that the survey unit satisfied the release criteria and the data quality objectives were met. Attachment 4 also revealed that direct measurement data represented essentially a skewed distribution, with variance consistent with expectations for a Class 1 survey unit.

The scan survey design for this survey unit was developed in accordance with the Forebay Technical Basis Document with significant aspects of the design discussed in Section B and Table 1. No areas of elevated activity were detected during the scan process; therefore no investigations were required.

It is concluded that FR0400 Survey Unit 8 meets the release criteria of 10CFR20.1402 and the State of Maine enhanced criteria.

J. REFERENCES

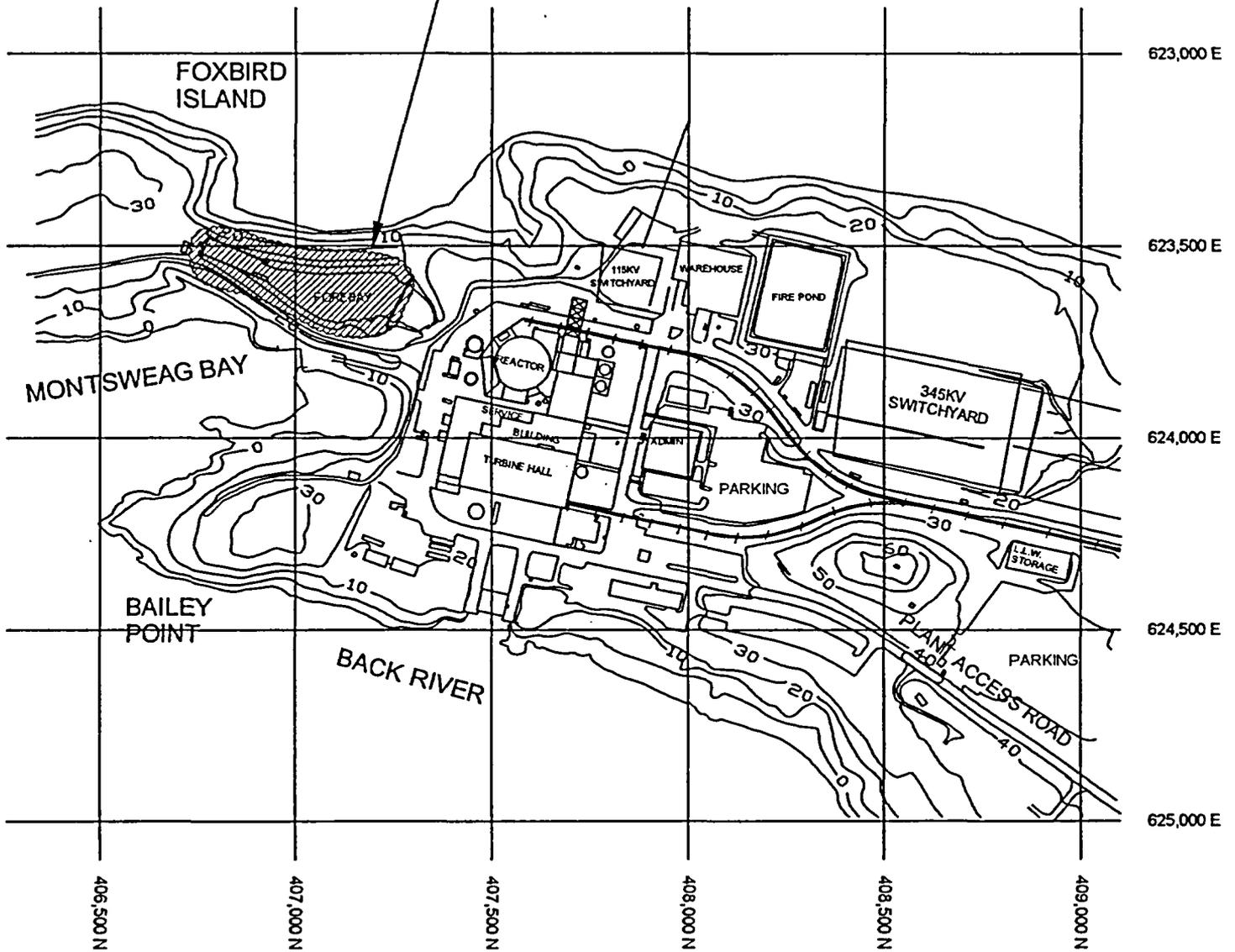
1. Maine Yankee License Termination Plan, Revision 3, October 15, 2002
2. Maine Yankee letter to the NRC, MN-02-061, dated November 26, 2002
3. NRC letter to Maine Yankee, ated February 28, 2003
4. Maine Yankee letter to the NRC, MN-03-051, "Forebay Technical Basis Document," dated September 3, 2003
5. Approach for Dealing with Background Radioactivity for Maine Yankee Final Status Surveys, Attachment E to Maine Yankee Procedure PMP 6.7.8, FSS Data Processing and Reporting
6. Maine Yankee Calculation EC-041-01, Diffuser and Forebay Dose Assessment
7. Maine Yankee Calculation EC-003-04, Use of Canberra In Situ Object Counting System (ISOCS) for FSS Surveys

Attachment 1
Survey Unit Maps

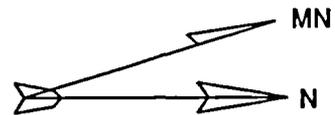
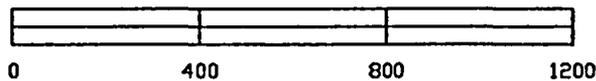
Survey Type: Remediation Turnover Final Status Survey

Survey Area Name: Forebay Site Map

SURVEY AREA (PARTIAL), FR 0400



SCALE



Note: Grid based on Maine State Coordinate System
(West Zone) NAD 1927

Survey Type:

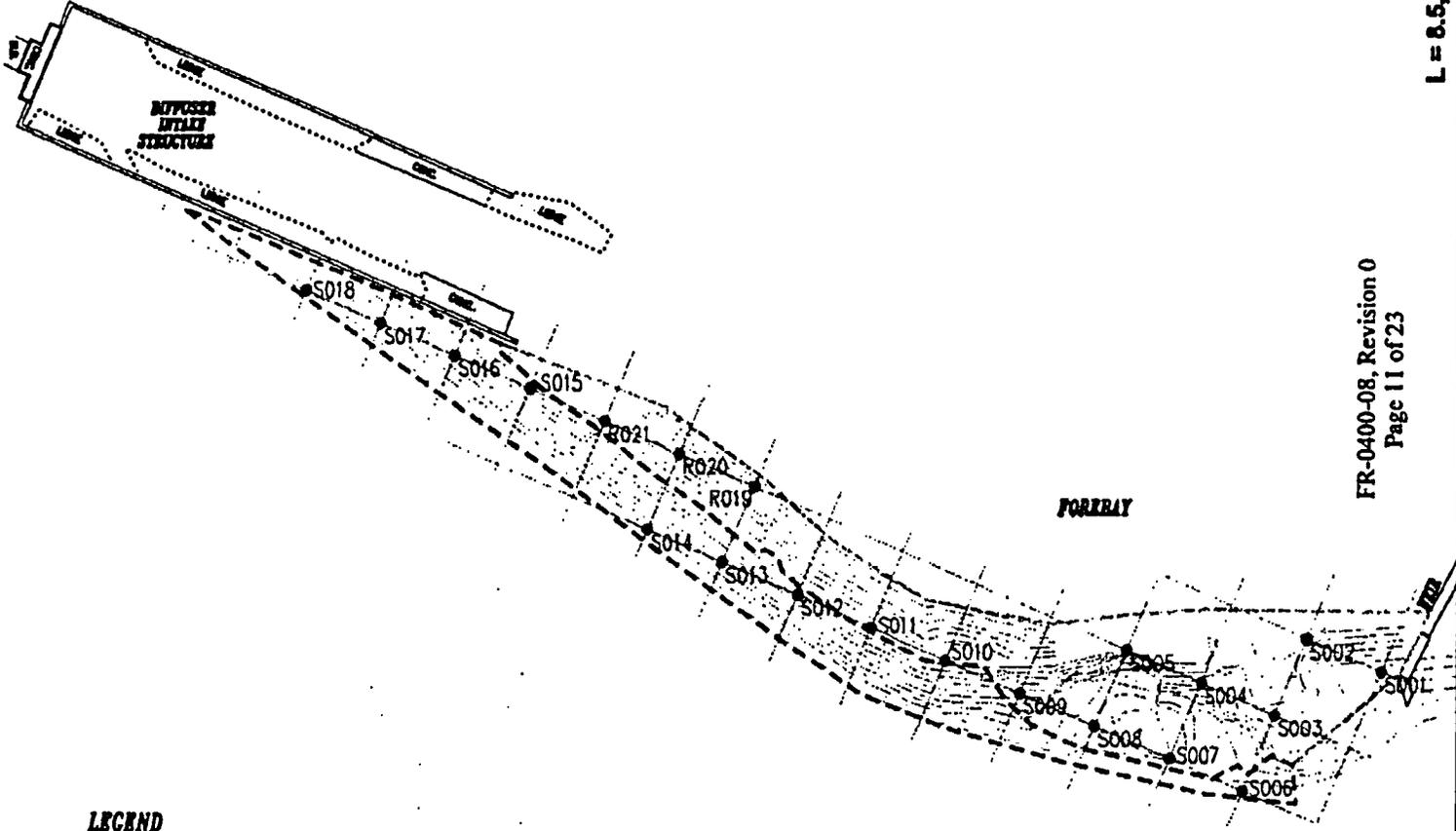
Characterization

Turnover

Final Status Survey

Survey Area Name: Forebay, East Dike

FR 0400: FOREBAY Survey Unit 8, East Bank Overview Final Status Survey



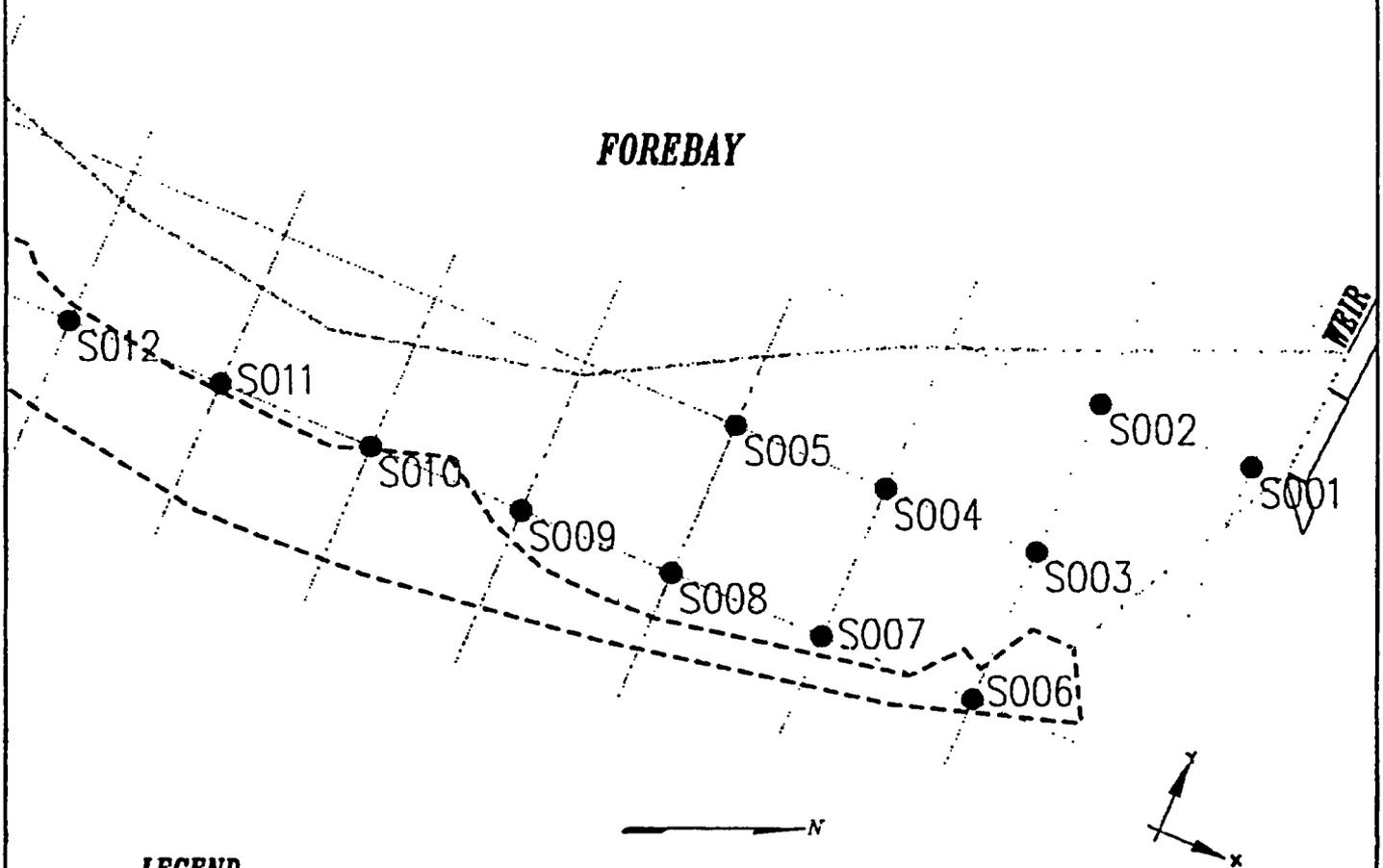
LEGEND

- Rock Bank Extent
- Rp-Rap Estimate (Bank Bottom)
- Concrete
- · - · - Ledge
- 8.5m (L) Square Grid
- S016 Direct Point Location

FR 0400: FOREBAY

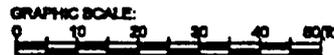
Survey Unit 8, North Section of East Bank

Direct Points S001 - S012



LEGEND

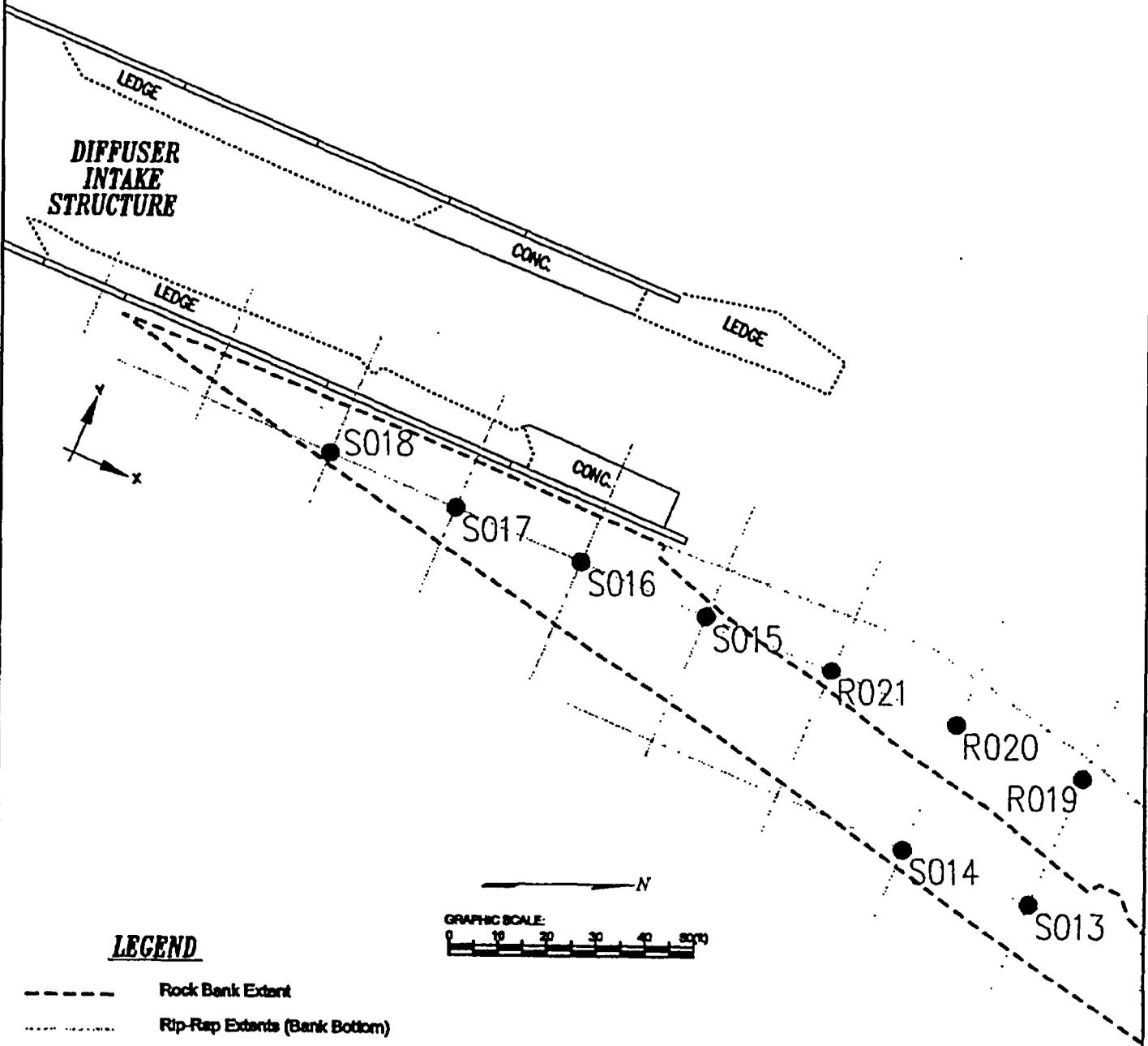
- Rock Bank Extent
- Rip-Rap Extents (Bank Bottom)
- Concrete
- · - · - · Ledge
- 8.5m (L) Square Grid
- W016 Direct Point Location



FR 0400: FOREBAY

Survey Unit 8, South Section of East Bank

Direct Points S013 - S018 and R019 - R021



LEGEND

- Rock Bank Extent
- Rip-Rap Extents (Bank Bottom)
- Concrete
- - - Ledge
- 8.5m (L) Square Grid
- W016 Direct Point Location

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Page 13 of 23

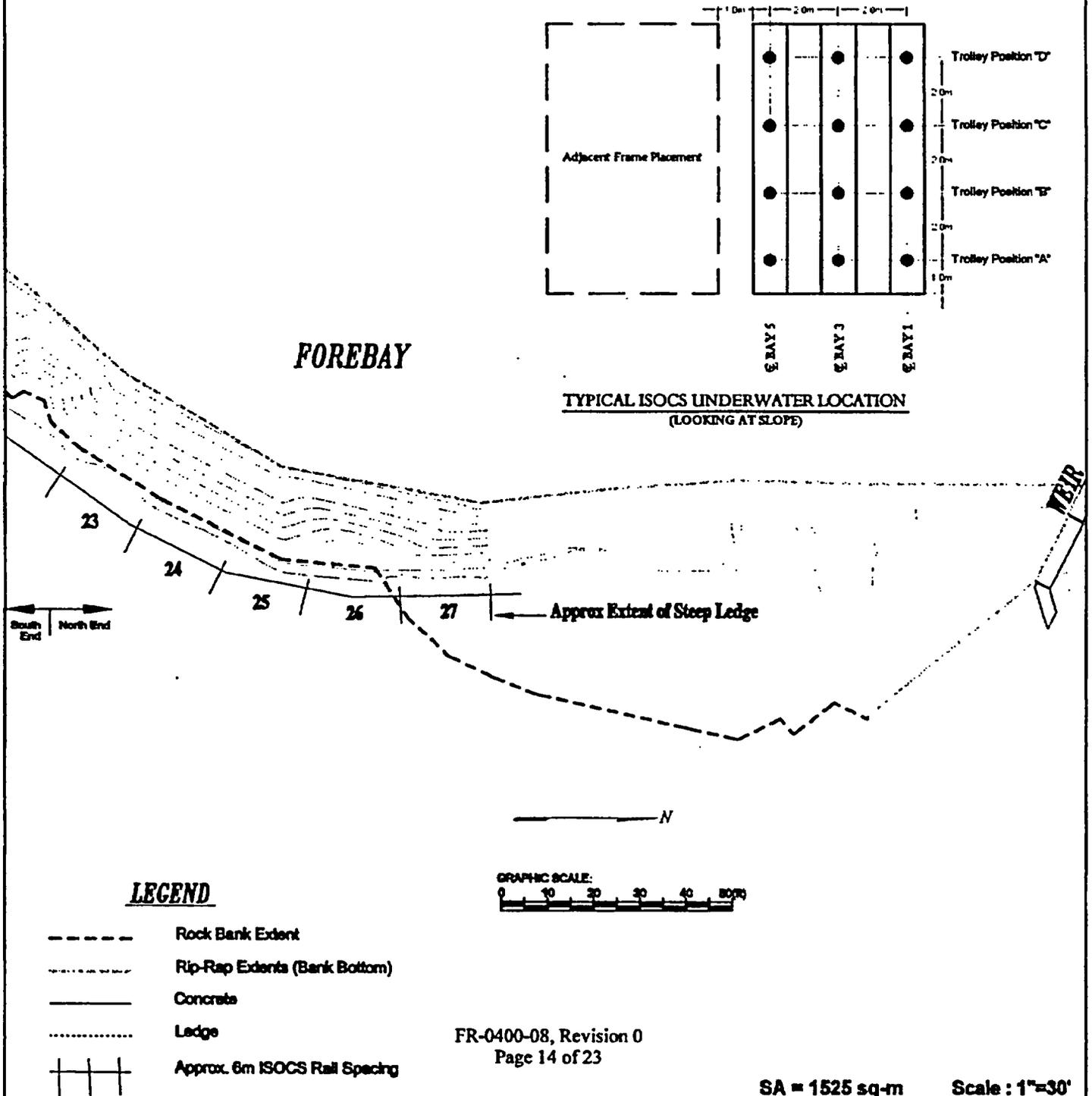
L = 8.5, N = 20 SA = 1525 sq-m Scale : 1"=30'

Survey Type: Characterization Turnover Final Status Survey Survey Area Name: Forebay, East Dike

FR 0400: FOREBAY

Survey Unit 8, North Section of East Bank

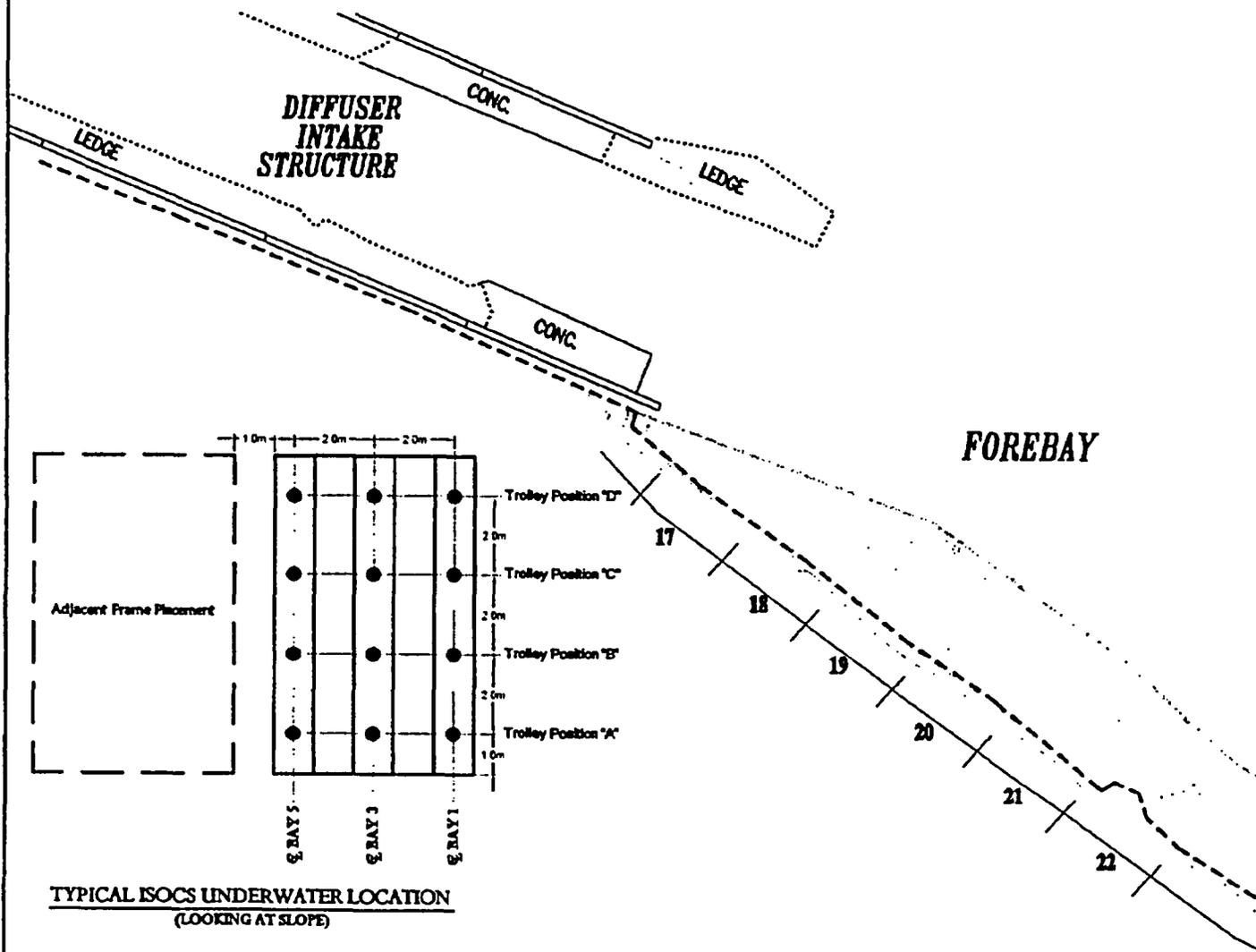
Underwater ISOCS Frames 23 thru 27



FR 0400: FOREBAY

Survey Unit 8, South Section of East Bank

Underwater ISOCS Frames 17 thru 22



TYPICAL ISOCS UNDERWATER LOCATION
(LOOKING AT SLOPE)

LEGEND

- Rock Bank Extent
- - - Rip-Rap Edents (Bank Bottom)
- Concrete
- Ledge
- ||| Approx. 6m ISOCS Rail Spacing



Attachment 2
Survey Unit Instrumentation

TABLE 2-1

INSTRUMENT INFORMATION

ISOCS Detectors (in situ measurements)

Detector Number	MDC (pCi/g)
7605	Table 2-2
7607	Table 2-2

HPGe Detectors (Laboratory Measurements)

Detector Number	MDC (pCi/g)
FSS-1	0.10 nominal
FSS-2	0.10 nominal

TABLE 2-2

**INSTRUMENT SCAN MDC, DCGL,
INVESTIGATION LEVEL, AND DESIGN DCGL_{EMC}**

Detector	ISOCS	Comments
Scan MDC	MDC < 35 pCi/g Co-60 (nominal)	See Note 1
DCGL	12.01 pCi/g Co-60 34.76 pCi/g Cs-137	Reference 6
Investigation Level	DCGL	< DCGL _{EMC}
Design DCGL _{EMC}	16.8 pCi/g Co-60 48.7 pCi/g Cs-137	DCGL x 1.4 (1.4 is the actual AF for surface soil, LTP Table 6-12)

NOTE 1 The effective activity for non-detect Co-60 is 25% of the reported MDC as discussed in Section E.

Attachment 3

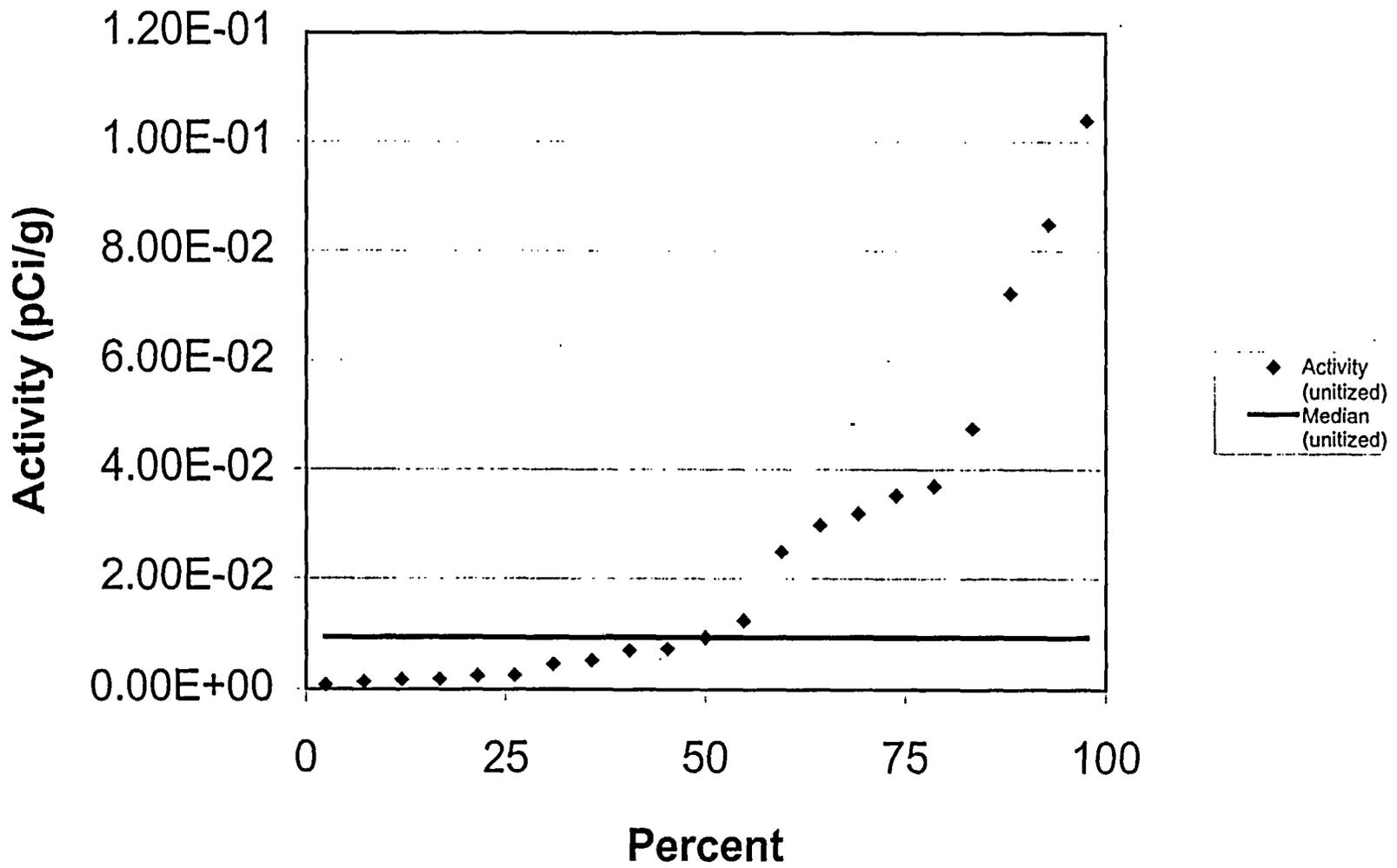
**Investigation Table
(No Investigations Required)**

Attachment 4
Statistical Data

Survey Package FR-0400 Unit 8 UNITY Soil Sign Test Summary

Evaluation Input Values		Comments
Survey Package:	FR-0400	Forebay
Survey Unit:	08	
Evaluator:	GP	
DCGL _w :	1.00E+00	
DCGL _{emc} :	1.40E+00	
LBGR:	5.00E-01	
Sigma:	1.82E-01	Unitized
Type I error:	0.05	
Type II error:	0.05	
Nuclide:	UNITY	
Soil Type:	N/A	
Calculated Values		Comments
Z _{1-α} :	1.645	
Z _{1-β} :	1.645	
Sign p:	0.99379	
Calculated Relative Shift:	2.7	
Relative Shift Used:	2.7	Uses 3.0 if Relative Shift is >3
N-Value:	12	
N-Value+20%:	15	
Sample Data Values		Comments
Number of Samples:	21	
Median:	9.60E-03	
Mean:	2.50E-02	
Net Sample Standard Deviation:	3.00E-02	
Total Standard Deviation:	3.00E-02	SRSS
Maximum:	1.04E-01	
Sign Test Results		Comments
Adjusted N Value:	21	
S+ Value:	21	
Critical Value:	14	
Sign test results:	Pass	
Criteria Satisfaction		Comments
Sufficient samples collected:	Pass	
Maximum value < DCGL _w :	Pass	
Median value < DCGL _w :	Pass	
Mean value < DCGL _w :	Pass	
Maximum value < DCGL _{emc} :	Pass	
Total Standard Deviation <= Sigma:	Pass	
Criteria comparison results:	Pass	
Final Status		Comments
The survey unit passes all conditions:	Pass	

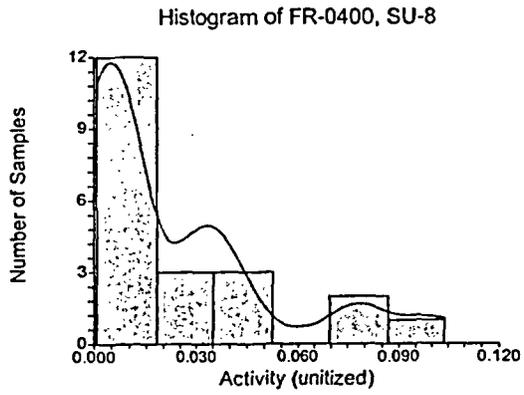
FR-0400 SU-8 Quantile Plot



One-Sample T-Test Report

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Database C:\Program Files\NCSS97\FR0400SU-8.S0
Variable C2

Plots Section



One-Sample T-Test Power Analysis

Page/Date/Time 2 12/20/04 5:12:14 AM

Chart Section

