Elim Subsistence Harbor Feasibility Study
Appendix B: Geotechnical Analysis
Elim, Alaska

November 2020

US Army Corps
of Engineers®
Alaska District

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

Department of the Army
Alaska District, U.S. Army Corps of Engineers
P.O. Box 6898
JBER, AK 99506-0898

CEPOA-EN-G-GM 17 July 2020

MEMORANDUM FOR CEPOA-PM-C (Attn: Dave Williams)

SUBJECT: Geotechnical Feasibility Report for the Elim Subsistence Harbor Feasibility Study, Elim, Alaska.

1. Enclosed is the Geotechnical Feasibility Report for the Elim Subsistence Harbor Feasibility Study. Included with this report are a discussion of existing geotechnical information pertaining to the project and preliminary geotechnical analysis and recommendations.
2. Questions should be addressed to Matthew Maher at 907-753-2850 or John Rajek at 907-753-5695.

// S //

MATTHEW L. MAHER, E.I.T
Civil Engineer
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Chief, Geotechnical and Materials Section
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FIGURES

ANNEXES

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1. INTRODUCTION

The purpose of this report is to summarize the results of investigations conducted along the coast of Elim, Alaska, to support the proposed development of navigation improvements for the community of Elim. This report also provides preliminary geotechnical design criteria for proposed rubble-mound breakwater construction and dredging of the proposed entrance channel and harbor basin. Information and assumptions in this report were developed through a site assessment and geophysical survey. It is intended for use by design engineers and planners to evaluate the feasibility of alternatives for navigation improvements in Elim, Alaska. Information in this report is not intended for use in construction contract documents.

2. LOCATION AND PROJECT DESCRIPTION

Elim is located on the Seward Peninsula, approximately 96 miles east of Nome, Alaska. Proposed navigation improvement sites are located along Norton Bay within an area southwest of the Community of Elim, starting at Airport Point and extending to the northeast through Elim Beach. The current Tentatively Selected Plan (TSP), Alternative 5, is located on Elim Beach just south of the Community of Elim. A project location and vicinity map, including a plan view of Alternative 5 is provided in Figure B-1.

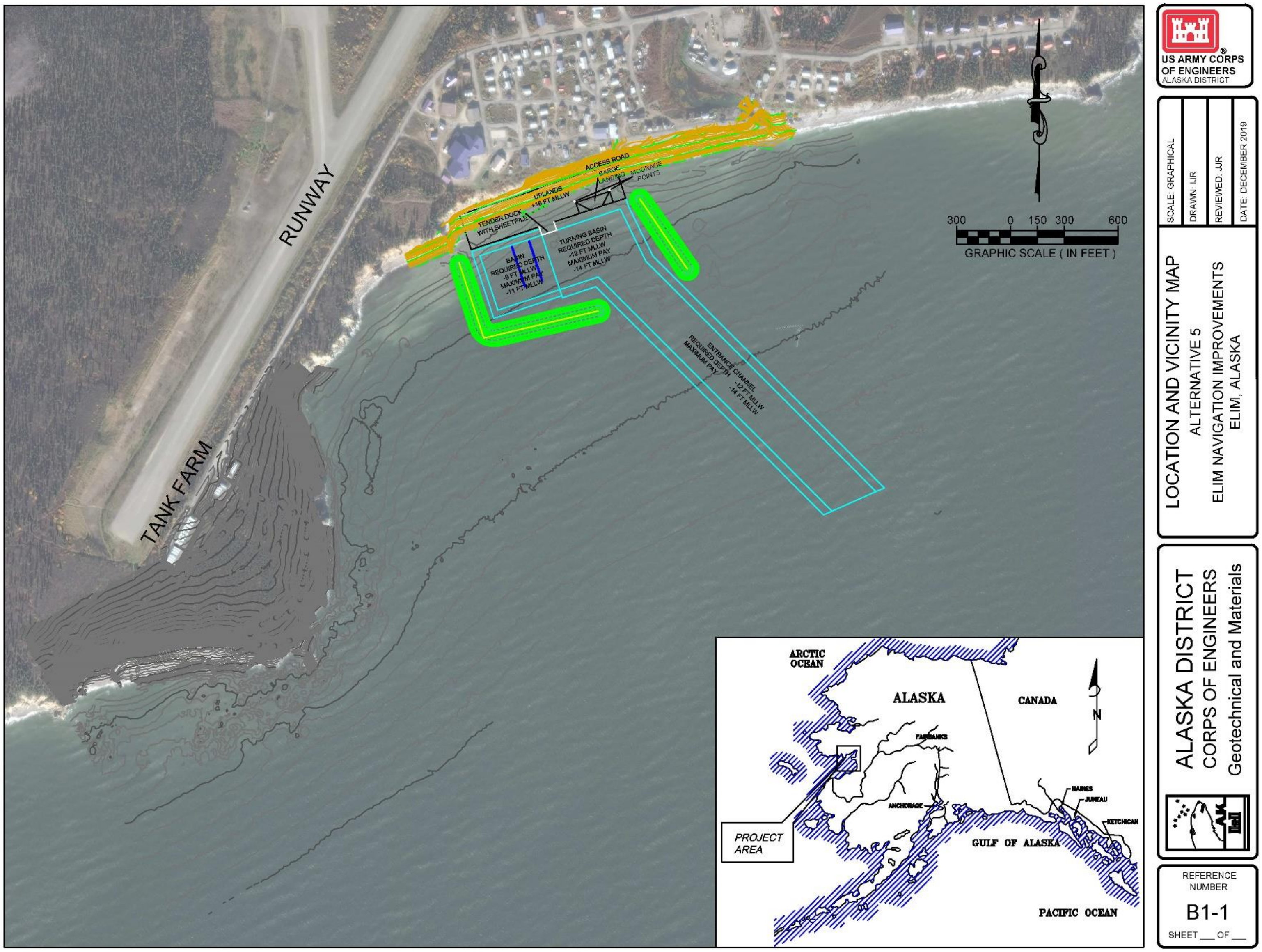

Figure B-1: Plan View of Alternative 5

3. GEOTECHNICAL SITE INFORMATION

Two recent geotechnical site assessments have been conducted within the proposed Elim project sites. These included collecting soil and sediment samples from hand-dug test pits and onshore and offshore geophysical surveys as described below.

The U.S. Army Corps of Engineers (USACE) conducted a site visit to Elim in October 2018 and collected samples from Elim Beach to characterize sediment for coastal sediment transport modeling. These field exploration efforts are documented in the Geotechnical Site Assessment Summary Report, Elim Navigation Improvements dated December 2018. For reference, this report has been included in Annex A.

Onshore and offshore geophysical surveys were conducted by Golder Associates in August 2019 to investigate the thicknesses of sediment over bedrock within the area of proposed navigation improvements. Along Elim Beach, coarse-grained soils and bedrock outcrops were sporadically visible at the surface along with varying-sized cobbles and boulders. The onshore and offshore geophysical explorations found three distinct layers of subsurface material at the Alternative 5 site. These layers consisted of loose alluvium at the surface, varying in thickness from nonexistent to about 3 feet thick; a layer of dense alluvium or weathered bedrock with an interpreted thickness of 2–9 feet; and bedrock. Cross-sections and plane view drawings displaying inferred alluvium and sediment thicknesses, and bedrock elevations are provided in the report titled Geophysical Survey Report Navigation Improvements Feasibility Study, Elim, Alaska, dated November 2019. For reference, this report has been included in Annex B.

4. PRELIMINARY GEOTECHNICAL ANALYSIS AND RECOMMENDATIONS

A review of existing geotechnical information collected along Elim Beach and offshore of the proposed Elim navigation improvements site indicates very favorable breakwater foundation conditions for all Elim alternatives.

4.1 Breakwater Slope Stability and Settlement

For geotechnical engineering analysis and evaluation purposes, it was assumed the proposed breakwater subsurface foundation conditions for Alternative 5 consist of relatively thin layers of loose to dense sediments consisting of coarse-grained soils with cobbles and boulders over shallow weathered bedrock and/or bedrock. The depth to bedrock varies, but it was assumed bedrock is within 2–12 feet of the existing ground or seafloor surface for evaluation purposes.

Given the current geotechnical information available, there are no anticipated height or width limitations on design or construction of the breakwater embankments. There are also no special foundation requirements needed to address concerns of breakwater slope stability, bearing capacity, or settlement of the breakwater embankments. For preliminary geotechnical design considerations, the breakwater embankment slopes can assume a slope angle of 1.5 horizontal to 1 vertical. Stability berms at the toe of the breakwater are not required for slope stability beyond what is needed for scour protection. The magnitude of the settlement of foundation soils below the proposed breakwater embankments is considered negligible, and settlement is assumed to occur simultaneously with the placement of rock fill.

4.2 Dredging

Mechanical dredging combined with heavy ripping and or drilling and blasting will be required to remove material from the proposed entrance channel and mooring basin. The TSP, Alternative 5, has a planned dredge depth of -13 feet Mean Lower Low Water (MLLW) plus 2 feet of allowable overdredge for the entrance channel and turning basin and -9 feet MLLW plus 2 feet of allowable overdredge for the mooring basin.

Anticipated dredging conditions for Alternative 5 consist of loose alluvium at the surface, varying in thickness from nonexistent to about 3 feet thick. This material can be mechanically dredged by clamshell or long-reach excavator. The thickness of loose sediment and depth to dense alluvium or bedrock varies within the proposed harbor entrance channel and basins. For estimating purposes, we anticipate dense alluvium deposits, weathered bedrock, or bedrock will be encountered within 1–3 feet of the seafloor surface. The type of equipment that will be required to remove dense alluvium deposits or weathered bedrock could consist of an excavator-mounted pneumatic or hydraulic rock breaker, jackhammer, rock ripper, xcentric ripper, or rock ripping bucket. It can be mechanically dredged by clamshell or long-reach excavator after dense alluvium or weathered bedrock is loosened or ripped. Bedrock encountered below dense alluvium deposits or weathered bedrock will require drilling and controlled blasting before it can be mechanically dredged.

Dredge cut slopes in the surface sediment, dense alluvium deposits, and weathered rock can be assumed to be stable at slopes of 1.5 horizontal to 1 vertical within the entrance channel and turning and mooring basins. Dredge cut slopes in bedrock may be cut at slopes of 0.25 horizontal to 1 vertical.

4.3 Future Geotechnical Site Investigation Recommendations

It is recommended that an onshore and offshore geotechnical site investigation be conducted consisting of drilling between 15 and 20 test borings below the proposed rubble-mound breakwaters, entrance channel, and maneuvering basin at the Alternative 5 site. The preferred drilling method would consist of using a sonic drill rig that would penetrate dense, coarse-grained sediments with cobbles and boulders and advance into the bedrock to depths below the proposed bottom of the navigation channel.

The main goal of conducting a geotechnical site investigation at the Alternative 5 site would be to properly characterize proposed dredge material, allow further evaluation and recommendations of the suitability of breakwater foundation material, and identify any geological conditions that would require special considerations during preconstruction engineering and design. Geotechnical information would also be used to establish the basis for accurate dredging cost estimates.

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ANNEX A

Geotechnical Site Assessment Summary Report, Elim Navigation Improvements, Elim, Alaska, Dated 21 December 2018

U.S. Army Corps of Engineers
Alaska District

Geotechnical Site Assessment Summary Report

Elim Navigation Improvements

Elim, Alaska
Alaska District, Pacific Ocean Division

21 December 2018
PN 468575
Status: Final

DEPARTMENT OF DEFENSE UNITED STATES OF AMERICA

Department of the Army
Alaska District, U.S. Army Corps of Engineers
P.O. Box 6898
JBER, AK 99506-0898

CEPOA-EN-G-GM 21 December 2018

MEMORANDUM FOR

Civil Works Project Management (CEPOA-PM-C), Dave Williams

SUBJECT: Geotechnical Site Assessment Summary Report for Elim Navigation Improvement, Elim, Alaska.

1. Enclosed is the Geotechnical Site Assessment Summary Report for the Elim Navigation Improvement project located in Elim, Alaska. Included with this report are the project location and vicinity map, test pit location maps, discussion of the findings, and geotechnical exploration logs.
2. Questions should be addressed to Matthew Maher at 907-753-2850 or John Rajek at 907-753-5695.

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TABLE OF CONTENTS

1. Introduction

The purpose of this report is to provide beach soil characterization for sediment transport modeling of proposed navigation improvements in Elim, Alaska. This report presents a summary of the findings based on site observations and results of laboratory testing. Information in this report is not intended for use in construction contract documents.

2. Location and Project Description

Proposed project sites considered for navigation improvements within the vicinity of the community of Elim consist of the Elim Beach located just south of Elim, Iron Creek, located approximately four miles east of Elim, Moses Point, located ten miles northeast of Elim, and Airport Point located at the southwest end of the Elim Runway. These general site locations are identified on the Vicinity Map located in Appendix A. The type of development for each site varies from constructing a boat launch, mooring points, dredging, or a protected harbor consisting of rubble mound breakwaters. Our geotechnical site assessment evaluated all sites except Airport Point.

3. Previous Geotechnical Investigations

Previous geotechnical investigations were performed within the proximity of the community of Elim. These reports have been included in Appendix D for reference.

1. Engineering Geology and Soils Report Elim Airport, Brazo, G. M., & Livingston, H. R. (1986), Alaska Department of Transportation and Public Facilities.

2. Preliminary Geologic Reconnaissance Potential Rock Quarry Sites Elim, Alaska, (2000), Hattenburg & Dilley Engineering Consultants.

4. Field Exploration

The field exploration for this project was conducted 30 to 31 October 2018. A total of 15 shallow test pits were hand excavated with a shovel to a maximum depth of 1.8 feet below the ground surface or to refusal. Test pit locations conducted at each site are shown on Test Pit Location maps provided in Appendix A.

4.1 Field Sampling

Test pits were generally located on the beach near the tidal water elevation and or approximately halfway up to the tidal high water mark. Soil samples were collected at the surface and to a maximum depth of 1.8 feet below the surface depending on the soils encountered. Samples were classified in the field in general accordance with ASTM D2488 “Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)”. Horizontal coordinates of test pit locations were determined by a handheld IPad with global positioning system (GPS) capabilities and should be considered approximate. Test pit location coordinates reported on the exploration logs are based on NAD83 (CORS), Alaska State Plane Zone 7, in feet. The elevations at each test pit location were not recorded. A summary table of test pit coordinates and exploration logs for each test pit are presented in Appendix B.

5. Laboratory Testing and Soil Classification

A laboratory testing program was established to classify and determine the physical and engineering properties of collected soil samples. The program consisted of particle-size analysis and engineering classification. Terra Firma, under contract with the Alaska District, performed the tests using the latest version of the test standards listed in Table 1. Laboratory test results are provided in Appendix C.

Table 1. Soils Laboratory Test Standards

Test Designation	Test Description
ASTM D 7928	Standard Test Method for Particle-Size Analysis of Soils (Sieve and Hydrometer)
ASTM D 2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

6. Site Conditions

Soil descriptions and classifications contained in this report and presented on the final exploration logs are the project engineer's interpretation of the field logs and results of the laboratory testing program.

6.1 Elim Beach

Surface material at Elim Beach varied from poorly to well graded gravel with sand, cobbles, and boulders. Bedrock outcrops consisting of weathered limestone were observed at the east and west ends of the beach (see Figure 1) and approximately halfway between these ends at approximately 300 feet east of TP-4. Elim Beach included sub-angular to sub-rounded gravel, fine to coarse sand, and cobbles ranging in size from three to 12-inches, and boulders ranging in size up to six-feet in diameter. The volume of cobbles and boulders as observed from the surface ranged from 10 to 75 percent at various locations along the beach. Fragments of weathered limestone bedrock were also observed at the west and east ends of the beach and throughout the area. Figures 1 through 9 provide an example of surface conditions along Elim Beach.

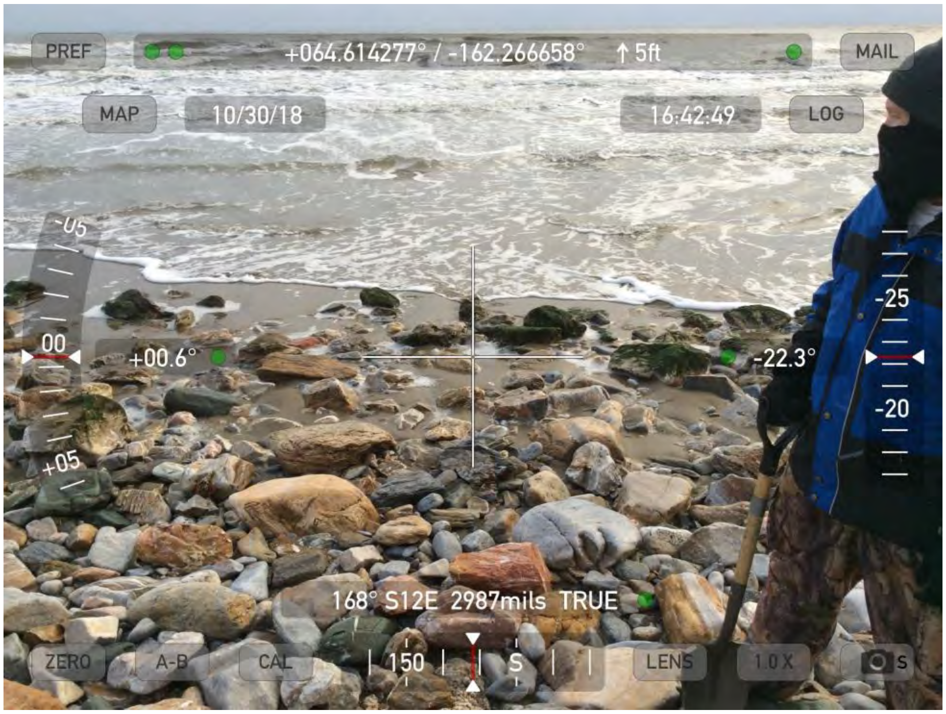


Figure 1. Southwest Section of Elim Beach at TP-1.

Figure 2. Elim Beach at TP-2 looking west.

Figure 3. Elim Beach at TP-2 sample 1 at a depth of 4 inches.

Figure 4. Elim Beach at TP-2 sample 2 at a depth of one foot.

Figure 5. Elim Beach located approximately 200 feet east of TP-4.

Figure 6. Elim Beach looking Northeast from TP-5.

Figure 7. Elim Beach at TP-6 Sample 1.

Figure 8. Elim Beach at TP-6 Sample 2.

Figure 9. Northeast section of Elim Beach approximately 200 ft. past TP-9.

6.2 Iron Creek Beach

Surface material at the Iron Creek Beach consisted of poorly to well graded gravel, sand, cobbles, and boulders. The Iron Creek Beach included sub-angular to sub-rounded gravel, fine to coarse sand, and cobbles ranging in size from three to 12-inches, and boulders larger than one foot in diameter. The volume of cobbles and boulders ranged from 10 to 65 percent at various locations along the beach. Sampling was difficult due to the presences of cobbles and boulders. Figures 10 through 13 provide an example of surface conditions along the Iron Creek Beach.

Figure 10. Iron Creek Beach looking Northeast by TP-8.

Figure 11. Iron Creek Beach at TP-9.

Figure 12. Iron Creek Beach at TP-10.

Figure 13. Iron Creek Beach at TP-11.

6.3 Moses Point Beach

Surface material at the Moses Point Beach consisted of poorly graded fine to coarse sand with gravel. Hand excavating shallow test pits was not difficult in the beach soils and the percentage of gravel general increased with depth. Figures 14 and 15 provide an example of surface conditions along the Moses Point Beach.

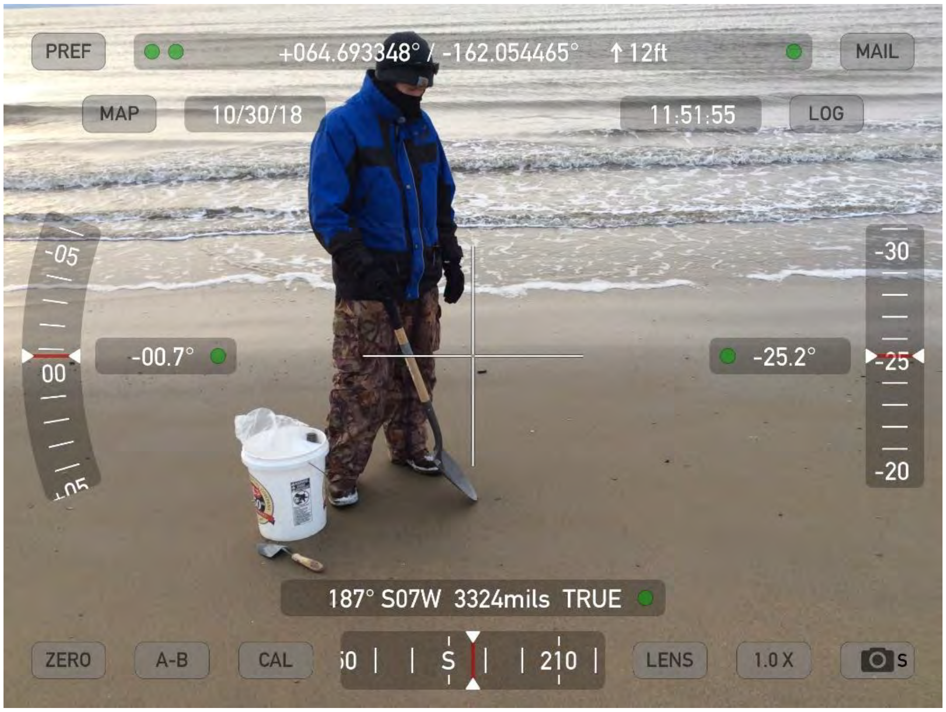
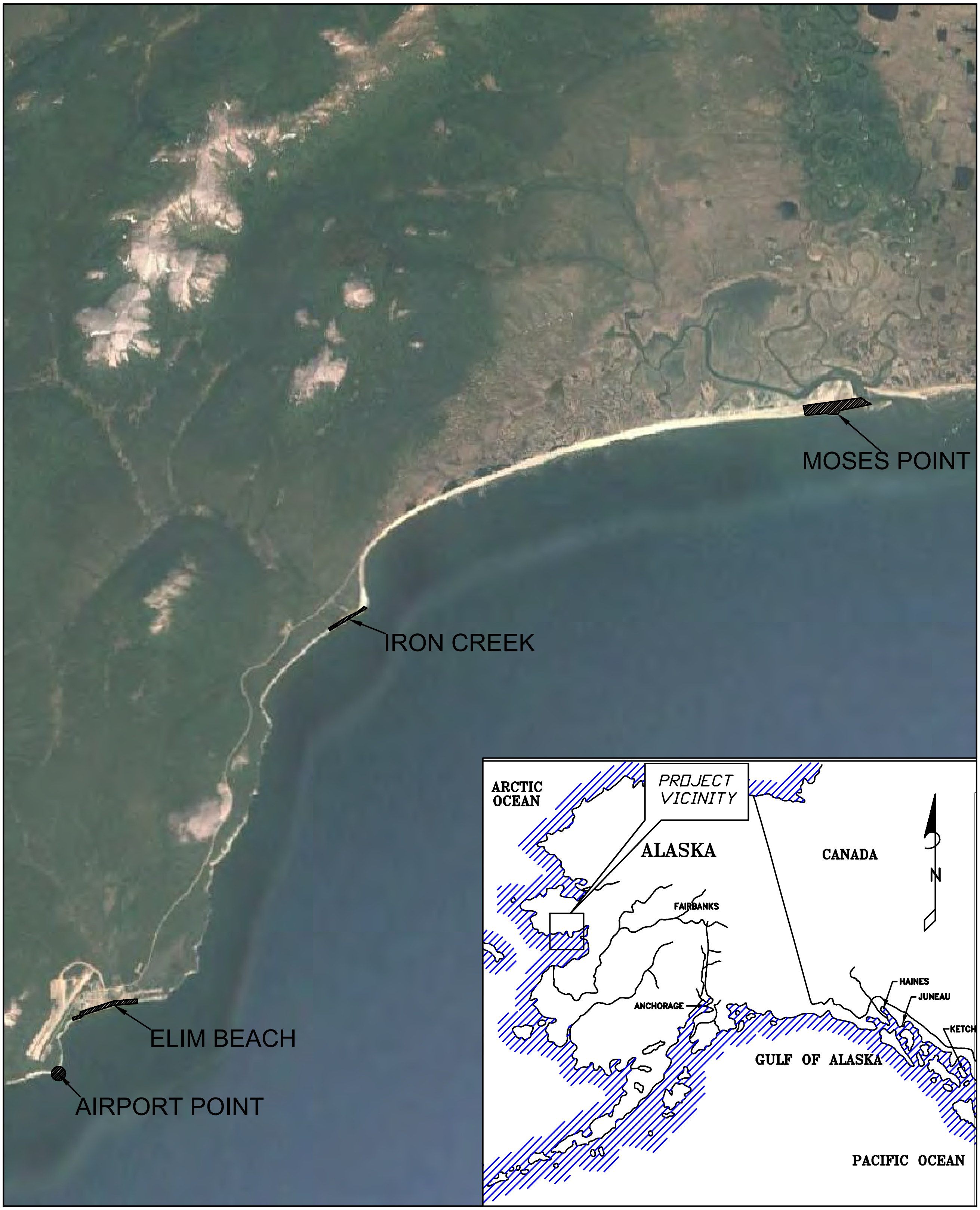


Figure 14. Moses Point Beach at TP-13.

Figure 15. Moses Point surface at TP-15.

APPENDIX A
MAPS AND SKETCHES



ALASKA DISTRICT
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SITE LOCATIONS VICINITY MAP
ELIM NAVIGATIONAL IMPROVEMENTS
ELIM ALASKA

SCALE:NOT TO SCALE
DATE:03 DEC 2018
DRAWN/RVW:MLM
FIGURE A-1

ALASKA DISTRICT
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TEST PIT LOCATION MAP
ELIM BEACH
ELIM, ALASKA

SCALE:GRAPHIC SCALE
DATE:03 DEC 2018
DRAWN/RVW:MLM

FIGURE A-2

ALASKA DISTRICT
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TEST PIT LOCATION MAP
IRON CREEK
ELIM, ALASKA

SCALE: GRAPHIC SCALE
DATE: 3 DEC 2018
DRAWN/RVW: MLM
FIGURE: A-3

ALASKA DISTRICT
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SOILS AND GEOLOGY

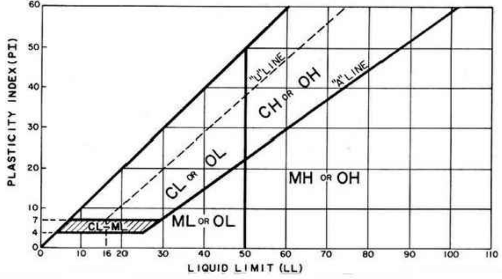
TEST PIT LOCATION MAP
MOSES POINT
ELIM, ALASKA

SCALE:GRAPHIC SCALE
DATE:03 DEC 2018
DRAWN/RVW:MLM
FIGURE A-4

APPENDIX B

EXPLORATION LOGS

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART (modified from ASTM D2487)

MAJOR DIVISIONS				SYMBOLS	DESCRIPTIONS	
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL AND GRAVELLY SOILS > 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS <5% FINES	$C_u \geq 4$ AND $1 \leq C_c \leq 3$	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	If soil contains ≥15% sand, add "with sand"
			$C_u < 4$ AND/OR [$C_c < 1$ OR $C_c > 3$]	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	
		GRAVELS WITH FINES >12% FINES	FINES CLASSIFY AS ML OR MH	GM	Silty gravels, gravel-sand-silt mixtures	
			FINES CLASSIFY AS CL OR CH	GC	Clayey gravels, gravel-sand-clay mixtures	
	SAND AND SANDY SOILS > 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SANDS <5% FINES	$C_u \geq 6$ AND $1 \leq C_c \leq 3$	SW	Well-graded sands, gravelly sands, little or no fines	If soil contains ≥15% gravel, add "with gravel"
			$C_u < 6$ AND/OR [$C_c < 1$ OR $C_c > 3$]	SP	Poorly graded sands, gravelly sands, little or no fines	
		SANDS WITH FINES >12% FINES	FINES CLASSIFY AS ML OR MH	SM	Silty sands, sand-silt mixtures	
			FINES CLASSIFY AS CL OR CH	SC	Clayey sands, sand-clay mixtures	
FINE GRAINED SOILS 50% OR MORE PASSES THE NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT <50	PLASTICITY CHART		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	If soil contains coarse-grained soil from 15% to 29%, add "with sand" or "with gravel" for whichever type is prominent, or for ≥30%, add "sandy" or "gravelly"
				ML	Inorganic silts, very fine sands, rock flour, silty/clayey fine sands or clayey silts of slight plasticity	
				OL	Organic silts and organic silty clays of low plasticity	
	SILTS AND CLAYS LIQUID LIMIT ≥50			CH	Inorganic clays of high plasticity, fat clays	
				MH	Inorganic silts, macaceous or dimaceous fine sandy or silty soils, elastic silt	
				OH	Organic clays of high plasticity, fat clays	
HIGHLY ORGANIC SOILS		PRIMARILY ORGANIC MATTER, DARK IN COLOR, AND ORGANIC ODOR		PT	Peat humus, swamp soils with high organic content	

COMPONENT DEFINITIONS BY GRADATION

COMPONENT	SIZE RANGE
BOULDERS	> 12 IN. (300 MM)
COBBLES	12 IN. (300 MM) to 3 IN. (75 MM)
GRAVEL	3 IN. (75 MM) to #4 SIEVE (4.76 MM)
COARSE GRAVEL	3 IN. (75 MM) to 3/4 IN. (18.75 MM)
FINES GRAVEL	3/4 IN. to #4 SIEVE (4.76 MM)
SAND	#4 (4.76 MM) to #200 (0.074 MM)
COARSE SAND	#4 (4.76 MM) to #10 (2.0 MM)
MEDIUM SAND	#10 (2.0 MM) to #40 (0.42 MM)
FINE SAND	#40 (0.42 MM) to #200 (0.074 MM)
SILT & CLAY (FINES)	< #200 (0.074 MM)

FROST DESIGN SOIL CLASSIFICATION (UFC 3-250-01FA, TABLE 18-2)

GROUP	TYPICAL SOILS
F1	Gravelly Soils
F2	Gravelly Soils, Sands
F3	Gravelly Soils, Sands, Except Very Fine Silt Sands
F4	All Silts, Very Fine Silty Sands, Clays, PI >12, Varved Clays and Other Fine-Grained Banded Sediments
NFS	Non-Frost-Susceptible
PFS	Possibly Frost Susceptible
S1	Gravelly Soils
S2	Sandy Soils

DESCRIPTION OF FROZEN SOILS (ASTM D4083)

GROUP	DESCRIPTION
ICE NOT VISIBLE	
Nf	Poorly Bonded or Friable
Nbn	Well Bonded, No Excess Ice
Nbe	Well Bonded, Excess Ice
VISIBLE ICE, < 1 IN. THICK	
Vx	Crystals
Vc	Ice Coatings or Particles
Vr	Ice Formations
Vs	Stratified or Distinctly Oriented Ice Formations
VISIBLE ICE, > 1 IN. THICK	
Ice	Ice without Soil Inclusions
Ice + Soil	Ice with Soil Inclusions

NOTES TO UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

NOTES:

1: **Coefficient of uniformity : $C_u = D_{60}/D_{10}$**

2: **Coefficient of curvature: $C_c = [(D_{30})^2] / (D_{10} \times D_{60})$**

3: **$D_{(x\%)}$ is soil particle diameter where x% is % finer.**

4: **Gravels or sands with 5% to 12% fines require dual symbols (GW-GM, GW-GC, GP-GM, GP-GC, SW-SM, SW-SC, SP-SM, SP-SC) and add "with clay" or "with silt" to group name. If fines classify as CL-ML for GM or SM, use dual symbol GC-GM or SC-SM.**

TEST BORING NOTES

TEST BORING NOTES:

1: **The number of blows required to drive each six-inch increment is recorded on the exploration logs. The reported blow count is an indication of the relative density or consistency of the soil. It should be noted that blow counts obtained in frozen soils do not represent the penetration of those same soils in a thawed state.**

2: **Soil classifications and descriptions reported on the exploration logs are in accordance with ASTM D 2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) and ASTM D 2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).**

3: **The soil classifications and descriptions contained on the exploration logs are the project engineer's interpretation of the field logs and results of the laboratory testing program. The stratification lines shown on the exploration logs represent approximate boundaries between soil types. The actual transitions are often gradual or not discernable by drill action.**

CRITERIA FOR DESCRIBING MOISTURE CONDITION (ASTM D2488)

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

OTHER MATERIAL SYMBOLS

ASPHALT PAVEMENT	■
BASALT	⬡
BEDROCK	▨
PORTLAND CEMENT CONCRETE	▒
COBBLES/BOULDERS	◯

SAMPLER ABBREVIATIONS/SYMBOLS

AUGER	Auger Cuttings	▐
CORE	Rock Core	▚
GRAB	Grab Sample	▨
LPT	Large Penetration Test	⧗
NR	No Recovery	○
SH	Shelby Tube	■
SPT	Standard Penetration Test (ASTM D 1586)	☒
UNDIST	Undisturbed Sample	■
VANE	Vane Shear	◫

ALASKA DISTRICT
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Geotechnical and Materials

LEGEND TO EXPLORATION LOGS

SCALE: NTS
DATE: MAY 2018
DRAWN/RVW: GF/CJC
LOG LEGEND

Elim Test Pit Coordinates

Permanent Number	Field Number	Latitude	Longitude	Northing *	Easting *
TP-1	ELIM 1-1	64.614360	-162.266790	3,879,050.0100	1598534.138
TP-2	ELIM 2-1	64.614940	-162.265000	3,879,260.9500	1598816.03
TP-3	ELIM 3-1	64.615150	-162.263480	3,879,336.7600	1599054.963
TP-4	ELIM 4-1	64.615420	-162.261690	3,879,434.3500	1599336.367
TP-5	ELIM 6-1	64.616090	-162.256320	3,879,675.9400	1600180.34
TP-6	ELIM 7-1	64.616230	-162.255240	3,879,726.4600	1600350.08
TP-7	ELIM 8-1	64.616310	-162.253700	3,879,754.7500	1600591.939
TP-8	ELIM 10-1	64.663730	-162.198540	3,897,066.9300	1609304.993
TP-9	ELIM 11-1	64.665000	-162.194060	3,897,529.2390	1610008.439
TP-10	ELIM 11-2	64.665022	-162.193934	3,897,549.4010	1609993.301
TP-11	ELIM 12-1	64.666640	-162.189410	3,898,126.8390	1610738.861
TP-12	ELIM 13-1	64.693550	-162.054480	3,907,928.1280	1631888.872
TP-13	ELIM 13-2	64.693403	-162.054465	3,907,874.3630	1631891.174
TP-14	ELIM 14-1	64.694990	-162.036070	3,908,452.7310	1634770.895
TP-15	ELIM 14-2	64.695049	-162.036098	3,908,474.4120	1634766.524

* Horizontal coordinates of test pit locations were determined by a handheld IPad with global positioning system (GPS) capabilities and should be considered approximate. Test pit location coordinates reported on the exploration logs are based on NAD83 (CORS), Alaska State Plane Zone 7, in feet. The elevations at each test pit location were not recorded. A summary table of test pit coordinates and exploration logs for each test pit are presented in Appendix B.

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Geotechnical and Materials Section

EXPLORATION LOG

Project: **Elim Navigation Improvement, 468575**
Elim, Alaska

Page 1 of 1

Date: **30 Oct 2018**

Drilling Agency: ☐ Alaska District ☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,879,050 ft. ±**
Easting: **1,598,534 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 1-1**

Permanent: **TP-1**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ______________
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **0.2 ft.**

Total Depth: **0.2 ft.**

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks **Surface Conditions: Elim Beach west end-cobbles, boulders, and weathered limestone with sand and gravel**
		1		**PFS***			▨	**SP-SM**	**Poorly graded SAND with Silt, Gravel, Cobbles and Boulders**			**Dark grayish brown, moist, about 20% gravel, about 78% fine sand, about 2% nonplastic fines, weathered limestone bedrock, boulders, and cobbles. Approximately 50 percent to 75 percent cobbles and boulders by volume.**
												Bottom of Hole 0.2 ft. **PID = (Cold/Hot) Photo Ionization Detector**
1												

* Indicates Estimated Frost Classification

Project: **Elim Navigation Improvement, 468575**

Hole Number: **TP-1**

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Geotechnical and Materials Section

EXPLORATION LOG

Project: **Elim Navigation Improvement, 468575**
Elim, Alaska

Page 1 of 1

Date: **30 Oct 2018**

Drilling Agency: ☐ Alaska District ☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,879,261 ft. ±**
Easting: **1,598,816 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 2-1**

Permanent: **TP-2**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ______
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **1.3 ft.**

Total Depth: **1.3 ft.**

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks **Surface Conditions: Elim Beach west end-sand and gravel**
		1		**NFS***			▨	**SP**	**Poorly graded SAND**			**Brown, wet, 12% subrounded to rounded gravel, 88% fine to coarse sand, 0% nonplastic fines, max size = 1 in.**
1		2		**NFS***			▨	**GW**	**Well-graded GRAVEL with Sand**			**Brown, moist, 54% subangular to rounded gravel, 46% fine to coarse sand, 0% nonplastic fines, max size = 1 in.**
												Bottom of Hole 1.3 ft. **PID = (Cold/Hot) Photo Ionization Detector**

* Indicates Estimated Frost Classification

Project: **Elim Navigation Improvement, 468575**

Hole Number: **TP-2**

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Date: **30 Oct 2018**

Drilling Agency: ☐ Alaska District ☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,879,337 ft. ±** Easting: **1,599,055 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 3-1**

Permanent: **TP-3**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ______________________
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **1.3 ft.**

Total Depth: **1.3 ft.**

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks
												Surface Conditions: Elim Beach west section-sand, gravel, and cobbles
		1		**NFS***			▨	**SW**	**Well-graded SAND with Cobbles**			**Brown, moist, about 10% subrounded to rounded gravel, about 90% fine to coarse sand, about 0% nonplastic fines, 3 inch to 6 inch cobbles ranging from 10 percent to 15 percent by volume**
1		2		**NFS***			▨	**SW**	**Well-graded SAND with Gravel and Cobbles**			**Brown, wet, 25% subrounded to rounded gravel, 75% fine to coarse sand, 0% nonplastic fines, 3 inch to 6 inch cobbles ranging from 10 percent to 15 percent by volume**
												Bottom of Hole 1.3 ft. **PID = (Cold/Hot) Photo Ionization Detector**

* Indicates Estimated Frost Classification

Project: **Elim Navigation Improvement, 468575**

Hole Number: **TP-3**

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Date: **30 Oct 2018**

Drilling Agency: ☐ Alaska District ☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,879,434 ft. ±** Easting: **1,599,336 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 4-1**

Permanent: **TP-4**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ____________
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **1.3 ft.**

Total Depth: **1.3 ft.**

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class: ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks **Surface Conditions: Elim Beach west section-sand, gravel, and cobbles**
		1		**NFS***			▨	**GP**	**Poorly graded GRAVEL with Sand and Cobbles**			**Brown, moist, about 65% subrounded to rounded gravel, about 35% fine to medium sand, about 0% nonplastic fines, 3 inch to 10 inch cobbles ranging from 15 percent to 30 percent by volume**
1		2		**NFS***			▨	**GP**	**Poorly graded GRAVEL with Sand and Cobbles**			**Brown, moist, 73% gravel, 27% fine sand, 0% nonplastic fines, 3 inch to 10 inch cobbles ranging from 15 percent to 30 percent by volume**
												Bottom of Hole 1.3 ft. **PID = (Cold/Hot) Photo Ionization Detector**

* Indicates Estimated Frost Classification

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Date: **30 Oct 2018**

Drilling Agency: ☐ Alaska District ☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,879,676 ft. ±**
Easting: **1,600,180 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 6-1**

Permanent: **TP-5**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ______
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **1.0 ft.**

Total Depth: **1.0 ft.**

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks **Surface Conditions: Elim Beach east section-sand, gravel, and cobbles**
		1		**NFS***			▨	**SP**	**Poorly graded SAND with Gravel and Cobbles**			**Brown, wet, 42% subrounded to rounded gravel, 58% medium to coarse sand, 0% nonplastic fines, 3 inch to 8 inch cobbles ranging from 15 percent to 30 percent by volume**
		2		**NFS***			▨	**GP**	**Poorly graded GRAVEL with Sand and Cobbles**			**Brown, moist, 77% subrounded to rounded gravel, 23% medium to coarse sand, 0% nonplastic fines, subangular to subrounded cobbles, subangular to subrounded boulders, 3 inch to 12 inch cobbles ranging from 15 percent to 50 percent by volume**
1												**Bottom of Hole 1.0 ft.** **PID = (Cold/Hot) Photo Ionization Detector**

* Indicates Estimated Frost Classification

Project: **Elim Navigation Improvement, 468575**

Hole Number: **TP-5**

EXPLORATION LOG ELIM_GRAB.GPJ BUCKLAND.GPJ 12/18/18

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Date: **30 Oct 2018**

Drilling Agency: ☐ Alaska District ☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,879,726 ft. ±** Easting: **1,600,350 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 7-1**

Permanent: **TP-6**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ____________
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **0.7 ft.**

Total Depth: **0.7 ft.**

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks **Surface Conditions: Elim Beach east section-sand, gravel, and cobbles**
		1		NFS*				GW	**Well-graded GRAVEL with Sand and Cobbles**			**Brown, wet, 67% angular to subrounded gravel, 33% medium to coarse sand, 0% nonplastic fines, 3 inch to 8 inch cobbles ranging from 10 percent to 30 percent by volume**
		2		*				GW	**Well-graded GRAVEL with Sand and Cobbles**			**Brown, moist, about 70% subangular to subrounded gravel, about 30% fine to coarse sand, about 0% nonplastic fines, 3 inch to 10 inch cobbles ranging from 25 percent to 50 percent by volume**
1												**Bottom of Hole 0.7 ft.** **PID = (Cold/Hot) Photo Ionization Detector**

* Indicates Estimated Frost Classification

Project: **Elim Navigation Improvement, 468575**

Hole Number: **TP-6**

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Date: **30 Oct 2018**

Drilling Agency: ☐ Alaska District ☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,879,755 ft. ±** Easting: **1,600,592 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 8-1**

Permanent: **TP-7**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ____________
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **1.0 ft.**

Total Depth: **1.0 ft.**

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks **Surface Conditions: Elim beach east end-sand, gravel, cobbles, and boulders**
		1		**NFS***				**SP**	**Poorly graded SAND with Gravel and Cobbles**			**Brown, moist, 25% angular to subrounded gravel, 75% medium to coarse sand, 0% nonplastic fines, 3 inch to 12 inch cobbles ranging from 10 percent to 30 percent by volume with boulders**
		2		**NFS***				**GW**	**Well-graded GRAVEL with Sand and Cobbles**			**Brown, moist, about 60% gravel, about 40% fine to coarse sand, about 0% nonplastic fines, 3 inch to 12 inch cobbles ranging from 25 percent to 50 percent by volume with boulders**
1												**Bottom of Hole 1.0 ft.** **PID = (Cold/Hot) Photo Ionization Detector**

* Indicates Estimated Frost Classification

Project: **Elim Navigation Improvement, 468575**

Hole Number: **TP-7**

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Drilling Agency: ☐ Alaska District
☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,897,067 ft. ±**
Easting: **1,609,305 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 10-1**
Permanent: **TP-8**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ____________
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **1.0 ft.**

Total Depth: **1.0 ft.**

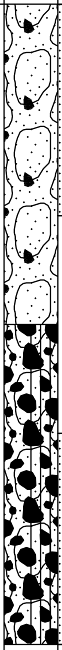
Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks **Surface Conditions: Iron Creek southwest end-sand, gravel, cobbles and boulders**
		1		**NFS***			▨	**SP**	**Poorly graded SAND with Gravel and Cobbles**			**Brown, moist, 16% subangular to subrounded gravel, 84% fine to coarse sand, 0% nonplastic fines, 3 inch to 12 inch cobbles ranging from 10 to 50 percent by volume with boulders**
		2		**NFS***			▨	**GW-GM**	**Well-graded GRAVEL with Silt, Sand, and Cobbles**			**Brown, moist, 60% subangular to subrounded gravel, 34% fine to coarse sand, 6% nonplastic fines, 3 inch to 12 inch cobbles ranging from 10 percent to 50 percent by volume with boulders**
1												**Bottom of Hole 1.0 ft.** **PID = (Cold/Hot) Photo Ionization Detector**

* Indicates Estimated Frost Classification

Project: **Elim Navigation Improvement, 468575**

Hole Number: **TP-8**

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Date: **30 Oct 2018**

Drilling Agency: ☐ Alaska District ☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,897,529 ft. ±**
Easting: **1,610,008 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 11-1**

Permanent: **TP-9**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ______________________
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **1.0 ft.**

Total Depth: **1.0 ft.**

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks **Surface Conditions: Iron Creek middle section-sand, gravel, cobbles, and boulders**
		1					▨	**GP**	**Poorly graded GRAVEL with Cobbles**			**Gray, wet, about 100% subangular to subrounded gravel, about 0% sand, about 0% nonplastic fines, 3 inch to 8 inch cobbles ranging from 10 percent to 30 percent by volume**
		2		**NFS***			▨	**GP**	**Poorly graded GRAVEL with Sand and Cobbles**			**Gray to brown, about 75% subangular to subrounded gravel, about 25% medium to coarse sand, about 0% nonplastic fines, 3 inch to 8 inch cobbles ranging from 10 percent to 30 percent cobbles by volume**
1												**Bottom of Hole 1.0 ft.** **PID = (Cold/Hot) Photo Ionization Detector**

* Indicates Estimated Frost Classification

Project: **Elim Navigation Improvement, 468575**

Hole Number: **TP-9**

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Date: **30 Oct 2018**

Drilling Agency: ☐ Alaska District ☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,897,549 ft. ±** Easting: **1,609,993 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 11-2**

Permanent: **TP-10**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ________ ☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **1.0 ft.**

Total Depth: **1.0 ft.**

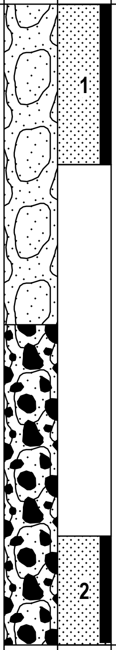
Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**



Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks **Surface Conditions: Iron Creek middle section-sand, gravel, cobbles, and boulders**
		1					▨	**SP**	**Poorly graded SAND with Cobbles**			**Brown, moist, about 0% gravel, about 100% fine to coarse sand, about 0% nonplastic fines, 3 inch to 10 inch cobbles ranging from 5 percent to 15 percent by volume**
		2					▨	**GW**	**Well-graded GRAVEL with Sand and Cobbles**			**Brown, moist, 73% subangular to subrounded gravel, 27% fine to coarse sand, 0% nonplastic fines, 3 inch to 10 inch cobbles ranging from 10 percent to 30 percent by volume**
1												**Bottom of Hole 1.0 ft.** **PID = (Cold/Hot) Photo Ionization Detector**

* Indicates Estimated Frost Classification

Project: **Elim Navigation Improvement, 468575**

Hole Number: **TP-10**

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Drilling Agency: ☐ Alaska District ☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,898,127 ft. ±** Easting: **1,610,739 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 12-1**

Permanent: **TP-11**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ____________
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **1.0 ft.**

Total Depth: **1.0 ft.**

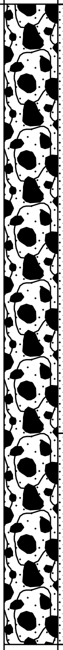
Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks **Surface Conditions: Iron Creek northeast end-sand, gravel, cobbles, and boulders**
		1					▨	**GW**	**Well-graded GRAVEL with Sand and Cobbles**			**About 70% gravel, about 30% sand, about 0% nonplastic fines, subangular to subrounded cobbles, subangular to subrounded boulders, 3 inch to 12 inch cobbles ranging from 25 percent to 65 percent by volume with boulders**
		2					▨	**GW**	**Well-graded GRAVEL with Sand and Cobbles**			**Brown, wet, 68% angular to subrounded gravel, 32% medium to coarse sand, 0% nonplastic fines, 3 inch to 12 inch cobbles ranging from 25 percent to 65 percent by volume with boulders**
1												**Bottom of Hole 1.0 ft.** **PID = (Cold/Hot) Photo Ionization Detector**

* Indicates Estimated Frost Classification

Project: **Elim Navigation Improvement, 468575**

Hole Number: **TP-11**

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Date: **30 Oct 2018**

Drilling Agency: ☐ Alaska District ☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,907,928 ft. ±**
Easting: **1,631,889 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 13-1**

Permanent: **TP-12**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ______
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **1.8 ft.**

Total Depth: **1.8 ft.**

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks **Surface Conditions: Moses Point west end-sand and gravel**
		1	**Nbn**	**NFS***			▨	**SP**	**Poorly graded SAND**			**Brown, wet, 8% subrounded to rounded gravel, 92% fine to coarse sand, 0% nonplastic fines, max size = 0.5 in.**
1												
		2		**NFS***			▨	**SP**	**Poorly graded SAND with Gravel**			**Brown, wet, 29% angular to rounded gravel, 70% fine to coarse sand, 1% nonplastic fines, max size = 1 in.**
												Bottom of Hole 1.8 ft. **PID = (Cold/Hot) Photo Ionization Detector**

* Indicates Estimated Frost Classification

Project: **Elim Navigation Improvement, 468575**

Hole Number: **TP-12**

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Drilling Agency: ☐ Alaska District ☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,907,874 ft. ±**
Easting: **1,631,891 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 13-2**

Permanent: **TP-13**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ________________
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **1.8 ft.**

Total Depth: **1.8 ft.**

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks **Surface Conditions: Moses Point west end-sand and gravel**
		1	**Nbn**	**NFS***			▨	**SP**	**Poorly graded SAND**			**Brown, frozen, about 0% gravel, about 100% fine to coarse sand, about 0% nonplastic fines**
1												
		2		**NFS***			▨	**GP**	**Poorly graded GRAVEL with Sand**			**Brown, moist, 72% subangular to subrounded gravel, 28% fine to coarse sand, 0% nonplastic fines, max size = 1 in.**
												Bottom of Hole 1.8 ft. **PID = (Cold/Hot) Photo Ionization Detector**

* Indicates Estimated Frost Classification

Project: **Elim Navigation Improvement, 468575**

Hole Number: **TP-13**

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Date: **30 Oct 2018**

Drilling Agency: ☐ Alaska District ☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,908,453 ft. ±**
Easting: **1,634,771 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 14-1**

Permanent: **TP-14**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ______
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **1.8 ft.**

Total Depth: **1.8 ft.**

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks **Surface Conditions: Moses Point east end-sand and gravel**
		1	**Nbn**	**NFS***			▧	**SP**	**Poorly graded SAND**			**Brown, wet, 10% gravel, 89% fine to coarse sand, 1% nonplastic (NP) fines, max size = 0.5 in.**
1												
		2		**NFS***			▧	**SP**	**Poorly graded SAND with Gravel**			**Brown, moist, 49% subangular to subrounded gravel, 51% fine to coarse sand, 0% nonplastic fines, max size = 2 in.**
												Bottom of Hole 1.8 ft. **PID = (Cold/Hot) Photo Ionization Detector**

* Indicates Estimated Frost Classification

Project: **Elim Navigation Improvement, 468575**

Hole Number: **TP-14**

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Drilling Agency: ☐ Alaska District ☒ Other **USACE**

Datum: Vertical
Horizontal **ASP7 NAD83**

Location: Northing: **3,908,474 ft. ±** Easting: **1,634,767 ft. ±**

Top of Hole Elevation:

Hole Number, Field: **ELIM 14-2**

Permanent: **TP-15**

Operator: **Matt Maher**

Inspector: **Robert Weakland**

Type of Hole: ☐ other ____________
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled: **1.8 ft.**

Total Depth: **1.8 ft.**

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: **Hand Shovel**

Type of Samples: **Grab**

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	N-Value	Sample Type	Symbol	Classification ASTM: D 2487 or D 2488	PID (ppm)	% Water	Description and Remarks **Surface Conditions: Moses Point east end-sand and gravel**
	▨	1	**Nbn**	**NFS***			▨	**SW**	**Well-graded SAND with Gravel**			**Brown, moist, about 40% subrounded gravel, about 60% fine to coarse sand, about 0% nonplastic fines, max size = 1.5 in.**
1	▨											
	▨	2		**NFS***			▨	**SW**	**Well-graded SAND with Gravel**			**Brown, moist, 45% subrounded to rounded gravel, 55% fine to coarse sand, 0% nonplastic fines, max size = 1.5 in.**
												Bottom of Hole 1.8 ft. **PID = (Cold/Hot) Photo Ionization Detector**

* Indicates Estimated Frost Classification

APPENDIX C
LABORATORY TEST RESULTS

Summary of Laboratory Test Results

Elim Small Boat Harbor

Elim, Alaska

NGE-TFT Project #:5196-18

Field TB Number	Sample Number	Depth Interval (ft) Top	Depth Interval (ft) Bottom	Atterberg Limit ASTM D4318	Particle Size Analysis ASTM C136/D422/D6913 (% By Mass) Gravel	Sand	Silt/Clay	Passing 0.02mm ASTM D7928 (% By Mass)	Frost Class.	Unified Soil Classification ASTM D2487
Elim 1-1	S1	0.0	0.333		0.1	97.5	2.4	2.2	NFS	(SP) Poorly graded sand
Elim 2-1	S1	0.0	0.333		11.8	88.1	0.1			(SP) Poorly graded sand
Elim 2-1	S2	1.0	1.333		53.5	46.3	0.2			(GW) Well graded gravel with sand
Elim 3-1	S2	1.0	1.333		24.9	74.9	0.2			(SW) Well graded sand with gravel
Elim 4-1	S2	1.0	1.333		72.5	27.3	0.2			(GP) poorly graded gravel with sand
Elim 6-1	S1	0.0	0.333		42.2	57.8	0.0			(SP) Poorly graded sand with gravel
Elim 6-1	S2	1.0	1.333		76.6	23.1	0.3			(GP) poorly graded gravel with sand
Elim 7-1	S1	0.0	0.333		67.0	32.9	0.1			(GW) Well graded gravel with sand
Elim 8-1	S1	0.0	0.333		40.4	59.6	0.0			(SP) Poorly graded sand with gravel
Elim 10-1	S1	0.0	0.333		15.6	84.2	0.2			(SP) Poorly graded sand with gravel
Elim 10-1	S2	0.667	1.0		60.3	33.8	5.9			(GW-GM) Well graded gravel with silt and sand
Elim 11-2	S2	1.0	1.333		72.6	27.1	0.3			(GW) Well graded gravel with sand
Elim 12-1	S2	0.667	1.0		67.6	32.0	0.4			(GW) Well graded gravel with sand
Elim 13-1	S1	0.0	0.333		7.5	92.3	0.2			(SP) Poorly graded sand
Elim 13-1	S2	1.5	1.83		29.3	70.2	0.5			(SP) Poorly graded sand with gravel
Elim 13-2	S2	1.5	1.83		71.7	27.9	0.4			(GP) poorly graded gravel with sand
Elim 14-1	S1	0.0	5.0		10.2	89.3	0.5			(SP) Poorly graded sand
Elim 14-1	S2	1.5	1.83		49.5	50.4	0.1			(SP) Poorly graded sand with gravel
Elim 14-2	S2	1.5	1.83		45.1	54.7	0.2			(SW) Well graded sand with gravel

NORTHERN GEOTECHNICAL ENGINEERING, INC. / TERRA FIRMA TESTING

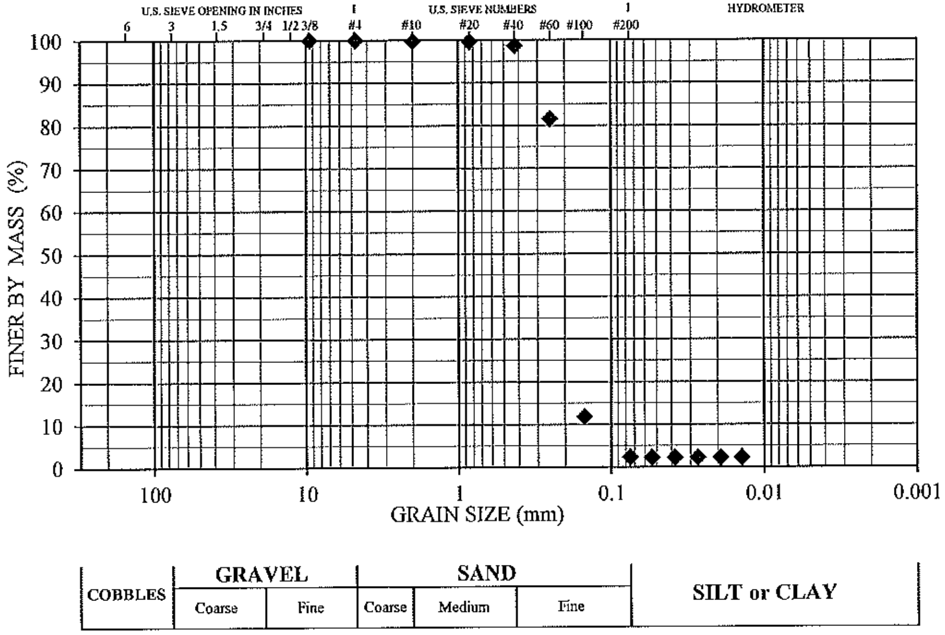
Laboratory Testing Geotechnical Engineering Instrumentation Construction Monitoring Services Thermal Analysis

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 1-1**
NUMBER/ DEPTH:	**S-1 / 0' - 0.333'**
DESCRIPTION:	**Poorly-graded sand**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**0.1**	USCS	**SP**
% SAND	**97.5**	USACOE FC	**NFS**
% SILT/CLAY	**2.4**	% PASS. 0.02 mm	**2.2**
% MOIST. CONTENT		% PASS. 0.002 mm	N/A

UNIFORMITY COEFFICIENT (C_u)	**1.6**
COEFFICIENT OF GRADATION (C_c)	**1.0**
ASTM D1557 (uncorrected)	**N/A**
ASTM D4718 (corrected)	**N/A**
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



SIEVE ANALYSIS RESULT

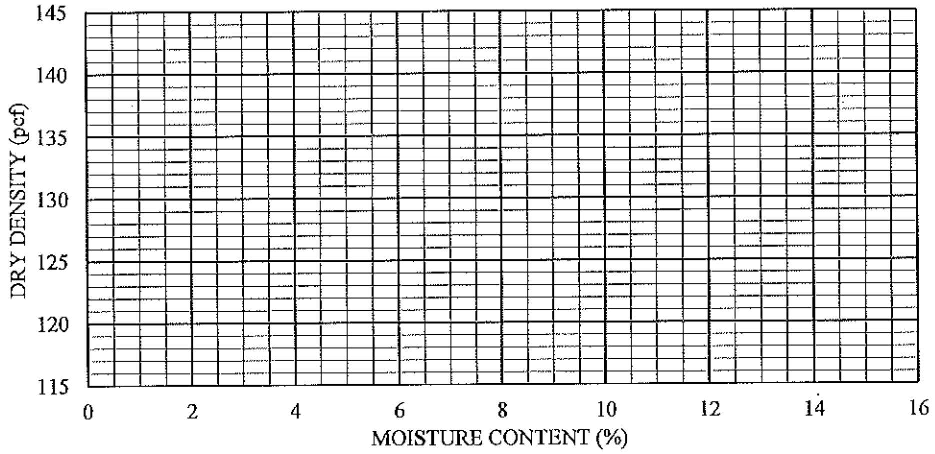
SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"		
19.00	3/4"		
12.70	1/2"		
9.50	3/8"	**100**	
4.75	#4	**100**	
2.00	#10	**100**	
0.85	#20	**100**	
0.43	#40	**99**	
0.25	#60	**82**	
0.15	#100	**12**	
0.075	#200	**2.4**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1	0.0542	2.2
2	0.0383	2.2
4	0.0271	2.2
8	0.0192	2.2
15	0.0140	2.2
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



The testing services reported herein have been performed to recognized industry standards, unless otherwise noted. No other warranty is made. Should engineering interpretation or opinion be required, NGE-TFT will provide upon written request.

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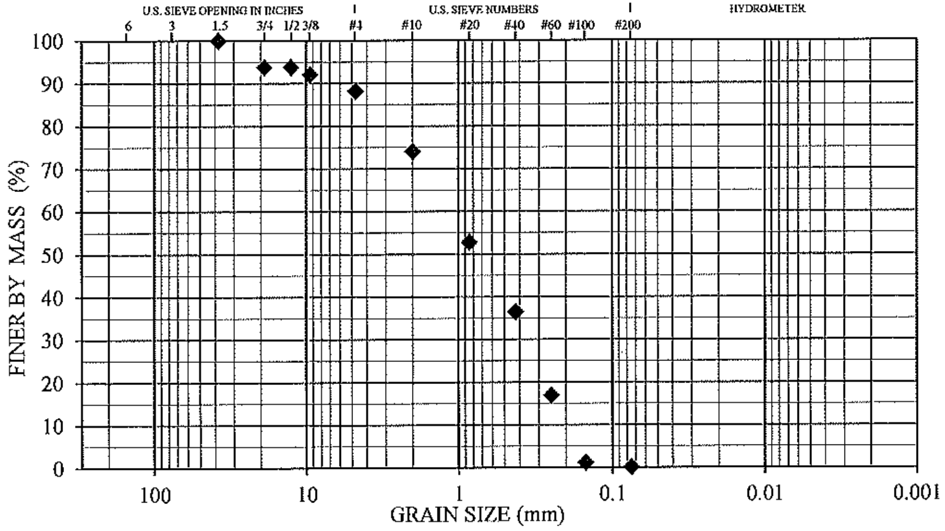
PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 2-1**
NUMBER/ DEPTH:	**S-1 / 0' - 0.333'**
DESCRIPTION:	**Poorly-graded sand**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**11.8**	USCS	**SP**
% SAND	**88.1**	USACOE FC	**N/A**
% SILT/CLAY	**0.1**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**

UNIFORMITY COEFFICIENT (C_u)	**6.0**
COEFFICIENT OF GRADATION (C_c)	**0.5**
ASTM D1557 (uncorrected)	**N/A**
ASTM D4718 (corrected)	**N/A**
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136

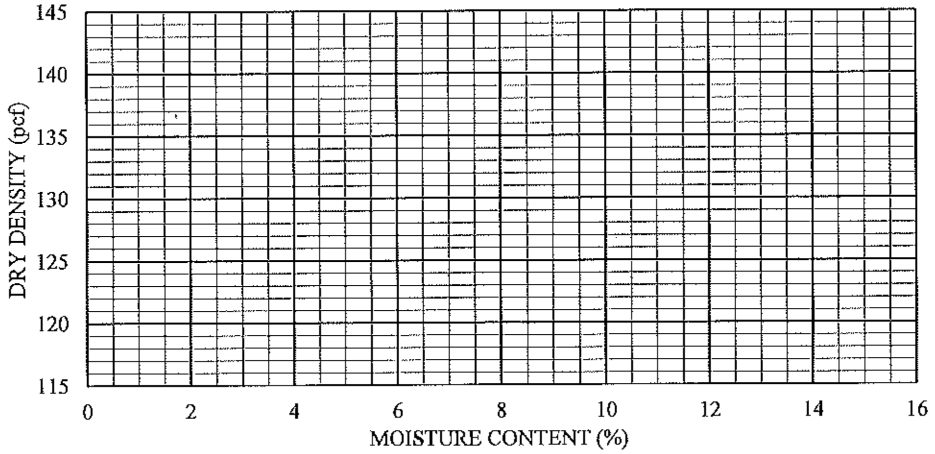


COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"	**100**	
19.00	3/4"	**94**	
12.70	1/2"	**94**	
9.50	3/8"	**92**	
4.75	#4	**88**	
2.00	#10	**74**	
0.85	#20	**53**	
0.43	#40	**36**	
0.25	#60	**17**	
0.15	#100	**1**	
0.075	#200	**0.1**	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

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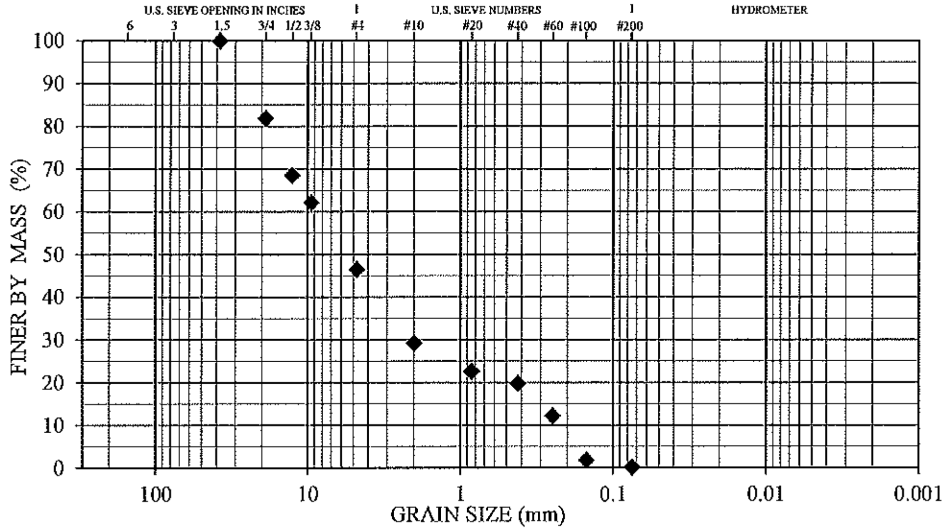
PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 2-1**
NUMBER/ DEPTH:	**S-2 / 1' - 1.333'**
DESCRIPTION:	**Well-graded gravel w/ sand**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**53.5**	USCS	**GW**
% SAND	**46.3**	USACOE FC	**N/A**
% SILT/CLAY	**0.2**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**

UNIFORMITY COEFFICIENT (C_u)	**38.6**
COEFFICIENT OF GRADATION (C_c)	**2.2**
ASTM D1557 (uncorrected)	**N/A**
ASTM D4718 (corrected)	**N/A**
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

SIEVE ANALYSIS RESULT

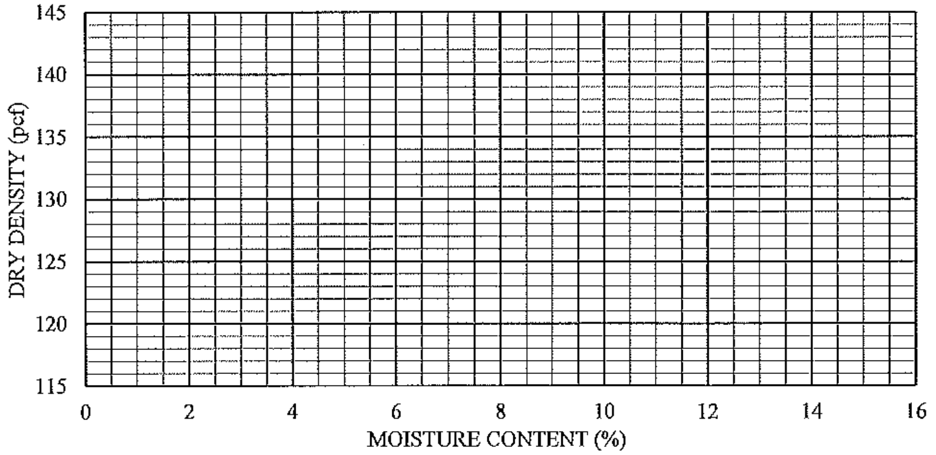
SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"	**100**	
19.00	3/4"	**82**	
12.70	1/2"	**69**	
9.50	3/8"	**62**	
4.75	#4	**46**	
2.00	#10	**29**	
0.85	#20	**23**	
0.43	#40	**20**	
0.25	#60	**12**	
0.15	#100	**2**	
0.075	#200	**0.2**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



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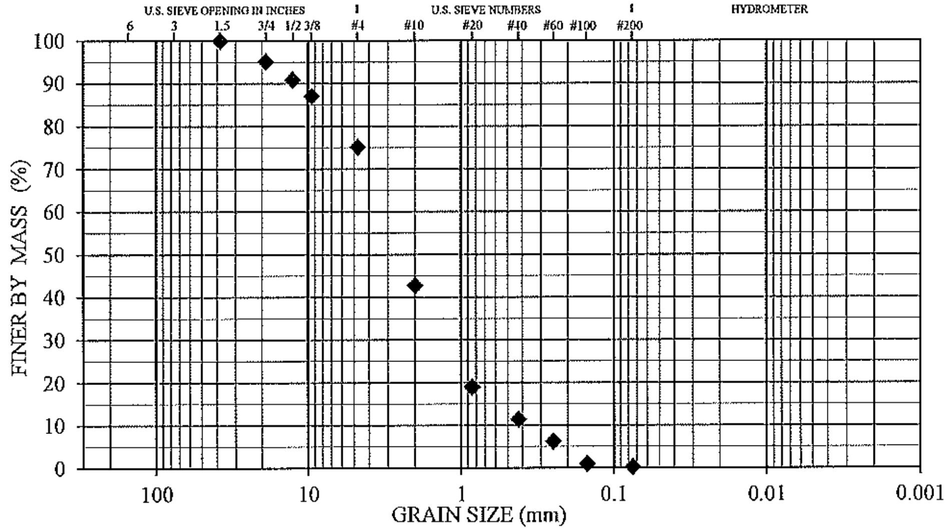
PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 3-1**
NUMBER/ DEPTH:	**S-2 / 1' - 1.333'**
DESCRIPTION:	**Well-graded sand w/ gravel**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**24.9**	USCS	**SW**
% SAND	**74.9**	USACOE FC	**N/A**
% SILT/CLAY	**0.2**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)		**9.2**	
COEFFICIENT OF GRADATION (C_c)		**1.5**	
ASTM D1557 (uncorrected)		**N/A**	
ASTM D4718 (corrected)		**N/A**	
OPTIMUM MOIST. CONTENT. (corrected)		**N/A**	

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

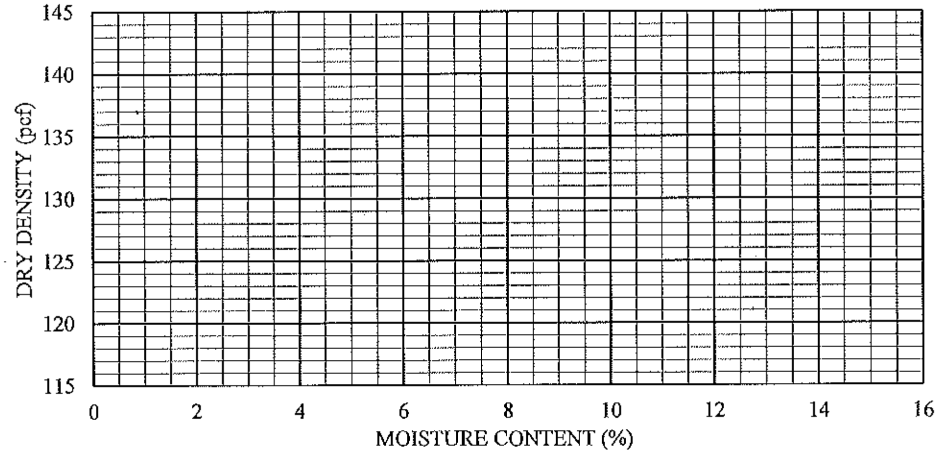
SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"	**100**	
19.00	3/4"	**95**	
12.70	1/2"	**91**	
9.50	3/8"	**87**	
4.75	#4	**75**	
2.00	#10	**43**	
0.85	#20	**19**	
0.43	#40	**11**	
0.25	#60	**6**	
0.15	#100	**1**	
0.075	#200	**0.2**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



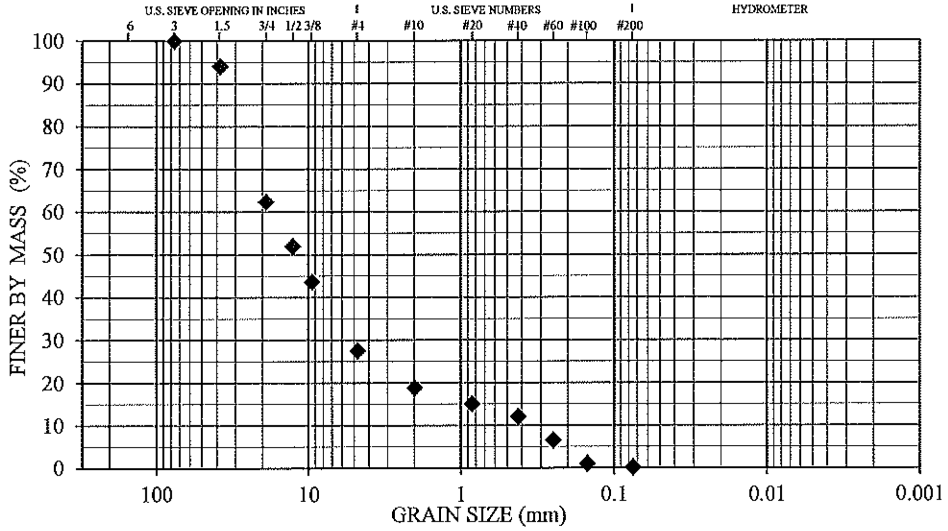
HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 4-1**
NUMBER/ DEPTH:	**S-2 / 1' - 1.333'**
DESCRIPTION:	**Poorly-graded gravel w/ sand**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**72.5**	USCS	**GP**
% SAND	**27.3**	USACOE FC	**N/A**
% SILT/CLAY	**0.2**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**

UNIFORMITY COEFFICIENT (C_u)	**48.8**
COEFFICIENT OF GRADATION (C_c)	**4.8**
ASTM D1557 (uncorrected)	**N/A**
ASTM D4718 (corrected)	**N/A**
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

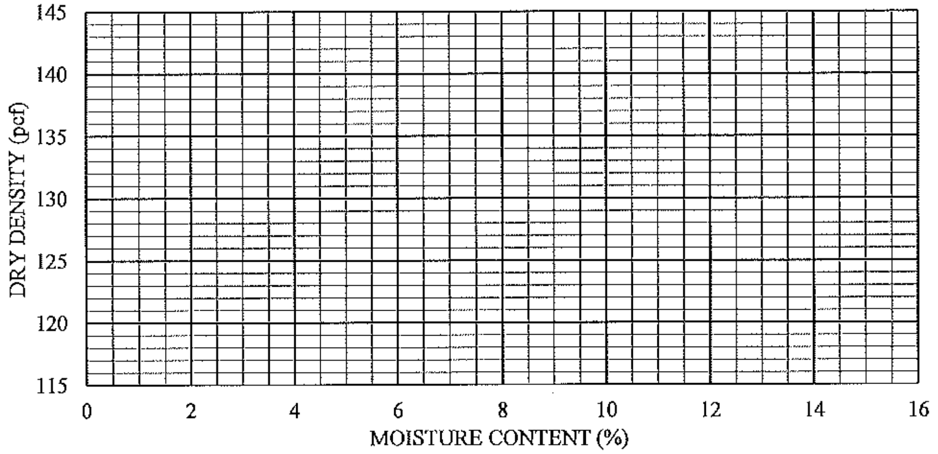
SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"	**100**	
38.10	1.5"	**94**	
19.00	3/4"	**62**	
12.70	1/2"	**52**	
9.50	3/8"	**44**	
4.75	#4	**27**	
2.00	#10	**19**	
0.85	#20	**15**	
0.43	#40	**12**	
0.25	#60	**6**	
0.15	#100	**1**	
0.075	#200	**0.2**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

MOISTURE-DENSITY RELATIONSHIP ASTM D1557

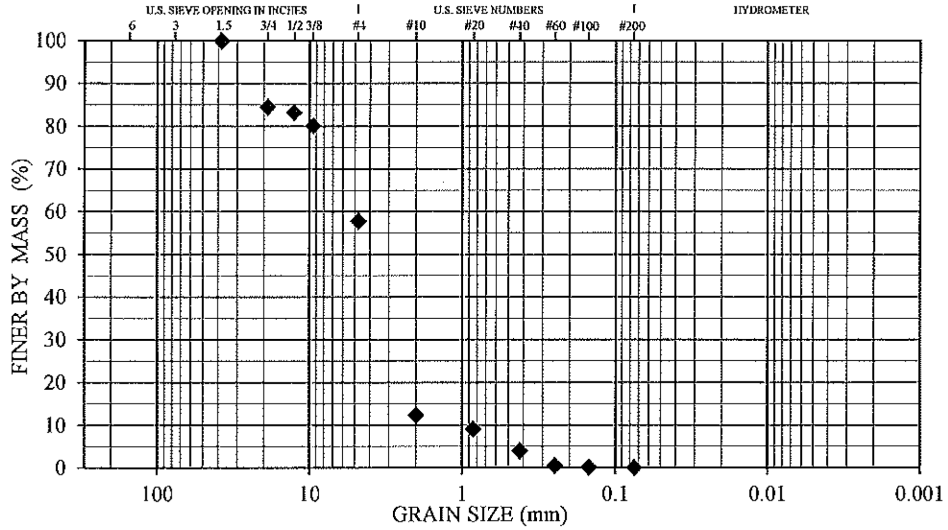


HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 6-1**
NUMBER/ DEPTH:	**S-1 / 0' - 0.333'**
DESCRIPTION:	**Poorly-graded sand w/ gravel**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

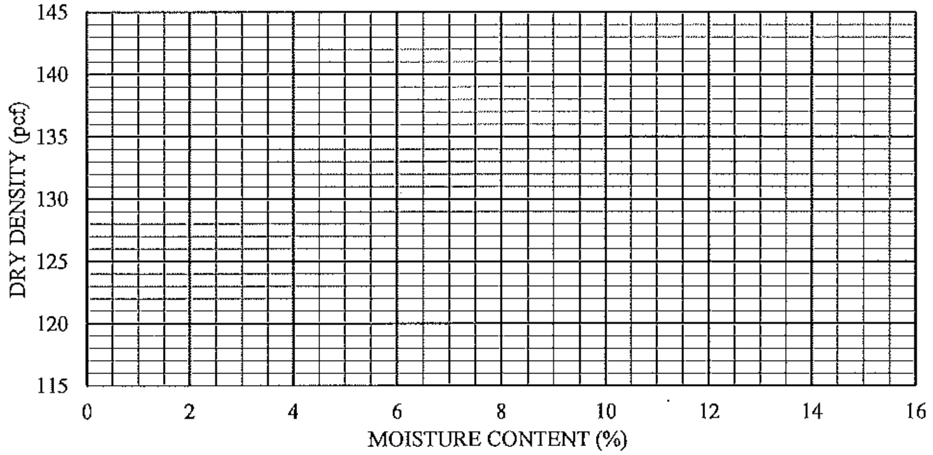
% GRAVEL	**42.2**	USCS	**SP**
% SAND	**57.8**	USACOE FC	**N/A**
% SILT/CLAY	**0.0**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)	**4.4**		
COEFFICIENT OF GRADATION (C_c)	**1.5**		
ASTM D1557 (uncorrected)	**N/A**		
ASTM D4718 (corrected)	**N/A**		
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**		

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"	**100**	
19.00	3/4"	**84**	
12.70	1/2"	**83**	
9.50	3/8"	**80**	
4.75	#4	**58**	
2.00	#10	**12**	
0.85	#20	**9**	
0.43	#40	**4**	
0.25	#60	**0**	
0.15	#100	**0**	
0.075	#200	**0.0**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

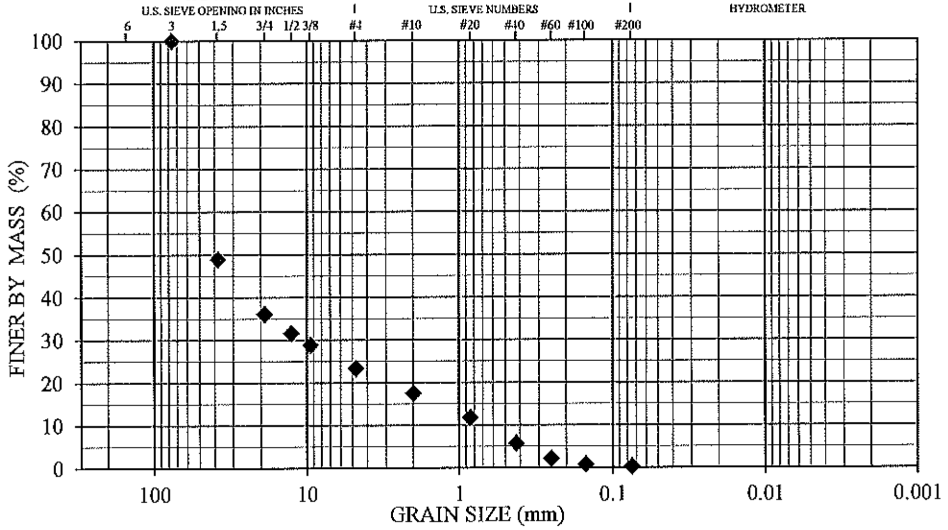
HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

The testing services reported herein have been performed to recognized industry standards, unless otherwise noted. No other warranty is made. Should engineering interpretation or opinion be required, NGE-TFT will provide upon written request.

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 6-1**
NUMBER/ DEPTH:	**S-2 / 1' - 1.333'**
DESCRIPTION:	**Poorly-graded gravel w/ sand**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

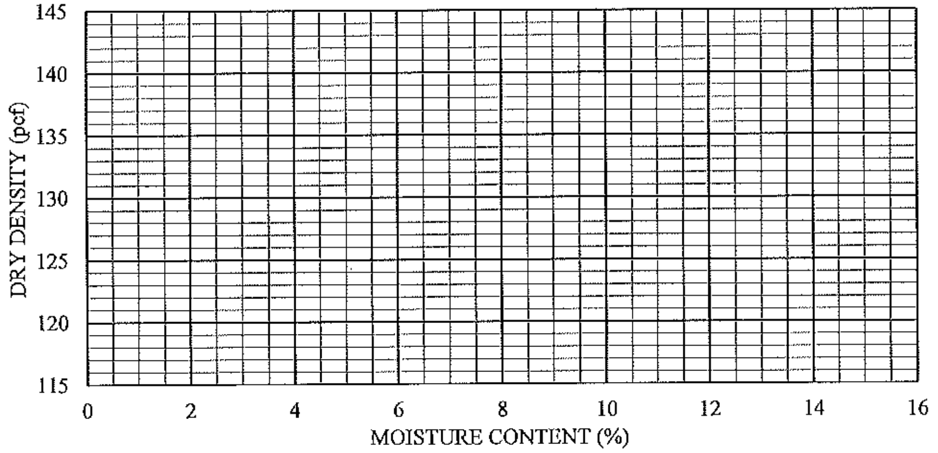
% GRAVEL	**76.6**	USCS	**GP**
% SAND	**23.1**	USACOE FC	**N/A**
% SILT/CLAY	**0.3**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)	**64.0**		
COEFFICIENT OF GRADATION (C_c)	**3.5**		
ASTM D1557 (uncorrected)	**N/A**		
ASTM D4718 (corrected)	**N/A**		
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**		

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"	**100**	
38.10	1.5"	**49**	
19.00	3/4"	**36**	
12.70	1/2"	**32**	
9.50	3/8"	**29**	
4.75	#4	**23**	
2.00	#10	**17**	
0.85	#20	**12**	
0.43	#40	**6**	
0.25	#60	**2**	
0.15	#100	**1**	
0.075	#200	**0.3**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

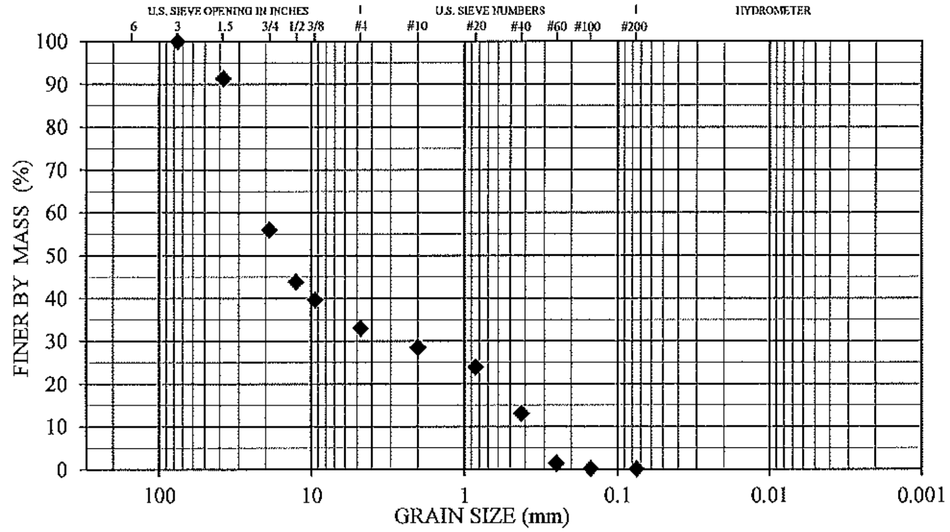
NORTHERN GEOTECHNICAL ENGINEERING, INC. / TERRA FIRMA TESTING

Laboratory Testing Geotechnical Engineering Instrumentation Construction Monitoring Services Thermal Analysis

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 7-1**
NUMBER/ DEPTH:	**S-1 / 0' - 0.333'**
DESCRIPTION:	**Well-graded gravel w/ sand**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**67.0**	USCS	**GW**
% SAND	**32.9**	USACOE FC	**N/A**
% SILT/CLAY	**0.1**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)			**55.8**
COEFFICIENT OF GRADATION (C_c)			**1.0**
ASTM D1557 (uncorrected)			**N/A**
ASTM D4718 (corrected)			**N/A**
OPTIMUM MOIST. CONTENT. (corrected)			**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

SIEVE ANALYSIS RESULT

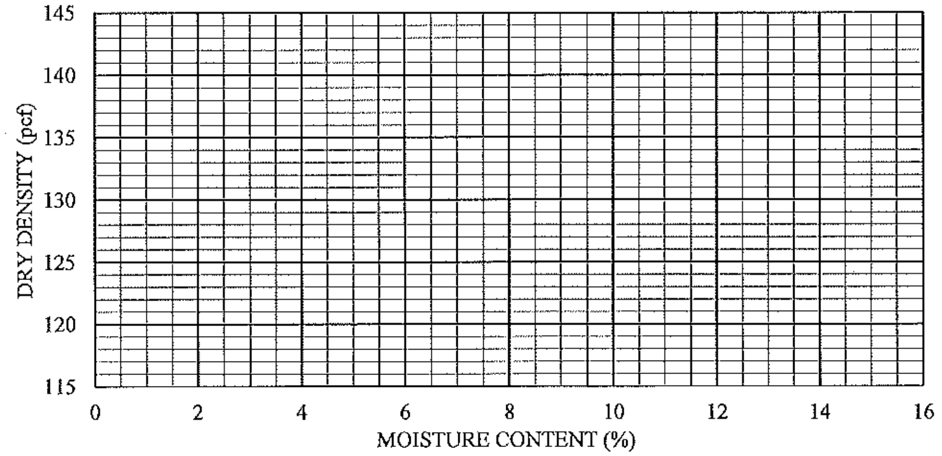
SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"	**100**	
38.10	1.5"	**91**	
19.00	3/4"	**56**	
12.70	1/2"	**44**	
9.50	3/8"	**40**	
4.75	#4	**33**	
2.00	#10	**29**	
0.85	#20	**24**	
0.43	#40	**13**	
0.25	#60	**1**	
0.15	#100	**0**	
0.075	#200	**0.1**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



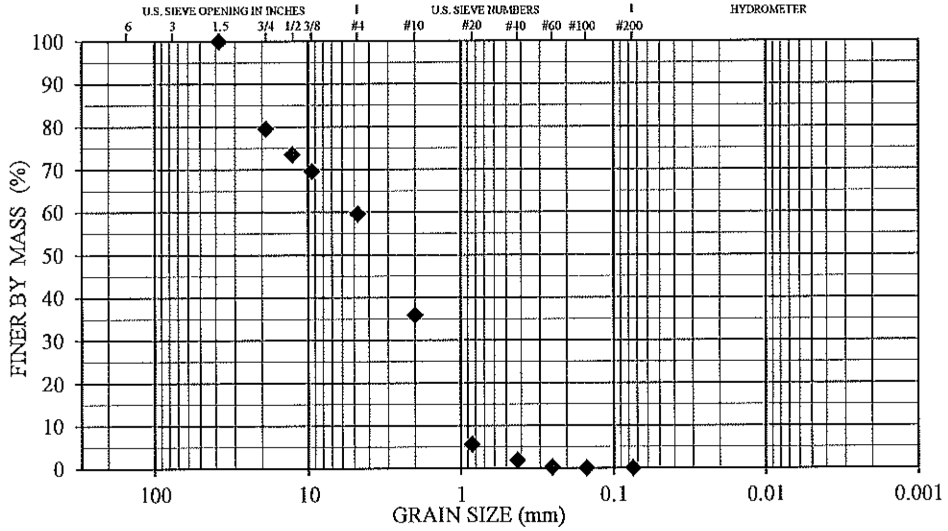
NORTHERN GEOTECHNICAL ENGINEERING, INC. / TERRA FIRMA TESTING

Laboratory Testing · Geotechnical Engineering · Instrumentation · Construction Monitoring Services · Thermal Analysis

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 8-1**
NUMBER/ DEPTH:	**S-1 / 0' - 0.333'**
DESCRIPTION:	**Poorly-graded sand w/ gravel**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**40.4**	USCS	**SP**
% SAND	**59.6**	USACOE FC	**N/A**
% SILT/CLAY	**0.0**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)		**4.9**	
COEFFICIENT OF GRADATION (C_c)		**0.6**	
ASTM D1557 (uncorrected)		**N/A**	
ASTM D4718 (corrected)		**N/A**	
OPTIMUM MOIST. CONTENT. (corrected)		**N/A**	

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

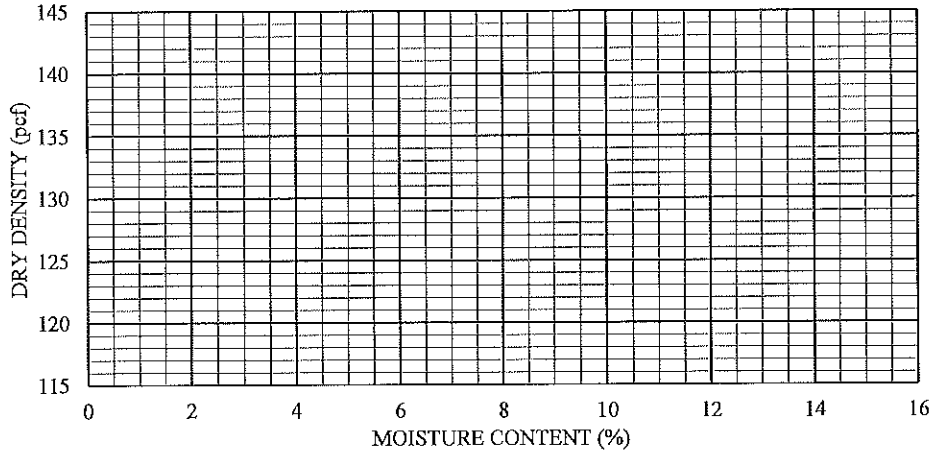
SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"	**100**	
19.00	3/4"	**80**	
12.70	1/2"	**73**	
9.50	3/8"	**70**	
4.75	#4	**60**	
2.00	#10	**36**	
0.85	#20	**6**	
0.43	#40	**2**	
0.25	#60	**0**	
0.15	#100	**0**	
0.075	#200	**0.0**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

NORTHERN GEOTECHNICAL ENGINEERING, INC. / TERRA FIRMA TESTING

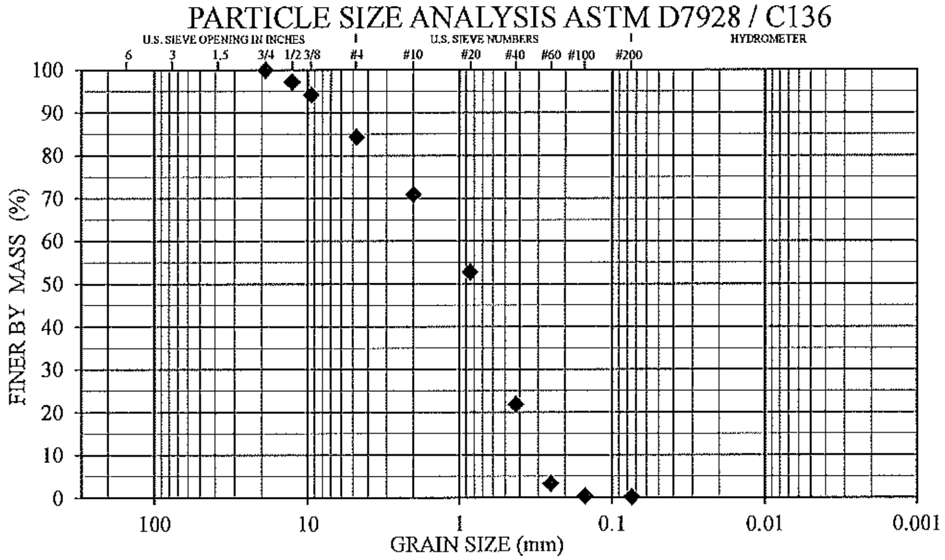
Laboratory Testing · Geotechnical Engineering · Instrumentation · Construction Monitoring Services · Thermal Analysis

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 10-1**
NUMBER/ DEPTH:	**S-1 / 0' - 0.333'**
DESCRIPTION:	**Poorly-graded sand w/ gravel**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**15.6**	USCS	**SP**
% SAND	**84.2**	USACOE FC	**N/A**
% SILT/CLAY	**0.2**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**

UNIFORMITY COEFFICIENT (C_u)	**4.2**
COEFFICIENT OF GRADATION (C_c)	**0.7**
ASTM D1557 (uncorrected)	**N/A**
ASTM D4718 (corrected)	**N/A**
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136

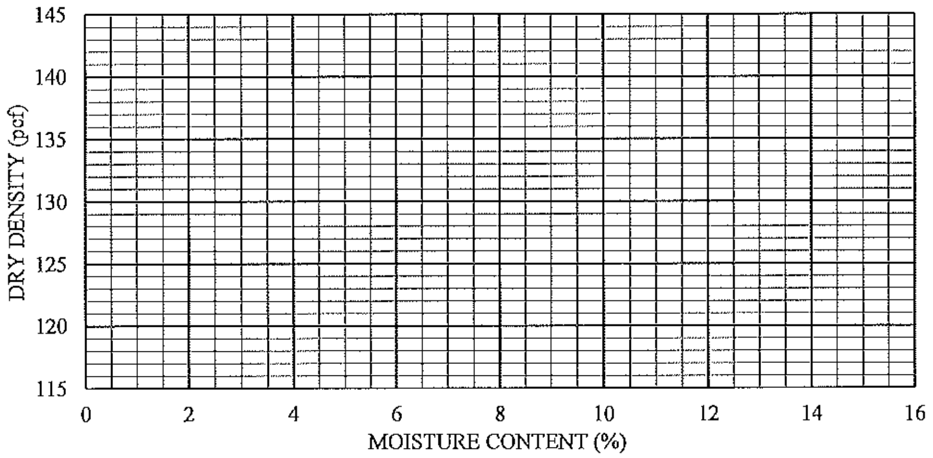


COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"		
19.00	3/4"	**100**	
12.70	1/2"	**97**	
9.50	3/8"	**94**	
4.75	#4	**84**	
2.00	#10	**71**	
0.85	#20	**53**	
0.43	#40	**22**	
0.25	#60	**3**	
0.15	#100	**0**	
0.075	#200	**0.2**	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

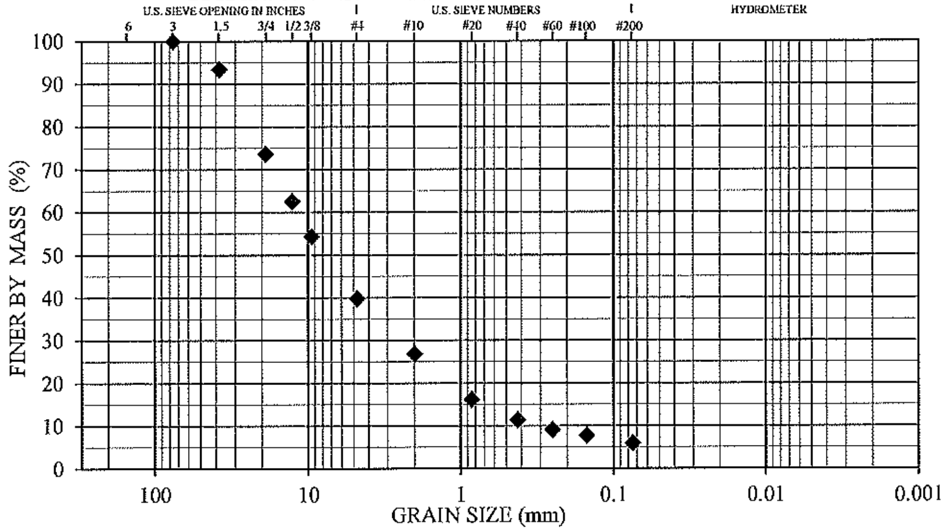
NORTHERN GEOTECHNICAL ENGINEERING, INC. / TERRA FIRMA TESTING

Laboratory Testing   Geotechnical Engineering   Instrumentation   Construction Monitoring Services   Thermal Analysis

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 10-1**
NUMBER/ DEPTH:	**S-2 / 0.667' - 1.0'**
DESCRIPTION:	**Well-graded gravel w/ silt and sand**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**60.3**	USCS	**GW-GM**
% SAND	**33.8**	USACOE FC	**N/A**
% SILT/CLAY	**5.9**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)			**36.7**
COEFFICIENT OF GRADATION (C_c)			**1.9**
ASTM D1557 (uncorrected)			**N/A**
ASTM D4718 (corrected)			**N/A**
OPTIMUM MOIST. CONTENT. (corrected)			**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136

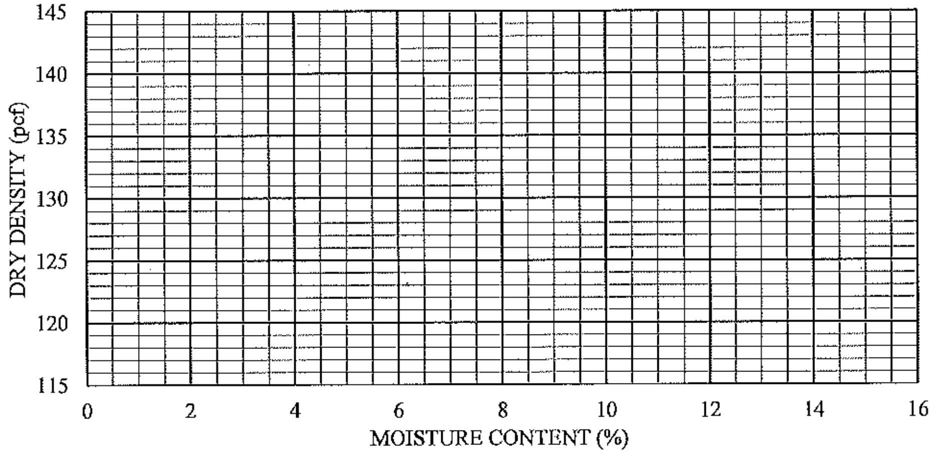


COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"	**100**	
38.10	1.5"	**93**	
19.00	3/4"	**74**	
12.70	1/2"	**63**	
9.50	3/8"	**54**	
4.75	#4	**40**	
2.00	#10	**27**	
0.85	#20	**16**	
0.43	#40	**11**	
0.25	#60	**9**	
0.15	#100	**8**	
0.075	#200	**5.9**	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

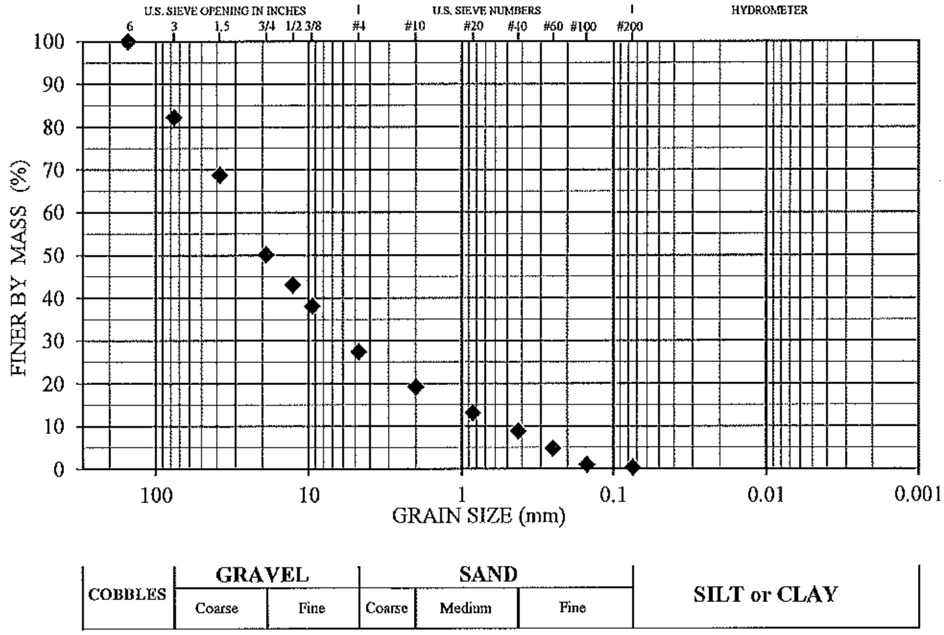
HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 11-2**
NUMBER/ DEPTH:	**S-2 / 1' - 1.333'**
DESCRIPTION:	**Well-graded gravel w/ sand**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**72.6**	USCS	**GW**
% SAND	**27.1**	USACOE FC	**N/A**
% SILT/CLAY	**0.3**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**

UNIFORMITY COEFFICIENT (C_u)	**53.7**
COEFFICIENT OF GRADATION (C_c)	**2.2**
ASTM D1557 (uncorrected)	**N/A**
ASTM D4718 (corrected)	**N/A**
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**

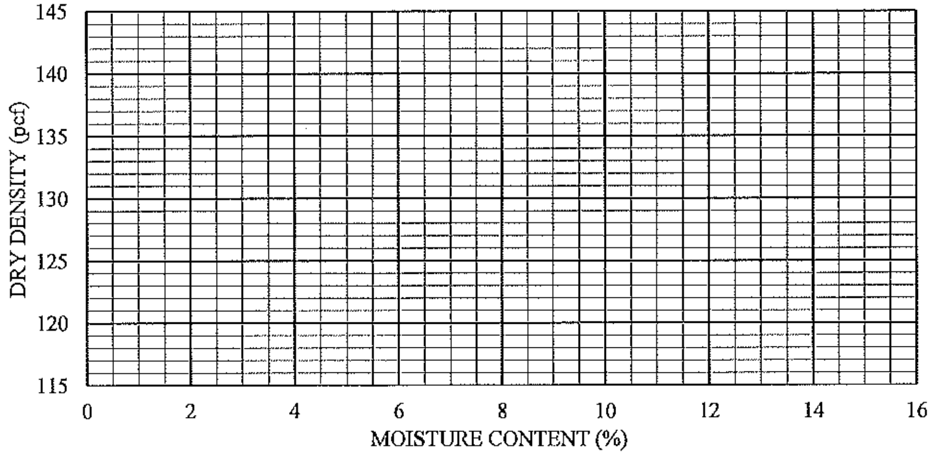
PARTICLE SIZE ANALYSIS ASTM D7928 / C136



SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"	**100**	
76.20	3"	**82**	
38.10	1.5"	**69**	
19.00	3/4"	**50**	
12.70	1/2"	**43**	
9.50	3/8"	**38**	
4.75	#4	**27**	
2.00	#10	**19**	
0.85	#20	**13**	
0.43	#40	**9**	
0.25	#60	**5**	
0.15	#100	**1**	
0.075	#200	**0.3**	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

NORTHERN GEOTECHNICAL ENGINEERING, INC. / TERRA FIRMA TESTING

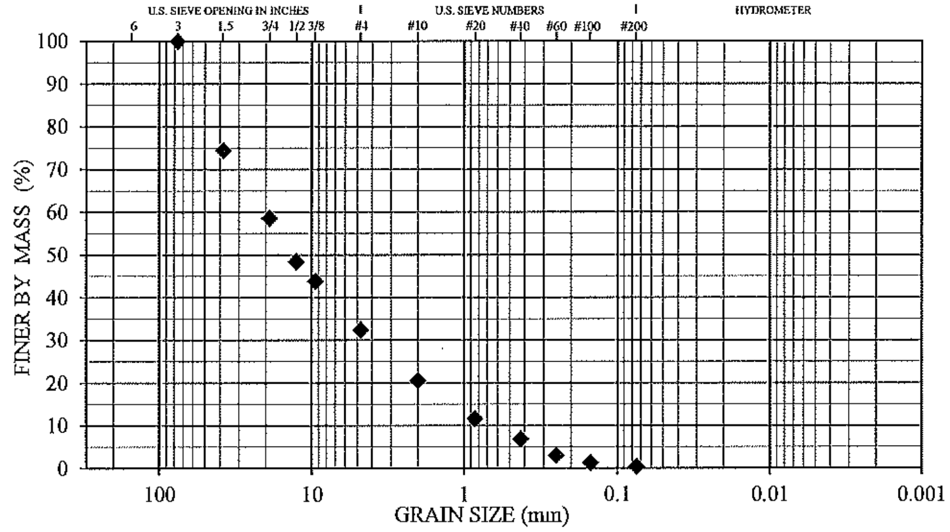
Laboratory Testing · Geotechnical Engineering · Instrumentation · Construction Monitoring Services · Thermal Analysis

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 12-1**
NUMBER/ DEPTH:	**S-2 / 0.667' - 1.0'**
DESCRIPTION:	**Well-graded gravel w/ sand**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**67.6**	USCS	**GW**
% SAND	**32.0**	USACOE FC	**N/A**
% SILT/CLAY	**0.4**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**

UNIFORMITY COEFFICIENT (C_u)	**29.4**
COEFFICIENT OF GRADATION (C_c)	**1.2**
ASTM D1557 (uncorrected)	**N/A**
ASTM D4718 (corrected)	**N/A**
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136

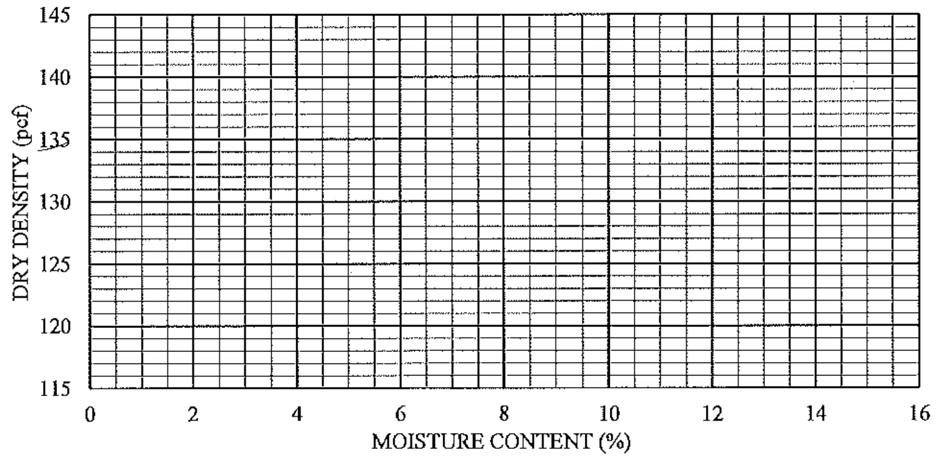


COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"	**100**	
38.10	1.5"	**74**	
19.00	3/4"	**59**	
12.70	1/2"	**48**	
9.50	3/8"	**44**	
4.75	#4	**32**	
2.00	#10	**21**	
0.85	#20	**12**	
0.43	#40	**7**	
0.25	#60	**3**	
0.15	#100	**1**	
0.075	#200	**0.4**	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

NORTHERN GEOTECHNICAL ENGINEERING, INC. / TERRA FIRMA TESTING

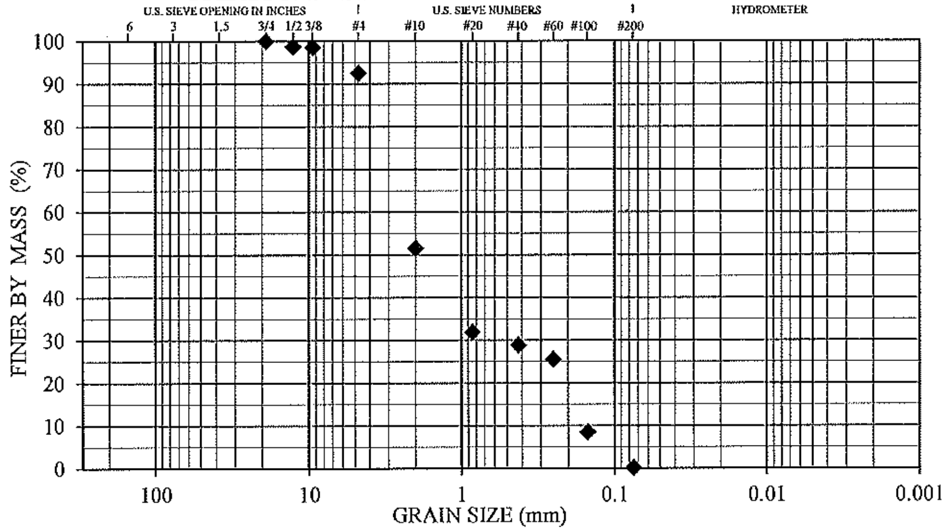
Laboratory Testing Geotechnical Engineering Instrumentation Construction Monitoring Services Thermal Analysis

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 13-1**
NUMBER/ DEPTH:	**S-1 / 0.0' - 0.333'**
DESCRIPTION:	**Poorly-graded sand**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**7.5**	USCS	**SP**
% SAND	**92.3**	USACOE FC	**N/A**
% SILT/CLAY	**0.2**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**

UNIFORMITY COEFFICIENT (C_u)	**16.2**
COEFFICIENT OF GRADATION (C_c)	**0.8**
ASTM D1557 (uncorrected)	**N/A**
ASTM D4718 (corrected)	**N/A**
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

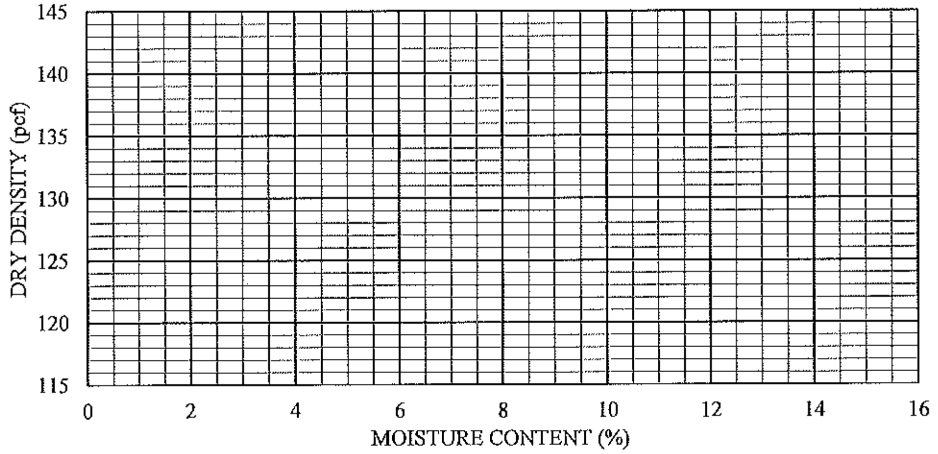
SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"		
19.00	3/4"	**100**	
12.70	1/2"	**99**	
9.50	3/8"	**99**	
4.75	#4	**93**	
2.00	#10	**52**	
0.85	#20	**32**	
0.43	#40	**29**	
0.25	#60	**26**	
0.15	#100	**9**	
0.075	#200	**0.2**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



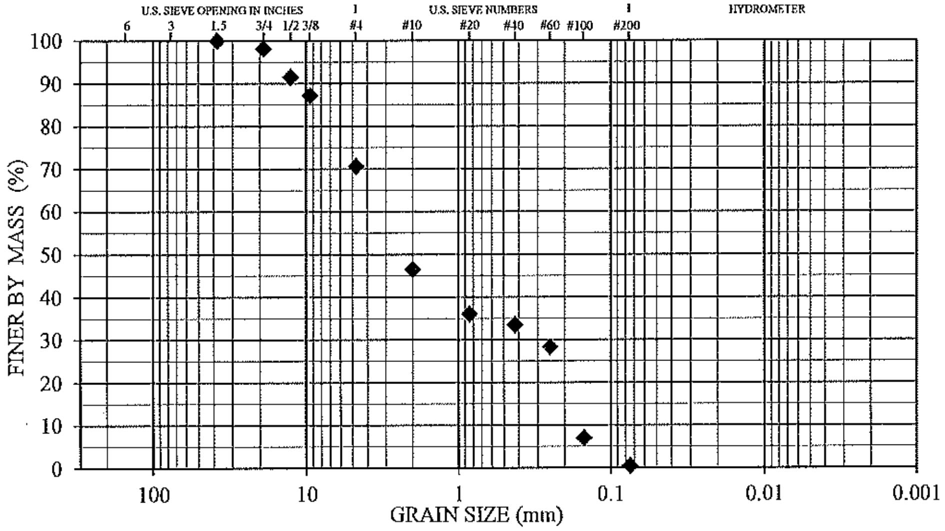
HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 13-1**
NUMBER/ DEPTH:	**S-2 / 1.5' - 1.83'**
DESCRIPTION:	**Poorly-graded sand w/ gravel**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**29.3**	USCS	**SP**
% SAND	**70.2**	USACOE FC	**N/A**
% SILT/CLAY	**0.5**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**

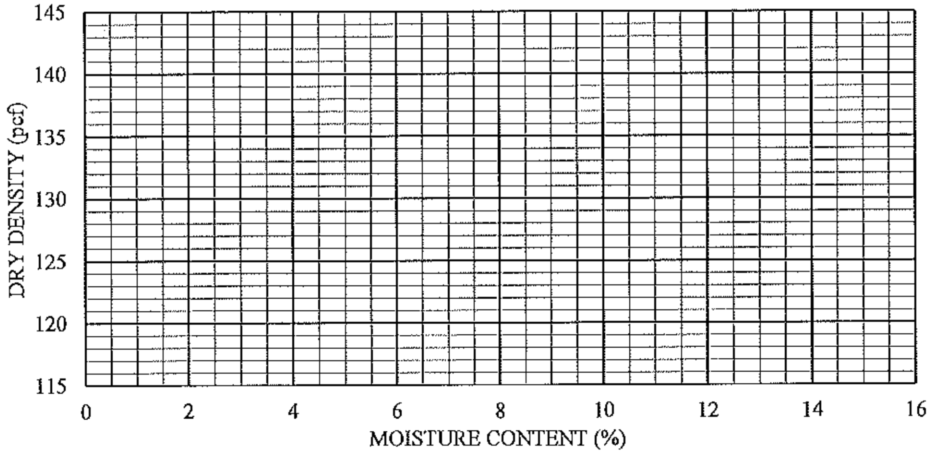
UNIFORMITY COEFFICIENT (C_u)	**21.6**
COEFFICIENT OF GRADATION (C_c)	**0.2**
ASTM D1557 (uncorrected)	**N/A**
ASTM D4718 (corrected)	**N/A**
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"	**100**	
19.00	3/4"	**98**	
12.70	1/2"	**92**	
9.50	3/8"	**87**	
4.75	#4	**71**	
2.00	#10	**46**	
0.85	#20	**36**	
0.43	#40	**33**	
0.25	#60	**28**	
0.15	#100	**7**	
0.075	#200	**0.5**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

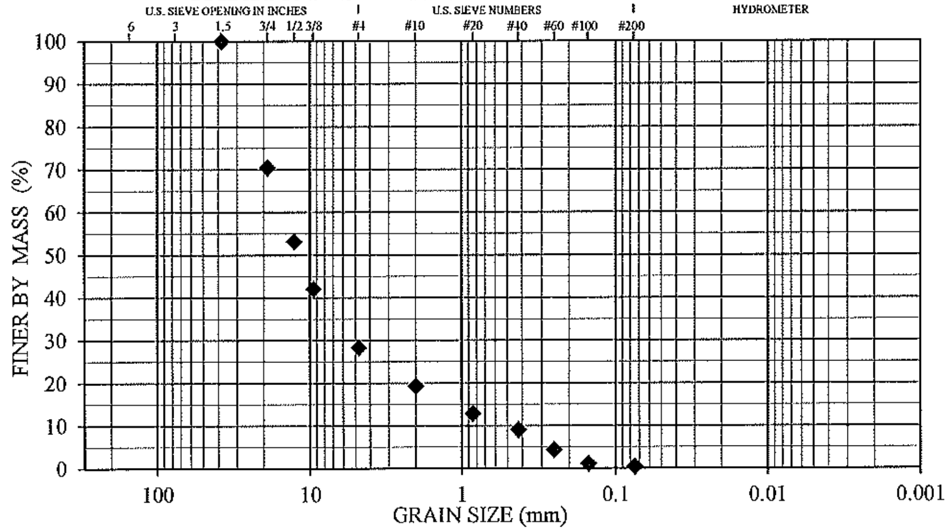
NORTHERN GEOTECHNICAL ENGINEERING, INC. / TERRA FIRMA TESTING

Laboratory Testing · Geotechnical Engineering · Instrumentation · Construction Monitoring Services · Thermal Analysis

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 13-2**
NUMBER/ DEPTH:	**S-2 / 1.5' - 1.83'**
DESCRIPTION:	**Poorly-graded gravel w/ sand**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

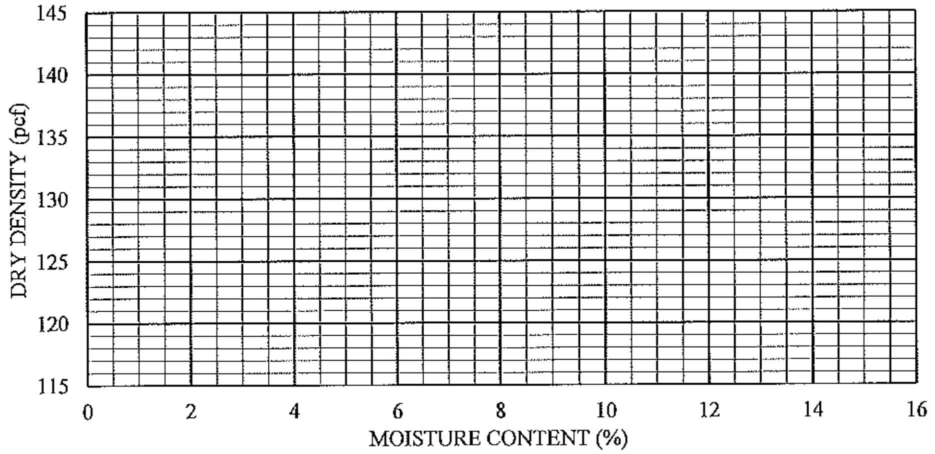
% GRAVEL	71.7	USCS	**GP**
% SAND	27.9	USACOE FC	**N/A**
% SILT/CLAY	0.4	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**
UNIFORMITY COEFFICIENT (C_u)	**28.7**		
COEFFICIENT OF GRADATION (C_c)	**3.5**		
ASTM D1557 (uncorrected)	N/A		
ASTM D4718 (corrected)	N/A		
OPTIMUM MOIST. CONTENT. (corrected)	N/A		

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"	**100**	
19.00	3/4"	**70**	
12.70	1/2"	**53**	
9.50	3/8"	**42**	
4.75	#4	**28**	
2.00	#10	**19**	
0.85	#20	**13**	
0.43	#40	**9**	
0.25	#60	**4**	
0.15	#100	**1**	
0.075	#200	**0.4**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

NORTHERN GEOTECHNICAL ENGINEERING, INC. / TERRA FIRMA TESTING

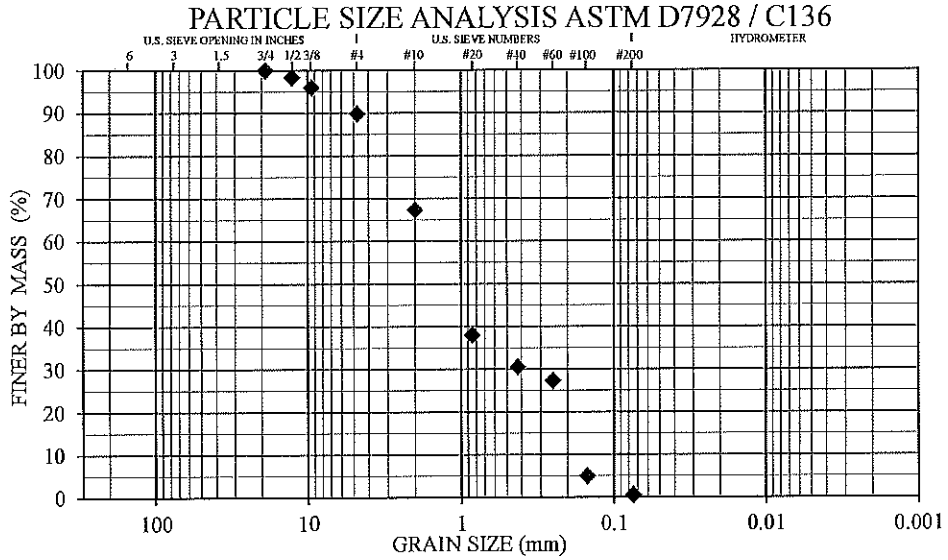
Laboratory Testing · Geotechnical Engineering · Instrumentation · Construction Monitoring Services · Thermal Analysis

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 14-1**
NUMBER/ DEPTH:	**S-1 / 0.0' - 0.5'**
DESCRIPTION:	**Poorly-graded sand**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**10.2**	USCS	**SP**
% SAND	**89.3**	USACOE FC	**N/A**
% SILT/CLAY	**0.5**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**

UNIFORMITY COEFFICIENT (C_u)	**9.9**
COEFFICIENT OF GRADATION (C_c)	**0.5**
ASTM D1557 (uncorrected)	**N/A**
ASTM D4718 (corrected)	**N/A**
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

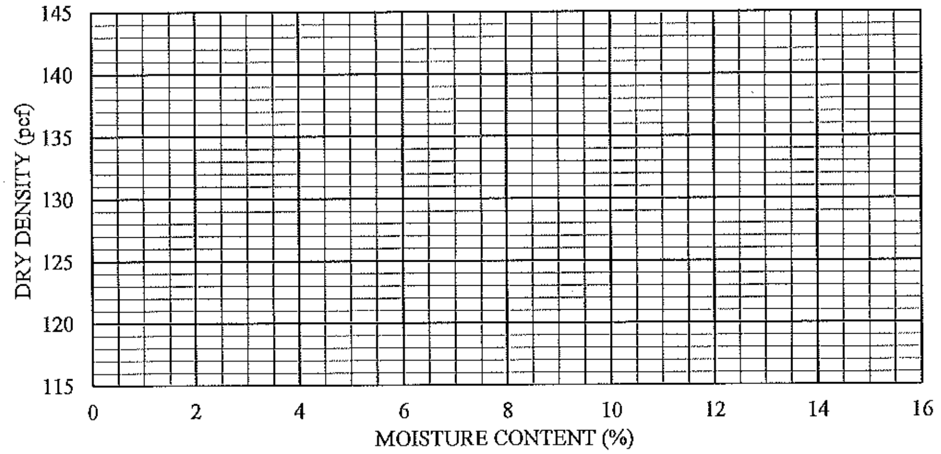
SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"		
19.00	3/4"	**100**	
12.70	1/2"	**98**	
9.50	3/8"	**96**	
4.75	#4	**90**	
2.00	#10	**67**	
0.85	#20	**38**	
0.43	#40	**31**	
0.25	#60	**27**	
0.15	#100	**5**	
0.075	#200	**0.5**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

NORTHERN GEOTECHNICAL ENGINEERING, INC. / TERRA FIRMA TESTING

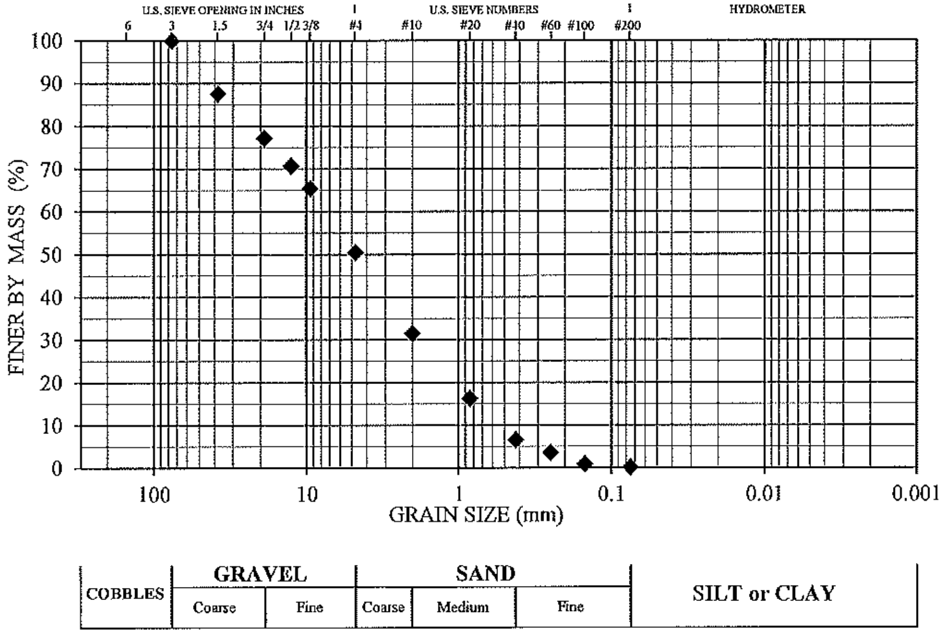
Laboratory Testing · Geotechnical Engineering · Instrumentation · Construction Monitoring Services · Thermal Analysis

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 14-1**
NUMBER/ DEPTH:	**S-2 / 1.5' - 1.83'**
DESCRIPTION:	**Poorly-graded sand w/ gravel**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**49.5**	USCS	**SP**
% SAND	**50.4**	USACOE FC	**N/A**
% SILT/CLAY	**0.1**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**

UNIFORMITY COEFFICIENT (C_u)	**13.5**
COEFFICIENT OF GRADATION (C_c)	**0.8**
ASTM D1557 (uncorrected)	**N/A**
ASTM D4718 (corrected)	**N/A**
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



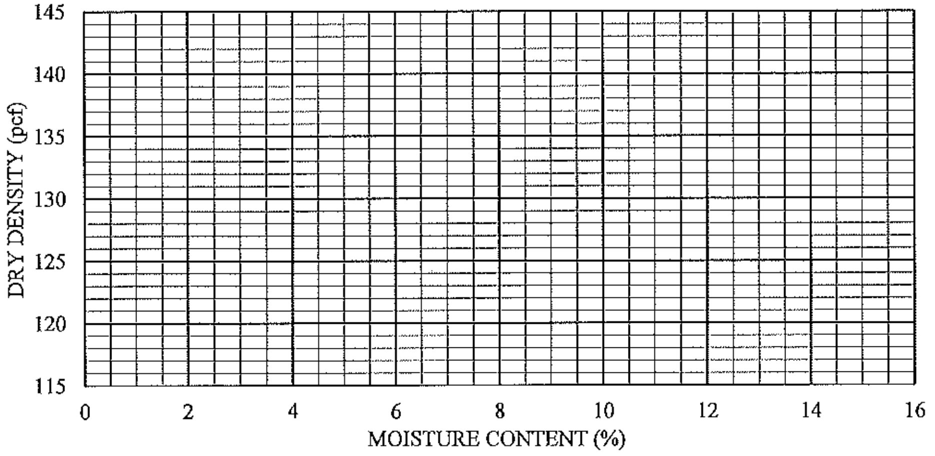
SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"	**100**	
38.10	1.5"	**88**	
19.00	3/4"	**77**	
12.70	1/2"	**71**	
9.50	3/8"	**65**	
4.75	#4	**50**	
2.00	#10	**31**	
0.85	#20	**16**	
0.43	#40	**7**	
0.25	#60	**4**	
0.15	#100	**1**	
0.075	#200	**0.1**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

NORTHERN GEOTECHNICAL ENGINEERING, INC. / TERRA FIRMA TESTING

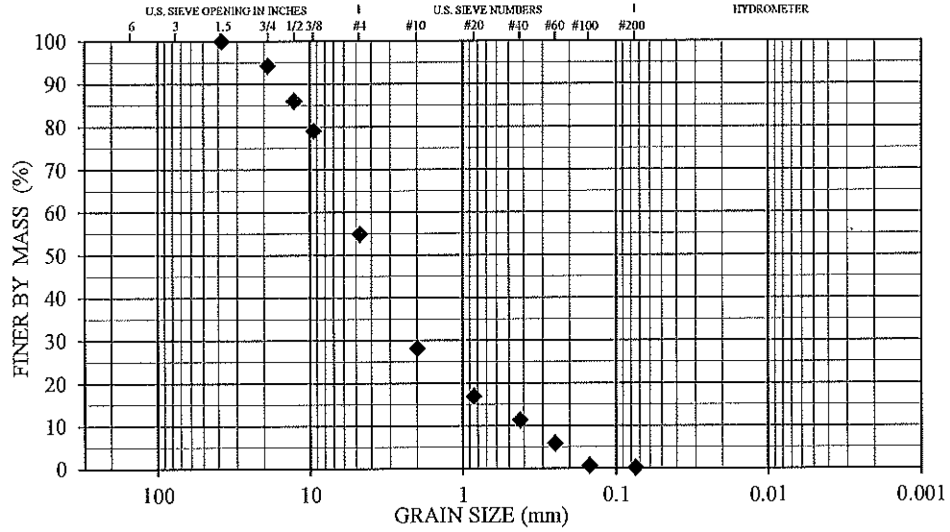
Laboratory Testing · Geotechnical Engineering · Instrumentation · Construction Monitoring Services · Thermal Analysis

PROJECT CLIENT:	**U.S. Army Corps of Engineers**
PROJECT NAME:	**Elim Small Boat Harbor**
PROJECT NO.:	**5196-18**
SAMPLE LOC.:	**Elim 14-2**
NUMBER/ DEPTH:	**S-2 / 1.5' - 1.83'**
DESCRIPTION:	**Well-graded sand w/ gravel**
DATE RECEIVED:	**11/3/2018**
TESTED BY:	**JA**
REVIEWED BY:	**RJPC**

% GRAVEL	**45.1**	USCS	**SW**
% SAND	**54.7**	USACOE FC	**N/A**
% SILT/CLAY	**0.2**	% PASS. 0.02 mm	**N/A**
% MOIST. CONTENT		% PASS. 0.002 mm	**N/A**

UNIFORMITY COEFFICIENT (C_u)	**15.1**
COEFFICIENT OF GRADATION (C_c)	**2.2**
ASTM D1557 (uncorrected)	**N/A**
ASTM D4718 (corrected)	**N/A**
OPTIMUM MOIST. CONTENT. (corrected)	**N/A**

PARTICLE SIZE ANALYSIS ASTM D7928 / C136



COBBLES	GRAVEL		SAND			SILT or CLAY
	Coarse	Fine	Coarse	Medium	Fine	

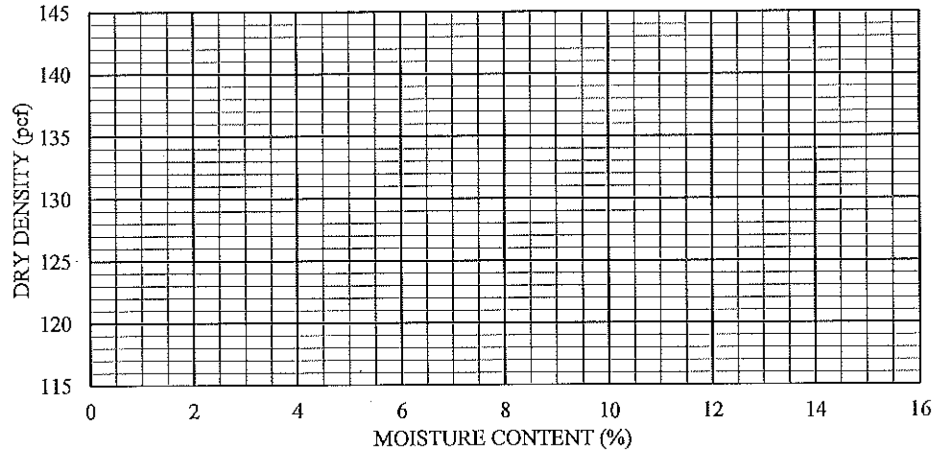
SIEVE ANALYSIS RESULT

SIEVE SIZE (mm)	SIEVE SIZE (U.S.)	TOTAL % PASSING	SPECIFICATION (% PASSING)
152.40	6"		
76.20	3"		
38.10	1.5"	**100**	
19.00	3/4"	**94**	
12.70	1/2"	**86**	
9.50	3/8"	**79**	
4.75	#4	**55**	
2.00	#10	**28**	
0.85	#20	**17**	
0.43	#40	**11**	
0.25	#60	**6**	
0.15	#100	**1**	
0.075	#200	**0.2**	

HYDROMETER RESULT

ELAPSED TIME (MIN)	DIAMETER (mm)	TOTAL % PASSING
0		
0.5		
1		
2		
4		
8		
15		
30		
60		
250		
1440		

MOISTURE-DENSITY RELATIONSHIP ASTM D1557



HYDRAULIC COND. (ASTM D2434)	
DEGRADATION (ATM T-313)	
ATTERBERG LIMITS ASTM 4318	

APPENDIX D
EXISTING GEOTECHNICAL INFORMATION

1. Engineering Geology and Soils Report Elim Airport, Brazo, G. M., & Livingston, H. R. (1986). Alaska Department of Transportation and Public Facilities.
2. Preliminary Geologic Reconnaissance Potential Rock Quarry Sites Elim, Alaska, (2000), Hattenburg & Dilley Engineering Consultant

ENGINEERING GEOLOGY & SOILS REPORT

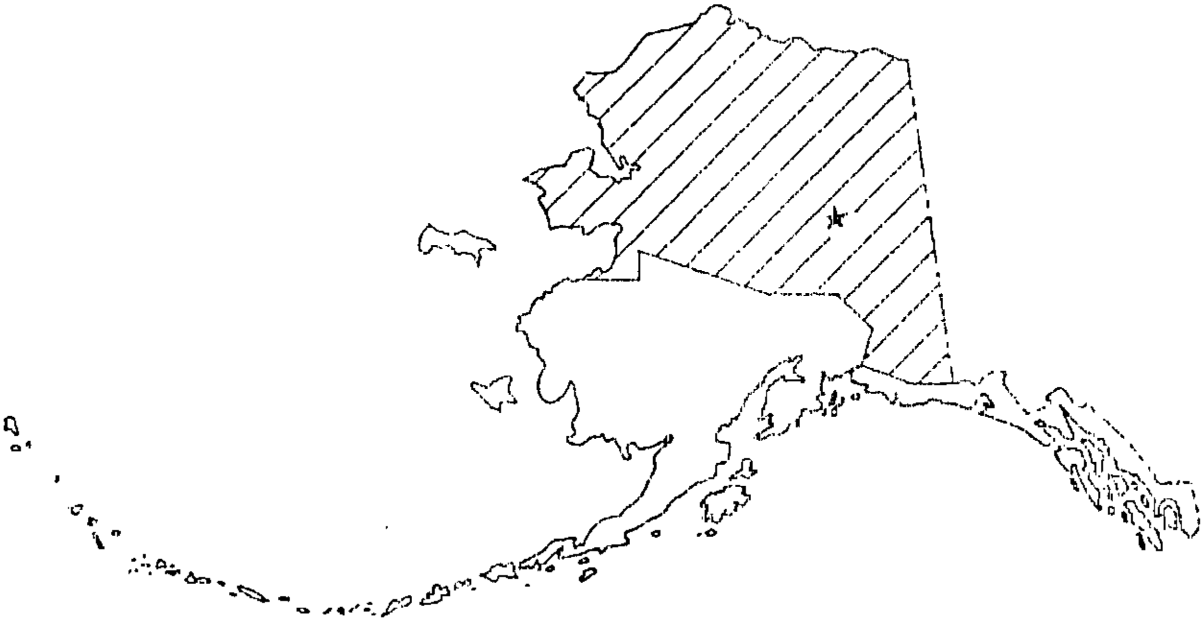
ELIM AIRPORT

CHARGE NO. 30378722
CODE NO. D11720

APRIL 1986

REVISED

Supercedes Report Dated August 1982



Prepared By

INTERIOR REGION DESIGN and CONSTRUCTION

DEPARTMENT of TRANSPORTATION and PUBLIC FACILITIES

ENGINEERING GEOLOGY AND SOILS REPORT

ELIM AIRPORT

CODE NO. D11720
CHARGE NO. 3D378722
NORTHERN REGION

APRIL 1986

PREPARED BY:

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Engineering Geologist

EDITED BY:

Harold R Livingston
HAROLD R. LIVINGSTON
Senior Engineering
Geologist

REVIEWED AND
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Chief of Geotechnical
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STATE OF ALASKA
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REGISTERED PROFESSIONAL ENGINEER

PAUL W. MISTEREK
Supervising Materials
Engineer

CONTENTS

ILLUSTRATIONS

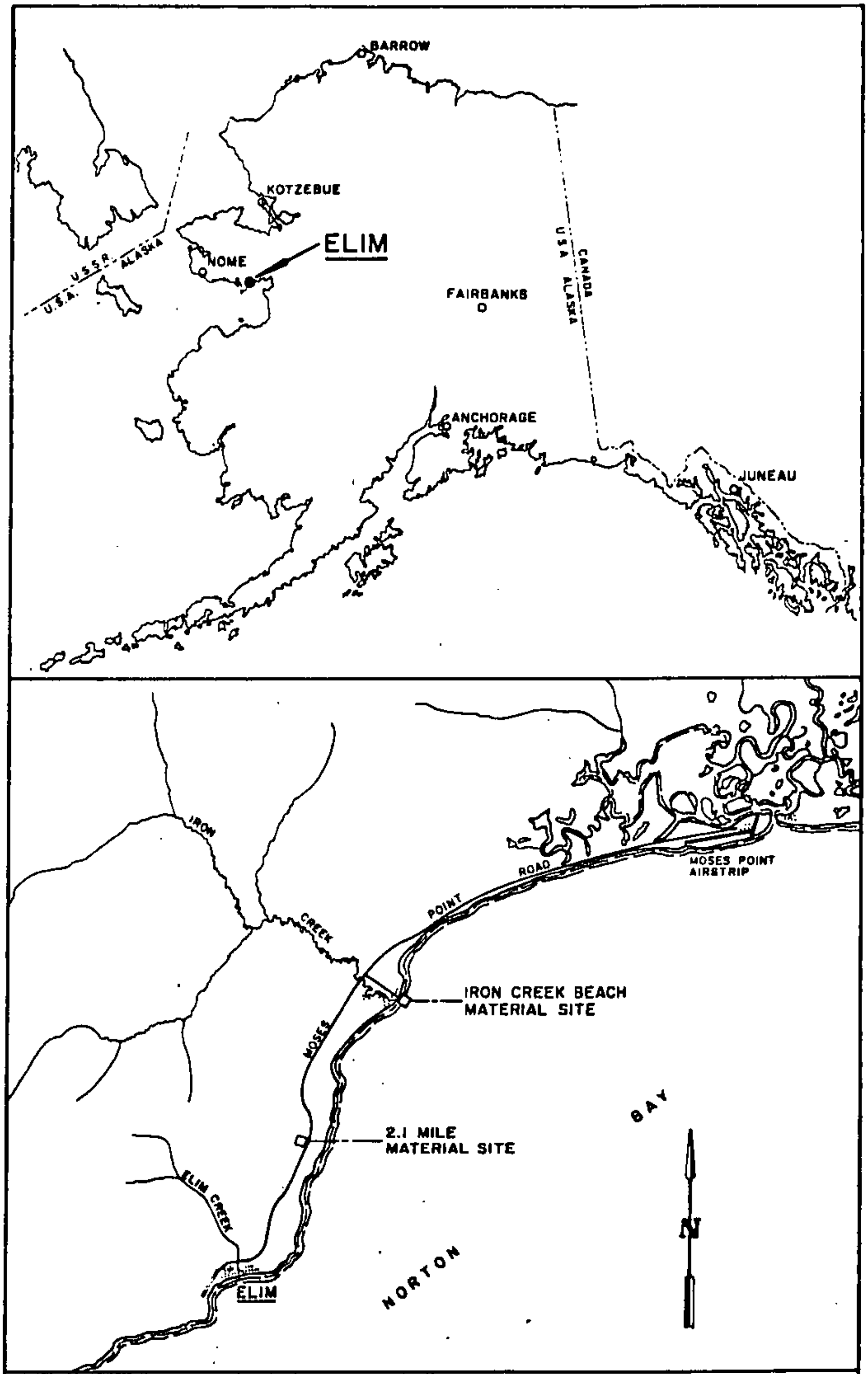


FIGURE 1

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
ENGINEERING GEOLOGY UNIT

ELIM AIRPORT

APPROVED: H.R.L	LOCATION SKETCH
DRAWN: JM	
DATE: APR 86	SCALE: NONE

ELIM AIRPORT
CHARGE NO. 30378722
CODE NO. D11720
NORTHERN REGION

INTRODUCTION

The Department of Transportation and Public Facilities (DOT&PF) proposes construction of several improvements to the Elim Airport. The improvements include:

1. Widening and lengthening the runway.
2. Improving the safety area.
3. Constructing a taxiway and apron.
4. Constructing a new access road.
5. Installing runway lighting.

At the request of the Project Manager, Cindy Little, the Engineering Geology Unit conducted a field investigation of the runway, proposed access road, and potential borrow areas. This report describes the foundation materials and conditions in the vicinity of the airport and presents design recommendations for the airport improvements.

The field investigation was conducted in two phases. The first phase was accomplished on May 13, 1982. H.R. Livingston, Senior Engineering Geologist, conducted the field investigation. He was assisted by T.A. Johnson, Driller's Helper. Cold Regions Consulting Engineers, a private contractor, provided a Prospectorpac Drill and operators, Scott Wilkes and Alan Muellerleille, to drill the test holes.

The second phase of field investigation was accomplished during October 5 - 7, 1985. This phase was conducted by G.M. Brazo, Engineering Geologist. A Mobile B-24 Drill mounted on a Raid-Trac carrier was operated by T.A. Johnson and J.M. Manthey to drill the test holes. Four-inch diameter solid-flight auger was used with the drill. Personnel and equipment were transported by a Casa 212 aircraft.

A total of 30 test holes were accomplished during both phases of field work. Twenty-one were for the runway and the balance were for the taxiway, apron, access road, and material site. All test holes were located, logged, and sampled by the geologist in the field. Samples were taken directly from the auger flight and visually identified. Several samples were transported to the Northern Region Materials Laboratory in Fairbanks for testing. Logs of the test holes and laboratory test results are included in this report.

A Bison Signal Enhancement Seismograph, Model 1570B was also used during the second phase of field work. Seismic data were recorded in the left backslope and the left ditch of the runway, and in the borrow area west of Station 23+00. The seismic phone distances were 10 to 100 feet long and were taken at 300 foot intervals, not continuously for the length of the runway. Recordings were made in two directions at each location. The recorded seismic data are included in this report.

LOCATION

Elim is an Eskimo village situated about 90 miles east of Nome along the northwest shore of Norton Bay. the airport is located about one-half mile southwest of the village and is 100 to 150 feet higher in elevation.

GEOLOGY AND TOPOGRAPHY

This project lies within the physiographic province of the Seward Peninsula. Most of the peninsula consists of extensive highlands surrounded by groups of rugged mountains. Mt. Osborn, at 4720 feet above sea level, is the peninsula's highest peak. Few other peaks rise above 3000 feet and the general surface of the peninsula is less than 2000 feet above sea level. Much of the upland area is made up of broad, convex hills and ridges separated by sharp, V-shaped valleys. Lowland basins occupy the interior while low coastal plains fringe much of the peninsula.

The upland hills form the coast in the immediate vicinity of Elim. Cliffs drop sharply from the hillsides to a rock-strewn beach north and south of the village, which is located on both sides of Elim Creek. In the vicinity of the creek mouth, the beach is several hundred yards long between the cliffs and fronts the village on the south. It is composed of gravelly and rocky material transported by the creek, by ice, and by wave and storm action on Norton Bay.

The existing runway is located on the southeast slope of a large hill composed of limestone colluvium and limestone bedrock. The colluvium blankets the slopes of the hill and overlies the bedrock.

Limestone colluvium is made up of limestone rock fragments in a silt matrix. It is the result of weathering of the bedrock and mass wasting of the resultant material, chiefly by the force of gravity. It is generally saturated (when thawed) in the 2 to 3 feet from the surface, the seasonal freeze/thaw zone.

The weathered limestone bedrock at this site varies widely in its physical characteristics. On the basis of its resistance to augering, the degree of weathering ranges from extreme (weathered so extensively that it augered like a soil), to very little (shallow auger refusal). The bedding of the limestone is very steeply inclined, and the hardness of the rock varies substantially within short distances.

Drilling data indicates frozen materials are present virtually everywhere in the vicinity of the airport.

CLIMATOLOGY

The project area is located in the Transitional Climatic Zone of Alaska. This zone is characterized by modest diurnal and annual temperature variations; and modest cloudiness, precipitation, and humidity. The following data from the Environmental Atlas of Alaska are considered to be approximately applicable to the project area:

Mean Annual Precipitation, inches	20
Mean Annual Snowfall, inches	70
Mean Annual Temperature, °F.	25
Thawing Index, degree days	2200
Freezing Index, degree days	4500
Design Freezing Index (1 year in 10), degree days	5500

The large imbalance toward freezing degree days is indicative of the rigorous subarctic climate in the project area and results in the nearly universal presence of perennially frozen soils.

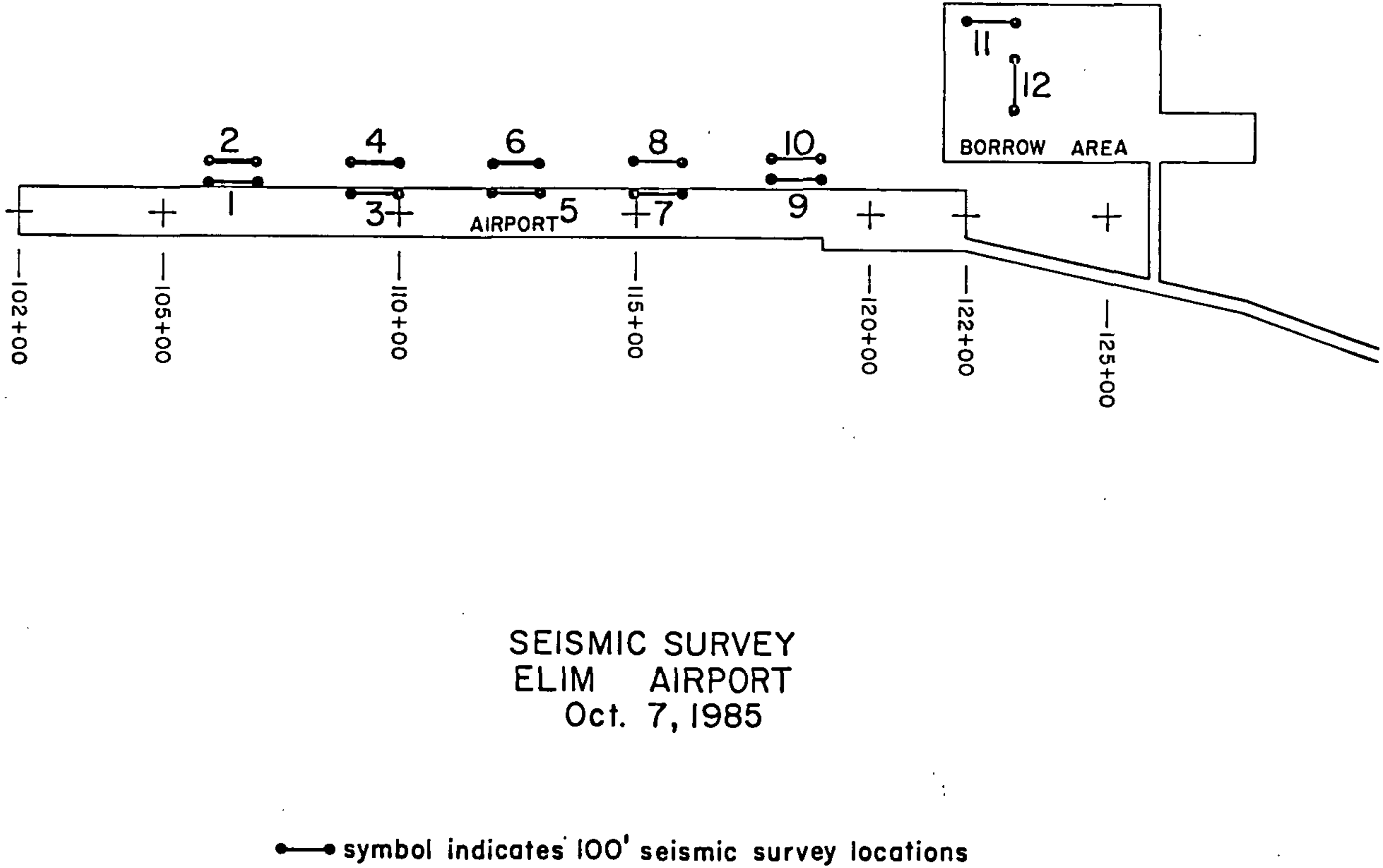
GENERAL MATERIAL SOURCES INFORMATION

Three potential borrow sources were sampled for this project:

1. Weathered limestone bedrock occurring in the vicinity of the airport.
2. Black to dark gray weathered shale bedrock occurring near Mile 2.1 on the Moses Point Road.
3. Alluvial material on the beach near Iron Creek, about Mile 4 on the Moses Point Road. This site has been extensively mined and may be depleted.

GENERAL RECOMMENDATIONS

1. Backslopes constructed in limestone colluviumn and in weathered limestone bedrock should be no steeper than 1½:1.
2. Fillslopes should not be steeper than 1½:1.
3. Handclearing should be required for all fill sections in undisturbed areas. Machine clearing by Hydro-Ax or equivalent should be acceptable only when the organic mat is frozen and will support the equipment.
4. Local silt overburden should not be used for blending because of its high organic content.
5. The weathered limestone bedrock is not recommended for crushing.
6. A 5 percent loss is recommended for quantity calculations of borrow from the weathered limestone bedrock.



SEISMIC SURVEY
ELIM AIRPORT
Oct. 7, 1985

●—● symbol indicates 100' seismic survey locations

Figure 2

SEISMIC DATA

The following data were obtained using a Bison Signal Enhancement Seismograph, Model 1570B. A sledgehammer was used to produce the seismic wave. G.M. Brazo, Engineering Geologist obtained the data on October 7, 1985.

Distance is the distance in feet between the sledgehammer and geophone. Stations and offset refer to the centerline of the existing runway. Time is noted in milliseconds.

Spread number 1: Station 106+00 to Station 107+00, 60 feet left

Distance Feet	Time A Geophone at 106+00	Time B Geophone at 107+00
0	-	22.3
10	6.0	26.9
20	13.5	26.5
30	17.5	24.5
40	17.8	20.3
50	22.0	19.0
60	20.7	15.6
70	23.5	14.7
80	22.3	9.7
90	27.7	9.0
100	27.9	-

Spread Number 2: Station 106+00 to Station 107+00, 100 feet left

Distance Feet	Time A Geophone at 106+00	Time B Geophone at 107+00
0	1.7	-
10	8.8	2.1
20	7.5	2.8
30	3.3	4.6
40	1.2	3.4
50	2.7	2.4
60	3.4	1.9
70	12.0	3.8
80	5.1	1.6
90	1.2	2.7
100	-	2.1

Spread Number 3: Station 109+00 to Station 110+00, 48 feet left

Distance Feet	Time A Geophone at 109+00	Time B Geohone at 110+00
0	-	19.7
10	2.6	18.6
20	1.5	7.8
30	5.5	3.5
40	3.5	4.7
50	0.9	14.5
60	0.9	11.4
70	1.7	7.0
80	1.7	3.0
90	0.9	4.3
100	0.6	-

Spread Number 4: Station 109+00 to Station 110+00, 105 feet left

Distance Feet	Time A Geophone at 109+00	Time B Geophone at 110+00
0	30.4	-
10	24.3	5.2
20	28.3	12.4
30	24.5	18.5
40	20.2	19.7
50	17.7	19.0
60	15.5	21.5
70	12.7	21.5
80	12.5	27.7
90	9.2	30.5
100	-	30.7

Spread Number 5: Station 112+00 to Station 113+00, 47 feet left

Distance Feet	Time A Geophone at 112+00	Time B Geophone at 113+00
0	-	21.5
10	4.8	24.5
20	8.0	21.7
30	12.0	19.7
40	12.8	17.3
50	16.2	16.5
60	18.7	14.6
70	21.9	13.9
80	23.7	9.5
90	24.9	5.8
100	25.3	-

Spread Number 6: Station 112+00 to Station 113+00, 100 feet left

Distance Feet	Time A Geophone at 112+00	Time B Geophone at 113+00
0	5.1	-
10	1.8	7.3
20	1.7	17.6
30	1.7	10.9
40	8.3	4.8
50	16.2	7.2
60	13.8	2.2
70	11.5	6.3
80	9.7	2.6
90	5.6	3.0
100	-	3.6

Spread Number 7: Station 115+00 to Station 116+00, 45 feet left

Distance Feet	Time A Geophone at 115+00	Time B Geophone at 116+00
0	-	28.3
10	5.0	24.5
20	5.0	20.3
30	13.9	23.1
40	16.9	21.9
50	10.7	18.3
60	22.5	21.8
70	27.1	19.2
80	27.5	12.2
90	31.3	7.9
100	30.7	-

Spread Number 8: Station 115+00 to Station 116+00, 110 feet left

Distance Feet	Time A Geophone at 115+00	Time B Geophone at 116+00
0	-	30.9
10	8.6	29.9
20	18.3	26.5
30	20.0	24.5
40	26.1	22.3
50	28.5	20.5
60	28.3	19.0
70	27.5	18.1
80	31.5	14.1
90	28.9	8.6
100	32.3	-

Spread Number 9: Station 118+00 to Station 119+00, 75 feet left

Distance Feet	Time A Geophone at 118+00	Time B Geophone at 119+00
0	-	23.3
10	4.8	23.3
20	9.5	20.7
30	9.8	19.9
40	13.3	19.1
50	17.5	18.6
60	17.9	16.3
70	19.4	15.2
80	23.1	15.5
90	28.7	8.4
100	28.3	-

Spread Number 10: Station 118+00 to Station 119+00, 115 feet left

Distance Feet	Time A Geophone at 118+00	Time B Geophone at 119+00
0	-	37.5
10	7.6	37.5
20	17.0	36.5
30	32.3	34.3
40	25.5	27.5
50	30.1	27.7
60	34.0	18.5
70	32.8	24.9
80	32.5	16.9
90	37.9	8.2
100	36.1	-

Spread Number 11: Station 122+00 to Station 123+00, 400 feet left

Distance Feet	Time A Geophone at 122+00	Time B Geophone at 123+00
0	-	21.1
10	1.7	17.9
20	6.3	17.7
30	7.5	16.5
40	9.1	13.5
50	13.5	13.5
60	15.7	10.5
70	17.5	5.9
80	21.3	5.9
90	21.1	3.1
100	23.1	-

Spread Number 12: Station 123+00, 220 feet left to 320 feet left

Distance Feet	Time A Geophone at 220 feet	Time B Geophone at 320 feet
0	-	9.5
10	7.1	27.0
20	13.9	28.1
30	20.5	27.5
40	23.0	26.1
50	25.4	21.9
60	29.3	21.3
70	28.9	15.5
80	28.3	12.3
90	30.5	7.1
100	32.1	-

CONVENTIONAL SYMBOLS

SIZE DEFINITIONS

+ 10"	BOULDERS
3" to 10"	COBBLES
*10 to 3"	GRAVEL
*200 to *10	SAND
MINUS *200	SILT/CLAY

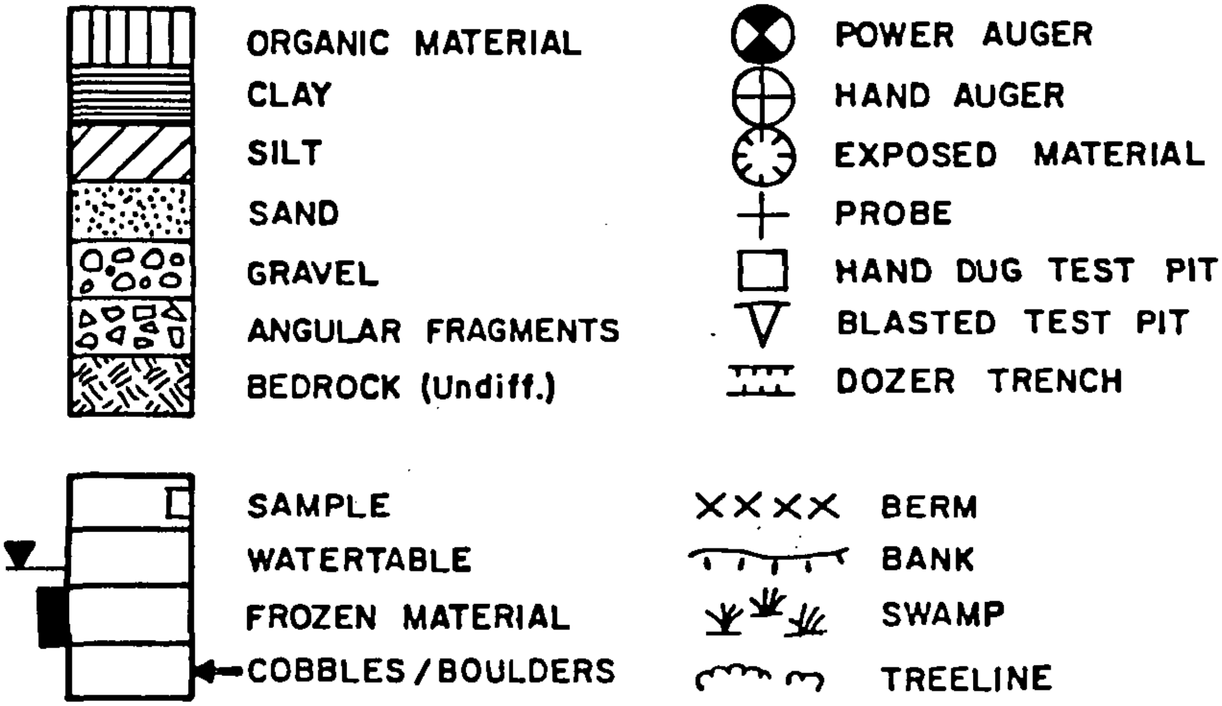


FIGURE 3

Rev. Jan. 3, 1983

ALASKA DEPARTMENT OF TRANSPORTATION TEXTURAL SOIL DESCRIPTIONS

NOTE: All silts with a plastic index > 4 shall be termed "clayey".

NOTE: Sands and gravels with 7% thru 12% silt and/or clay (#200) shall be termed slightly silty or if plastic, (P.I. > 4), slightly clayey sand or gravel.

(CLAYS...<#200)
(SILTS...<#200)
(SAND...#200 TO #10)
(GRAVEL...#10 TO 3" DIAMETER)
(COBBLES...3" TO 10" DIAMETER)
(BOULDERS...+10" DIAMETER)

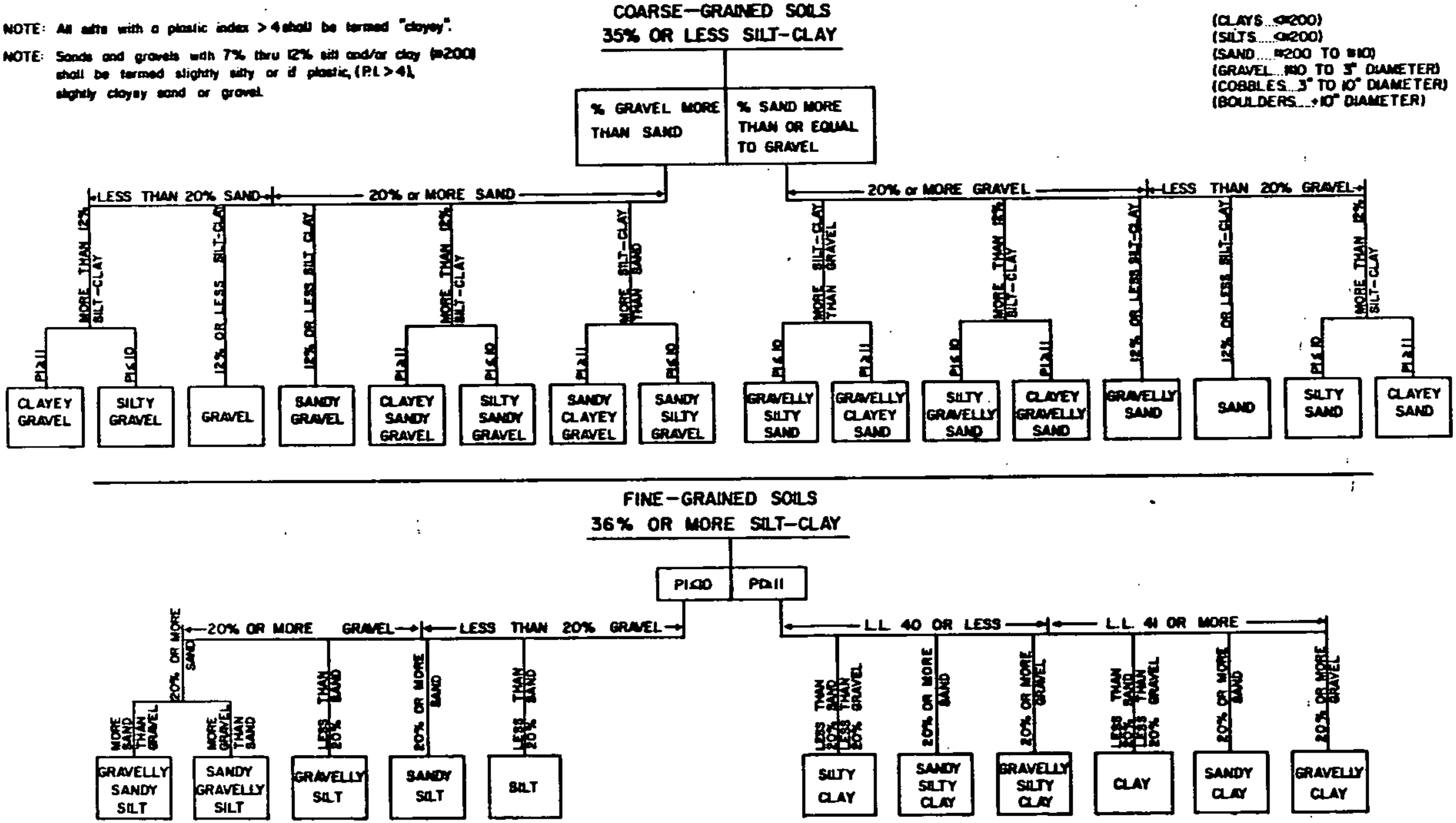


Figure 4

STATION-TO-STATION DESCRIPTION AND RECOMMENDATIONS

STATION 100+00 (B.O.P.) TO STATION 120+00

DESCRIPTION

The proposed grade in this interval is designed to add about 0.5 foot of subbase over the existing runway and to widen the runway to the left with a sidehill cut.

The existing runway rises from Station 102+00 to Station 106+00, then descends to Station 120+00. A moderate downslope is present from left to right because the original construction involved a cut on the left and a fill on the right.

Test hole data show the foundation material from Station 100+00 to Station 102+00 to consist of about 1 foot of colluvium over weathered limestone bedrock. This interval was previously cleared and has a regrowth of grass and small willows.

The foundation material from Station 109+00 to Station 120+00 includes 4.5 to 7 feet of colluvium over weathered limestone bedrock. A thin layer of topping material produced from shale bedrock was used from about Station 112+00 to Station 120+00. This material helped to maintain the trafficability of the colluvial runway surface.

The hillside left of the runway has up to 1 foot of silt and 1 to 3 feet of colluvium overlying weathered limestone bedrock. Test results show the natural moisture content of the colluvium to range from about 12 to 30 percent.

Vegetation on the runway fill and backslopes is a regrowth of grass and willow bushes up to 4 feet high.

DESIGN RECOMMENDATIONS

Based on experience with similar materials, the estimated optimum moisture for the silt and colluvium left of the runway is 10 percent. This material will be too wet for use and should be considered waste.

The weathered limestone bedrock can be used for the lower portion of the embankment if it is dry enough to compact (see Samples 85-1806 and 85-1808). Selective excavation of the weathered limestone bedrock may produce material with a P-200 of 12 percent or less. The hardness can change frequently over a short distance as the layers of steeply-dipping beds are crossed. It may be difficult to separate the harder material from the generally softer, more weathered, material. Blasting may be necessary in some of the rock. Based on a sample of the weathered limestone bedrock which had a degradation value of 16, it is not recommended that this material be used for crushing.

Provide for a minimum of one-half foot of embankment containing a maximum P-200 of 12 percent to help stabilize the subbase over the colluvium.

STATION 120+00 TO STATION 122+00

DESCRIPTION

The proposed grade in this interval is designed to cut up to 1.5 feet (at Station 121+30) of the existing runway as well as widen the runway with a sidehill cut on the left.

Test hole data indicate at least 2 feet of colluvium beneath the runway. There is up to 1 foot of silt and 2 feet of colluvium overlying weathered limestone bedrock in the left backslope.

Vegetation is as described in the previous interval.

DESIGN RECOMMENDATIONS

The colluvium from the existing runway could be used for the lower portion of the embankment if it is dry enough to compact. The silt and colluvium from the left backslope should be considered waste.

The weathered limestone bedrock should be used as described in the previous interval.

Provide for at least one-half foot of embankment with a P-200 of 12 percent or less beneath the subbase to help stabilize the subbase over the colluvial foundation material.

STATION 122+00 TO STATION 133+00 (E.O.P.)

DESCRIPTION

The proposed grade will provide a full fill section through this interval.

Test hole data indicate the foundation soils are up to 2 feet of silt overlying 6 to 7 feet of frozen colluvium. The colluvium is wet to saturated when thawed.

Vegetation consists of scattered small willows and weeds to about Station 127+00. From there to Station 133+00, moderately dense spruce trees from 3 to 6 inches in diameter are interspersed with clumps of willow and alder. Ground cover includes Labrador Tea bushes and moss.

DESIGN RECOMMENDATIONS

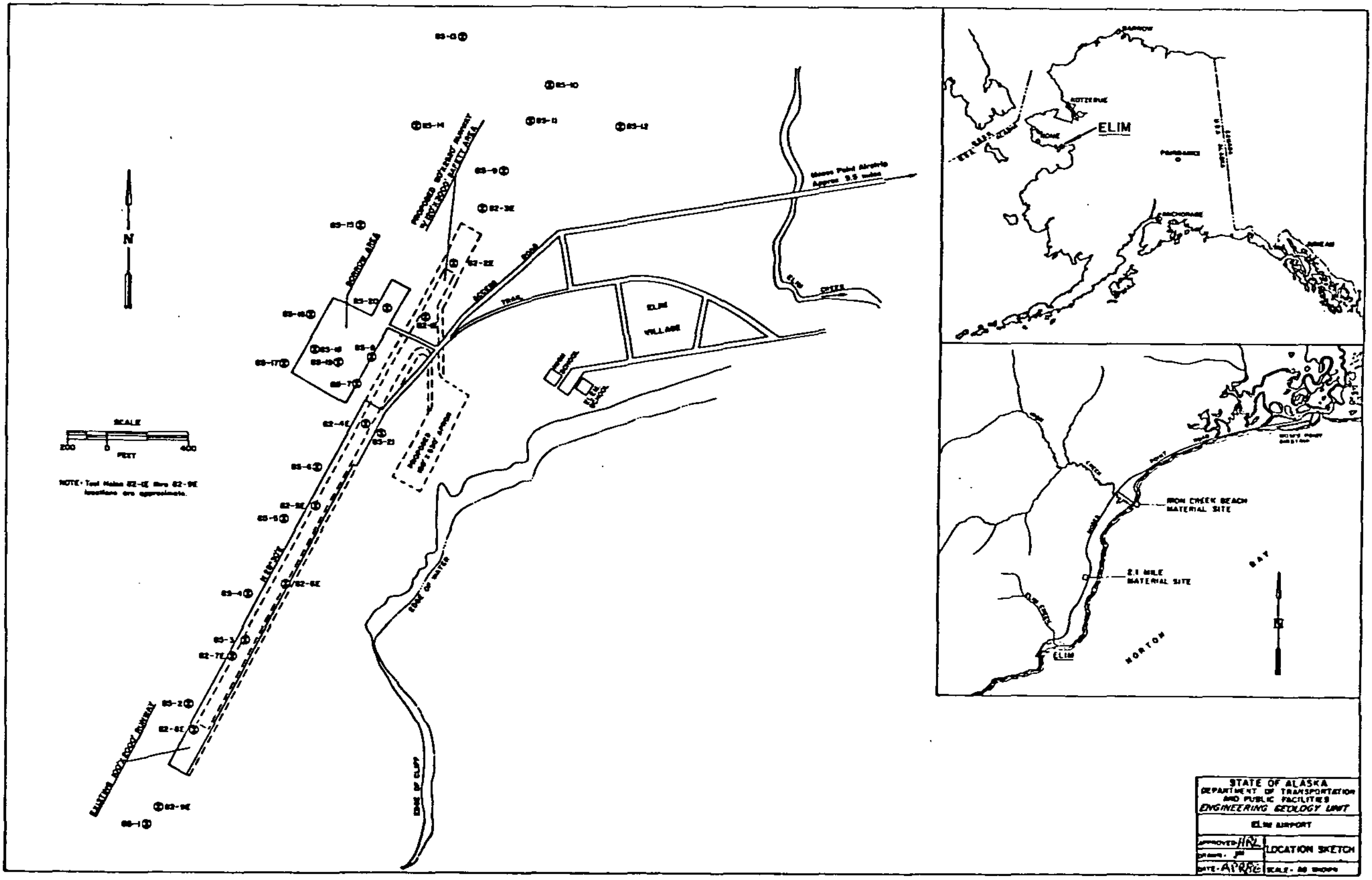
The proposed fill can be constructed of any material, free of organic material, which is sufficiently dry to be shaped and compacted. A minimum of 6 inches of material with a P-200 not greater than 12 percent should be placed beneath the surfacing material. One foot of settlement below the fill should be anticipated for quantity calculations.

APRON AREA

The proposed apron area is located right of Station 122+00 and downhill from the runway. No test holes were located in the immediate area. Data from Test Hole 85-21, located nearby, indicate the foundation soils are similar to those in the proposed runway extension area between Station 127+00 and Station 133+00. The vegetation is also similar.

DESIGN RECOMMENDATIONS

The fill for the proposed apron should be constructed of any available material, free of organic material, which is dry enough to be shaped and compacted. A minimum of 6 inches of material having a P-200 of 12 percent or less should be used as the surface layer. One foot of settlement below the fill should be anticipated for quantity calculations.


83-13
83-10
83-14
83-11
83-12
PROPOSED 60'x3000' RUNWAY & 180'x3000' SAFETY AREA
83-9
82-3E
83-15
BORROW AREA
82-2E
83-20
83-16
82-1E
83-18
83-8
83-17
83-19
83-7
82-4E
83-21
PROPOSED 150'x1100' APRON
83-6
82-5E
83-5
AIRSTRIP
82-6E
83-4
83-3
82-7E
83-2
82-8E
EXISTING 60'x2000' RUNWAY
82-9E
83-1
ROAD
TRAIL
ELIM VILLAGE
ELIM SCHOOL
EDGE OF WATER
EDGE OF CLIFF
Moses Point Airstrip Approx. 9.5 miles
ELIM CREEK
N
SCALE
200
0
400
FEET
NOTE: Test Holes 82-1E thru 82-9E locations are approximate.
BARROW
KOTZEBUE
NOME
ELIM
FAIRBANKS
ANCHORAGE
JUNEAU
IRON CREEK BEACH MATERIAL SITE
2.1 MILE MATERIAL SITE
ELIM CREEK
ROAD
NORTON
BAY
N
ELIM
STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
ENGINEERING GEOLOGY UNIT
ELIM AIRPORT
APPROVED HRL
DRAWN JM
DATE APR 86
LOCATION SKETCH
SCALE - AS SHOWN

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION
AND
PUBLIC FACILITIES

SOILS TESTING REPORT

CHECK ONE

☒ CENTERLINE PROJECT NAME & NO. Elim Airport D11720 30378722

☐ MATERIALS SITE: NO. SAMPLED BY: H. R. Livingston

STATION									
OFFSET (FEET)									
DEPTH (FEET)		2-4	1.5-6	3-6	0-4	1-2	2-3	0.5-3.5	1-4
TEST HOLE NO.		82-1E	82-2E	82-3E	82-4E	82-6E	82-7E	82-8E	82-9E
FIELD NO.		82-1519	82-1520	82-1521	82-1522	82-1523	82-1524	82-1525	82-1526
LAB NO.		82B-1519	82B-1520	82B-1521	82B-1522	82B-1523	82B-1524	82B-1525	82B-1526
DATE		13 May 82	13 May 82	13 May 82	13 May 82	13 May 82	13 May 82	13 May 82	13 May 82
ESTIMATED %+10"									
" % 3" to 10"									
PERCENT PASSING	3"								
	2"	100			100				100
	1"	98	100		98				95
	3/4"	94	96		96				94
	1/2"	86	87		93			100	91
	3/8"	76	84		91			96	89
	# 4	70	80	90	89			88	79
	#10	61	70	83	84			73	67
	#40	52	58	77	72			51	53
	#50	51	55	75	69			47	51
	#100	-	-	-	-			-	-
	#200	39	42	66	54			26	34
	.02mm	30	27		40			12	21
	.005mm	11	10		13			2	4
LIQUID LIMIT		22	38		31			NV	NV
PLASTIC INDEX		2	NP		NP			NP	NP
SOIL CLASS		GMd	GMu	ML	ML			* SMd	* SMd
SOIL DESCRIPTION		Colluvium	Colluvium	Colluvium	Colluvium	Colluvium	Colluvium	** WLB	** WLB
NAT. MOISTURE		12.2	22.3	8.6	29.2	3.8			
Sp.G. Fine		2.68	2.54						
Sp.G. Coarse									
Absorption									
Max. Density									
Opt. Moisture									
L.A. Abrasion									
Degradation									
Sult.Soundness									
Organics									

* Drill Cuttings **WLB = Weathered Limestone Bedrock

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION
AND
PUBLIC FACILITIES

SOILS TESTING REPORT

CHECK ONE

☒ CENTERLINE PROJECT NAME & NO. Elim Airport D11720 30378722

☐ MATERIALS SITE: NO. SAMPLED BY: G. M. Brazo

STATION		5+00	11+00	11+00	18+00	18+00	22+50		
OFFSET (FEET)		110 L	110 L	110 L	110 L	110 L	135 L		
DEPTH (FEET)		3-4	4-7	8-12	0.5-2	3-10	0-3		
TEST HOLE NO.		85-2	85-4	85-4	85-6	85-6	85-7		
FIELD NO.		85-1804	85-1805	85-1806	85-1807	85-1808	85-1809		
LAB NO.		85B-1804	85B-1805	85B-1806	85B-1807	85B-1808	85B-1809		
DATE		5 Oct 85	5 Oct 85	5 Oct 85	5 Oct 85	5 Oct 85	5 Oct 85		
ESTIMATED %+10"									
" % 3" to 10"									
PERCENT PASSING	3"								
	2"								
	1"	100			100	100	100		
	3/4"	98	100	100	97	99	98		
	1/2"	97	93	98	93	97	96		
	3/8"	92	89	95	86	95	96		
	# 4	77	75	84	75	84	95		
	#10	57	60	72	64	67	94		
	#40	38	39	45	49	47	93		
	#50	-	-	-	-	-	-		
	#100	30	31	34	39	35	91		
	#200	23	25	27	30	27	89		
	.02mm								
	.005mm								
LIQUID LIMIT		NV	NV	NV	NV	NV	38		
PLASTIC INDEX		NP	NP	NP	NP	NP	9		
SOIL CLASS		* SMd	*SMd	* SMd	SMd	* SMd	OL		
SOIL DESCRIPTION		** WLB	** WLB	** WLB	Colluvium	** WLB	Waste		
NAT. MOISTURE		9.7	10.7		16.3	9.8			
Sp.G. Fine				2.78					
Sp.G. Coarse									
Absorption									
Max. Density				131.0		129.4			
Opt. Moisture				7.4		9.2			
L.A. Abrasion									
Degradation									
Sult.Soundness									
Organics							12.0		

* Drill Cuttings

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION
AND
PUBLIC FACILITIES

SOILS TESTING REPORT

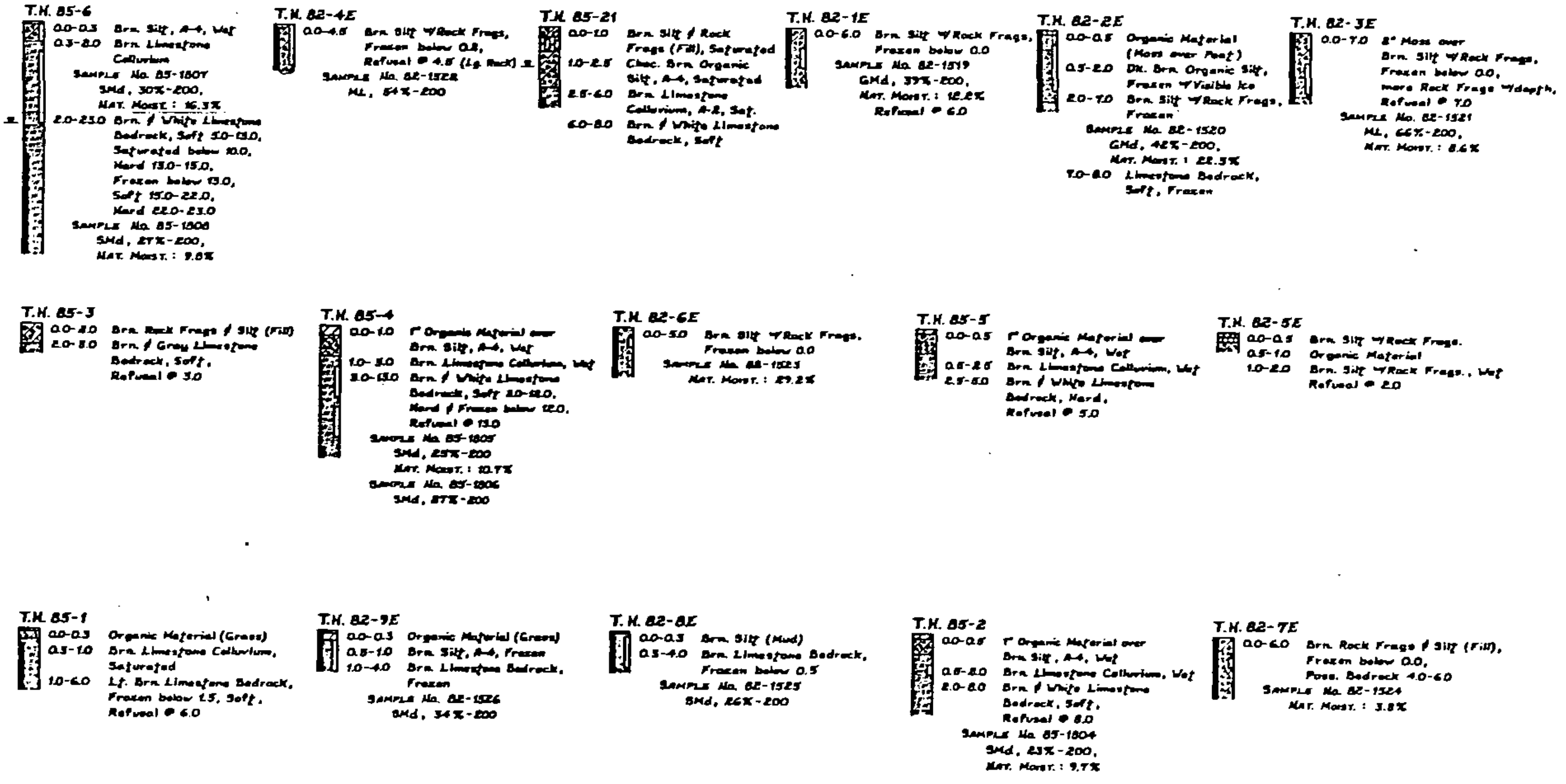
CHECK ONE

☒ CENTERLINE PROJECT NAME & NO. Elim Airport D11720 30378722

☐ MATERIALS SITE: NO. SAMPLED BY: G. M. Brazo

STATION		24+00	40+00	23+00	23+00	23+00	26+50		
OFFSET (FEET)		130 L	400 R	400 L	400 L	270 L	150 L		
DEPTH (FEET)		0-2	2-3	Grab	Grab	6-7	0-1		
TEST HOLE NO.		85-8	85-12	Near 85-18	Near 85-18	85-19	85-20		
FIELD NO.		85-1810	85-1811	85-1812	85-1813	85-1814	85-1815		
LAB NO.		85B-1810	85B-1811	85B-1812	85B-1813	85B-1814	85B-1815		
DATE		5 Oct 85	5 Oct 85	6 Oct 85	6 Oct 85	6 Oct 85	6 Oct 85		
ESTIMATED %+10"									
" % 3" to 10"									
PERCENT PASSING	3"			100					
	2"	100		91					
	1"	88	100	81					
	3/4"	88	96	77					
	1/2"	87	91	72					
	3/8"	86	89	69					
	# 4	84	86	62					
	#10	83	84	54					
	#40	82	79	44					
	#50	-	-	-			100		
	#100	80	68	36			99		
	#200	77	58	29			98		
	.02mm								
	.005mm								
LIQUID LIMIT		NV	38	NV			NV		
PLASTIC INDEX		NP	11	NP			NP		
SOIL CLASS		OL	CL	GMd			OL		
SOIL DESCRIPTION		Waste	Colluvium	** WLB	** WLB	** WLB	Org. Silt		
NAT. MOISTURE			38.5			14.6			
Sp.G. Fine				2.81					
Sp.G. Coarse									
Absorption									
Max. Density				130.0					
Opt. Moisture				9.1					
L.A. Abrasion					39A				
Degradation					16				
Sult.Soundness									
Organics		18.0					13.2		

* Drill Cuttings



T.H. 85-6
0.0-0.3 Brn. Silt, A-4, Wet
0.3-2.0 Brn. Limestone Colluvium
SAMPLE No. 85-1807
SMd, 30%-200,
NAT. MOIST.: 16.3%
2.0-23.0 Brn. & White Limestone Bedrock, Soft 5.0-13.0, Saturated below 10.0, Hard 13.0-15.0, Frozen below 13.0, Soft 15.0-22.0, Hard 22.0-23.0
SAMPLE No. 85-1808
SMd, 27%-200,
NAT. MOIST.: 9.8%

T.H. 82-4E
0.0-4.5 Brn. Silt w/Rock Frags, Frozen below 0.2, Refusal @ 4.5 (Lg. Rock)
SAMPLE No. 82-1528
ML, 54%-200

T.H. 85-21
0.0-1.0 Brn. Silt & Rock Frags (Fill), Saturated
1.0-2.5 Choc. Brn. Organic Silt, A-4, Saturated
2.5-6.0 Brn. Limestone Colluvium, A-2, Sat.
6.0-8.0 Brn. & White Limestone Bedrock, Soft

T.H. 82-1E
0.0-6.0 Brn. Silt w/Rock Frags, Frozen below 0.0
SAMPLE No. 82-1519
GMd, 39%-200,
NAT. MOIST.: 12.2%
Refusal @ 6.0

T.H. 82-2E
0.0-0.5 Organic Material (Moss over Peat)
0.5-2.0 Dk. Brn. Organic Silt, Frozen w/Visible Ice
2.0-7.0 Brn. Silt w/Rock Frags, Frozen
SAMPLE No. 82-1520
GMd, 42%-200,
NAT. MOIST.: 22.3%
7.0-8.0 Limestone Bedrock, Soft, Frozen

T.H. 82-3E
0.0-7.0 8" Moss over Brn. Silt w/Rock Frags, Frozen below 0.0, more Rock Frags w/depth, Refusal @ 7.0
SAMPLE No. 82-1521
ML, 66%-200,
NAT. MOIST.: 8.6%

T.H. 85-3
0.0-2.0 Brn. Rock Frags & Silt (Fill)
2.0-3.0 Brn. & Gray Limestone Bedrock, Soft, Refusal @ 3.0

T.H. 85-4
0.0-1.0 1" Organic Material over Brn. Silt, A-4, Wet
1.0-3.0 Brn. Limestone Colluvium, Wet
3.0-13.0 Brn. & White Limestone Bedrock, Soft 3.0-12.0, Hard & Frozen below 12.0, Refusal @ 13.0
SAMPLE No. 85-1805
SMd, 25%-200
NAT. MOIST.: 10.7%
SAMPLE No. 85-1806
SMd, 27%-200

T.H. 82-6E
0.0-5.0 Brn. Silt w/Rock Frags, Frozen below 0.0
SAMPLE No. 82-1523
NAT. MOIST.: 29.2%

T.H. 85-5
0.0-0.5 1" Organic Material over Brn. Silt, A-4, Wet
0.5-2.5 Brn. Limestone Colluvium, Wet
2.5-5.0 Brn. & White Limestone Bedrock, Hard, Refusal @ 5.0

T.H. 82-5E
0.0-0.5 Brn. Silt w/Rock Frags.
0.5-1.0 Organic Material
1.0-2.0 Brn. Silt w/Rock Frags., Wet Refusal @ 2.0

T.H. 85-1
0.0-0.3 Organic Material (Grass)
0.3-1.0 Brn. Limestone Colluvium, Saturated
1.0-6.0 Lt. Brn. Limestone Bedrock, Frozen below 1.5, Soft, Refusal @ 6.0

T.H. 82-9E
0.0-0.3 Organic Material (Grass)
0.5-1.0 Brn. Silt, A-4, Frozen
1.0-4.0 Brn. Limestone Bedrock, Frozen
SAMPLE No. 82-1526
GMd, 34%-200

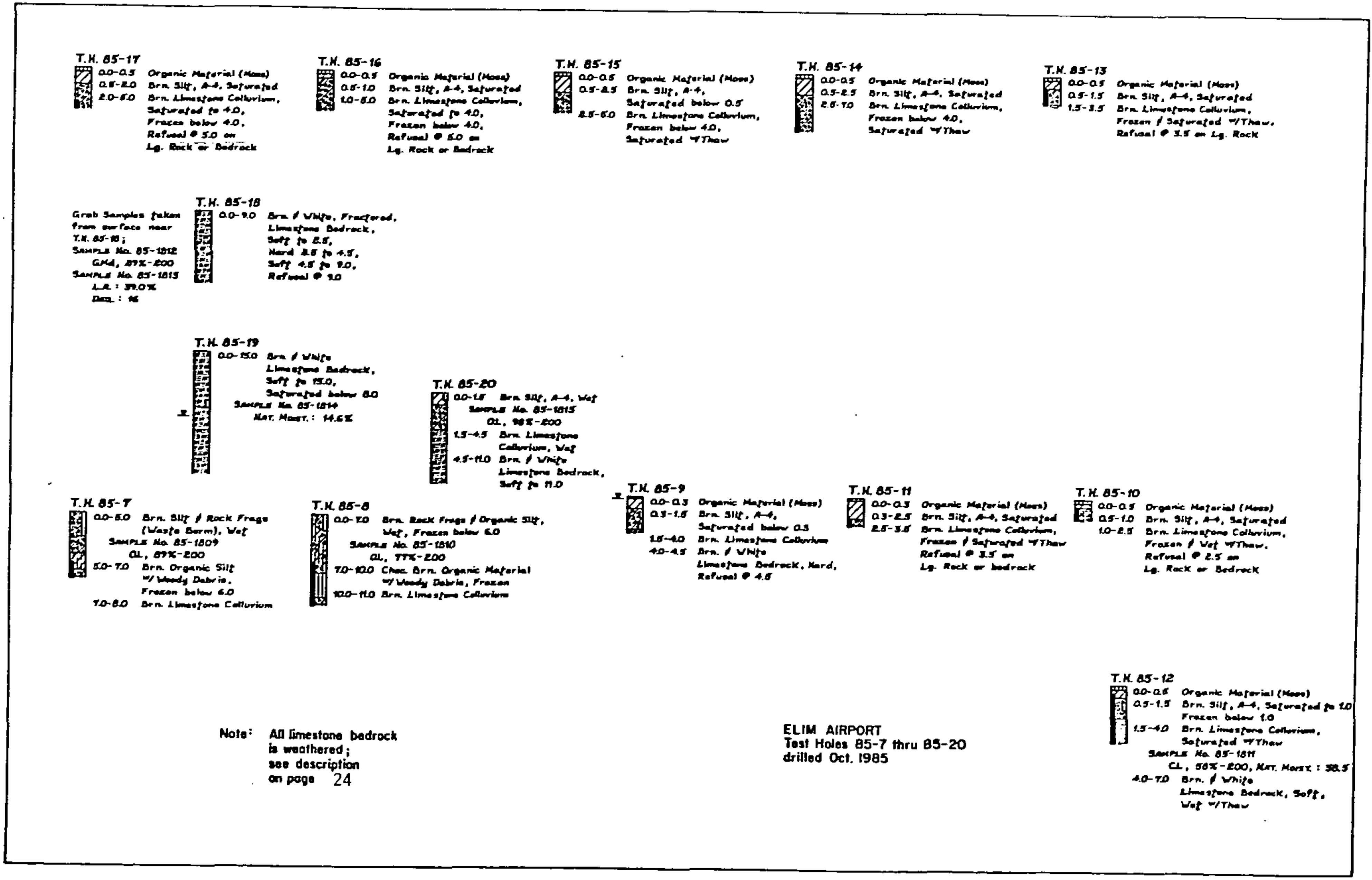
T.H. 82-8E
0.0-0.3 Brn. Silt (Mud)
0.3-4.0 Brn. Limestone Bedrock, Frozen below 0.5
SAMPLE No. 82-1525
SMd, 26%-200

T.H. 85-2
0.0-0.5 1" Organic Material over Brn. Silt, A-4, Wet
0.5-2.0 Brn. Limestone Colluvium, Wet
2.0-8.0 Brn. & White Limestone Bedrock, Soft, Refusal @ 8.0
SAMPLE No. 85-1804
SMd, 23%-200,
NAT. MOIST.: 9.7%

T.H. 82-7E
0.0-6.0 Brn. Rock Frags & Silt (Fill), Frozen below 0.0, Poss. Bedrock 4.0-6.0
SAMPLE No. 82-1524
NAT. MOIST.: 3.8%

Note: All limestone bedrock is weathered; see description on page 24

ELIM AIRPORT
Test Holes 82-1E thru 82-9E drilled May 1982
Test Holes 85-1 thru 85-21 drilled Oct. 1985



T.H. 85-17
0.0-0.5 Organic Material (Moss)
0.5-2.0 Brn. Silt, A-4, Saturated
2.0-5.0 Brn. Limestone Colluvium,
Saturated to 4.0,
Frozen below 4.0,
Refusal @ 5.0 on
Lg. Rock or Bedrock

T.H. 85-16
0.0-0.5 Organic Material (Moss)
0.5-1.0 Brn. Silt, A-4, Saturated
1.0-6.0 Brn. Limestone Colluvium,
Saturated to 4.0,
Frozen below 4.0,
Refusal @ 6.0 on
Lg. Rock or Bedrock

T.H. 85-15
0.0-0.5 Organic Material (Moss)
0.5-2.5 Brn. Silt, A-4,
Saturated below 0.5
2.5-6.0 Brn. Limestone Colluvium,
Frozen below 4.0,
Saturated w/Thaw

T.H. 85-14
0.0-0.5 Organic Material (Moss)
0.5-2.5 Brn. Silt, A-4, Saturated
2.5-7.0 Brn. Limestone Colluvium,
Frozen below 4.0,
Saturated w/Thaw

T.H. 85-13
0.0-0.5 Organic Material (Moss)
0.5-1.5 Brn. Silt, A-4, Saturated
1.5-3.5 Brn. Limestone Colluvium,
Frozen & Saturated w/Thaw,
Refusal @ 3.5 on Lg. Rock

Grab Samples taken
from surface near
T.H. 85-18;
Sample No. 85-1812
GM, 89%-200
Sample No. 85-1813
L.A.: 39.0%
Deg.: 16

T.H. 85-18
0.0-9.0 Brn. & White, Fractured,
Limestone Bedrock,
Soft to 2.5,
Hard 2.5 to 4.5,
Soft 4.5 to 9.0,
Refusal @ 9.0

T.H. 85-19
0.0-15.0 Brn. & White
Limestone Bedrock,
Soft to 15.0,
Saturated below 8.0
Sample No. 85-1814
Nat. Moist.: 14.6%

T.H. 85-20
0.0-1.5 Brn. Silt, A-4, Wet
Sample No. 85-1815
OL, 98%-200
1.5-4.5 Brn. Limestone
Colluvium, Wet
4.5-11.0 Brn. & White
Limestone Bedrock,
Soft to 11.0

T.H. 85-7
0.0-5.0 Brn. Silt & Rock Frags
(Waste Berm), Wet
Sample No. 85-1809
OL, 89%-200
5.0-7.0 Brn. Organic Silt
w/ Woody Debris,
Frozen below 6.0
7.0-8.0 Brn. Limestone Colluvium

T.H. 85-8
0.0-7.0 Brn. Rock Frags & Organic Silt,
Wet, Frozen below 6.0
Sample No. 85-1810
OL, 77%-200
7.0-10.0 Choc. Brn. Organic Material
w/ Woody Debris, Frozen
10.0-11.0 Brn. Limestone Colluvium

T.H. 85-9
0.0-0.3 Organic Material (Moss)
0.3-1.5 Brn. Silt, A-4,
Saturated below 0.3
1.5-4.0 Brn. Limestone Colluvium
4.0-4.5 Brn. & White
Limestone Bedrock, Hard,
Refusal @ 4.5

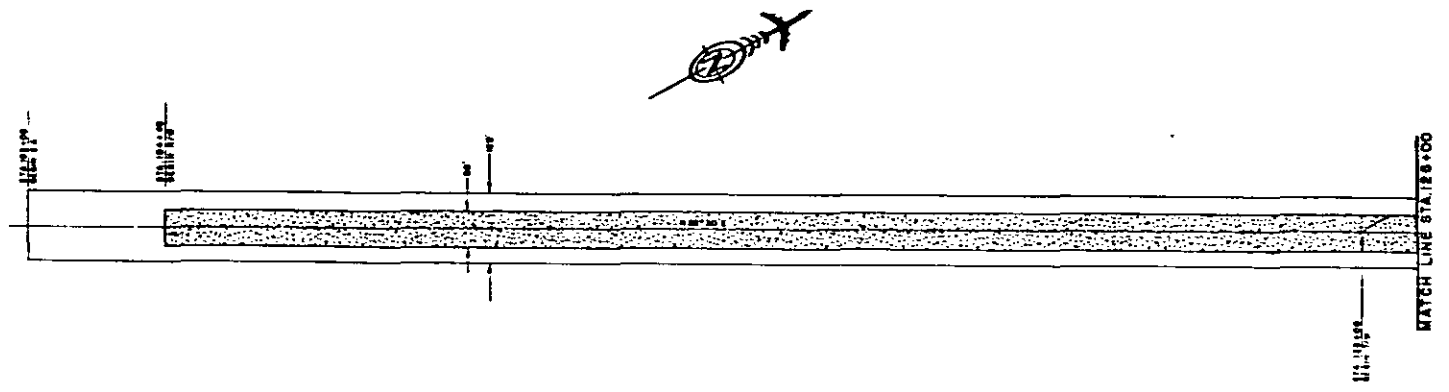
T.H. 85-11
0.0-0.3 Organic Material (Moss)
0.3-2.5 Brn. Silt, A-4, Saturated
2.5-3.5 Brn. Limestone Colluvium,
Frozen & Saturated w/Thaw
Refusal @ 3.5 on
Lg. Rock or bedrock

T.H. 85-10
0.0-0.5 Organic Material (Moss)
0.5-1.0 Brn. Silt, A-4, Saturated
1.0-2.5 Brn. Limestone Colluvium,
Frozen & Wet w/Thaw,
Refusal @ 2.5 on
Lg. Rock or Bedrock

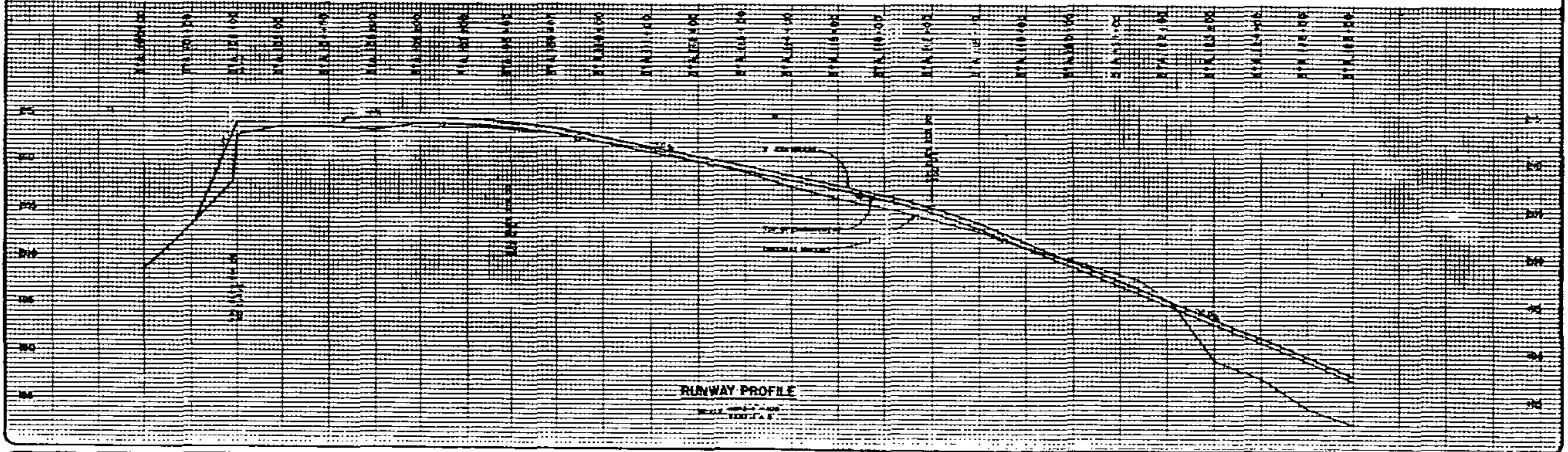
T.H. 85-12
0.0-0.5 Organic Material (Moss)
0.5-1.5 Brn. Silt, A-4, Saturated to 1.0
Frozen below 1.0
1.5-4.0 Brn. Limestone Colluvium,
Saturated w/Thaw
Sample No. 85-1811
CL, 58%-200, Nat. Moist.: 38.5
4.0-7.0 Brn. & White
Limestone Bedrock, Soft,
Wet w/Thaw

Note: All limestone bedrock
is weathered;
see description
on page 24

ELIM AIRPORT
Test Holes 85-7 thru 85-20
drilled Oct. 1985



RUNWAY PLAN



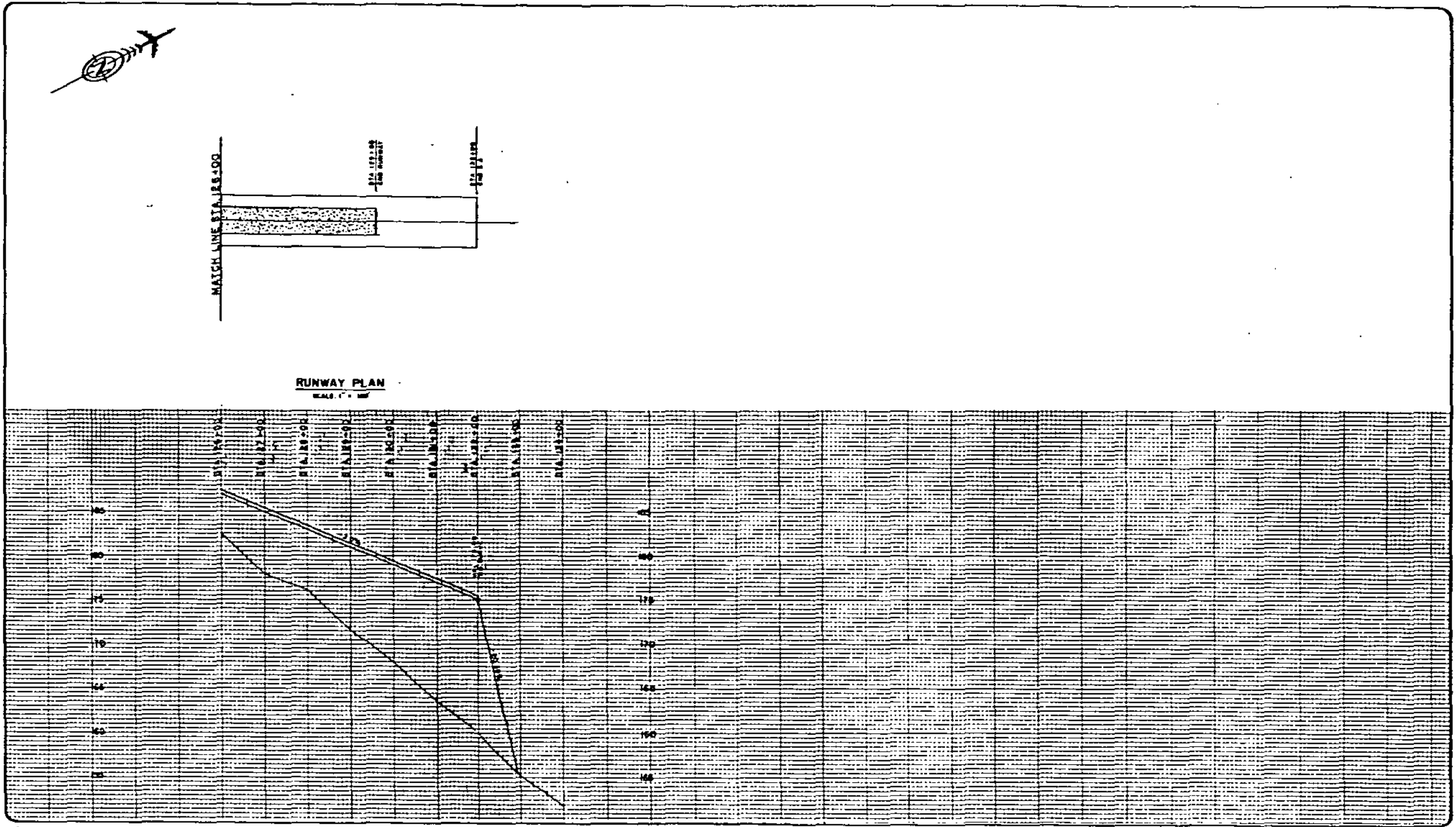
RUNWAY PROFILE

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
INTERIOR REGION - DESIGN AND CONSTRUCTION - AVIATION

APPROVED
DATE
[illegible], P.E.
REGIONAL DESIGN CHIEF

BY DATE REVISIONS

SHEET
OF



STATE OF ALASKA

DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

INTERIOR REGION - DESIGN AND CONSTRUCTION - AVIATION

APPROVED

DATE

REGIONAL DESIGN CHIEF

REVISIONS

SHEET

MATERIAL SOURCES

GENERAL

The existing runway was constructed of local materials taken from a sidehill cut left of the runway and from a small borrow site left of Station 123+00.

A thin (less than 4 inches thick) surface course of shale was added between Station 112+00 and Station 122+00 at a later time to improve trafficability. The shale came from a source at Mile 2.1 on the Moses Point Road.

ELIM AIRPORT SITE

The weathered limestone bedrock at this site varies widely in its physical characteristics. On the basis of its resistance to augering, the degree of weathering ranges from extreme (weathered so extensively that it augered like a soil), to very little (shallow auger refusal). The bedding of the limestone is very steeply inclined, and the hardness of the rock varies substantially within short distances.

A water table was present in Test Hole 85-19 at a depth of 8 feet.

The weathered limestone bedrock could be used for the lower portion of the embankment provided it is dry enough to shape and compact (see Centerline samples 85-1806, 85-1808, and 85-1812). Selective excavation may produce material with a P-200 of 12 percent or less. Because the quality and past performance of the limestone is poor and variable, it is not recommended for use in the production of crushed products (see Centerline sample 85-1813).

MILE 2.1 MOSES POINT ROAD SITE

This side-borrow site is about 1200 feet long and located on the west side of the Moses Point Road near its junction with the road to the local dump. The south half of the site has been mined to about 200 feet west of the road. The backslope was left at about 1½:1. The north half of the site has been cleared of spruce trees only.

The black to dark gray shale bedrock in this site is frost riven and highly fractured. No test holes or test pits were attempted. Wet colluvium, 2 to 4 feet thick, was exposed above the shale in the backslope.

The colluvium should be considered waste. The shale could be used for the lower portion of the embankment provided it is dry enough to shape and compact. Selective excavation may produce material with a P-200 of 12 percent or less. Material from this site was used for the recent construction of the Moses Point Road embankment.

The shale is slightly softer than the limestone of the Elim Airport Site; however, sample test data indicate it is of somewhat better quality (see samples 85-1800, 85-1801, and Centerline sample 85-1813). It may produce crushed material equal in quality to the beach deposits at Iron Creek which are discussed later in this report.

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION
AND
PUBLIC FACILITIES

SOILS TESTING REPORT

CHECK ONE

☐ CENTERLINE PROJECT NAME & NO. Elim Airport D11720 30378722

☒ MATERIALS SITE: NO. SAMPLED BY: H.R.Livingston & G.M.Brazo

STATION		Mile 2.1	Mile 2.1	Iron Cr.	Iron Cr.	Iron Cr.	Iron Cr.	Iron Cr.	
OFFSET (FEET)		Moses Pt.	Moses Pt.	Beach Site	Beach Site	Beach Site	Beach Site	Beach Site	
DEPTH (FEET)		Road	Road	0-1	0-1	0-1	0-1	0-1	
TEST HOLE NO.		Grab	Grab	Grab	Grab	Grab	Grab	Grab	
FIELD NO.		85-1800	85-1801	82-1527	82-1528	82-1529	85-1802	85-1803	
LAB NO.		85B-1800	85B-1801	82B-1527	82B-1528	82B-1529	85B-1802	85B-1803	
DATE		5 Oct 85	5 Oct 85	13 May 82	13 May 82	13 May 82	5 Oct 85	5 Oct 85	
ESTIMATED %+10"									
" % 3" to 10"			6					4	
PERCENT PASSING	3"	100	100	100	100		100	100	
	2"	90	86	95	91	100	98	93	
	1"	63	67	71	79	87	83	77	
	3/4"	52	60	59	72	78	72	67	
	1/2"	43	52	47	59	64	57	53	
	3/8"	38	48	39	51	54	48	43	
	# 4	32	42	21	35	34	34	30	
	#10	28	38	18	23	20	26	20	
	#40	26	33	6	6	6	14	8	
	#50	-	-	4	4	4	-	-	
	#100	24	30	-	-	-	8	3	
	#200	20	24	2	2	1	6	2	
	.02mm								
	.005mm								
LIQUID LIMIT		NV	NV	NV	NV	NV	NV	NV	
PLASTIC INDEX		NP	NP	NP	NP	NP	NP	NP	
SOIL CLASS		GMd	GMd	GW	GW	GW	GW-GMd	GP	
SOIL DESCRIPTION		Shale	Shale	SaGr	SaGr	SaGr	SaGr	Gravel	
NAT. MOISTURE			13.7						
Sp.G. Fine				2.69	2.63	2.71			
Sp.G. Coarse									
Absorption				0.01	0.01	0.01			
Max. Density				137.8					
Opt. Moisture				4.5					
L.A. Abrasion		45A	47A	42			46A	42A	
Degradation		29		31			21		
Sult.Soundness									
Organics									

* Drill Cuttings

REFERENCES

Hartman, C.W., and Johnson, P.R., 1978, Environmental Atlas of Alaska, University of Alaska, Institute of Water Resources, 95 p.

Staff, 1983, Geotechnical Procedures Manual, Division of Standards and Technical Services, Materials Section, Alaska Department of Transportation and Public Facilities, Anchorage, Alaska, 58 p.

_____, 1983, General Contract Provisions and Construction Specifications for Airports, Alaska Department of Transportation and Public Facilities.

PRELIMINARY GEOLOGIC RECONNAISSANCE
POTENTIAL ROCK QUARRY SITES
ELIM, ALASKA

November 2000

Prepared for:
City of Elim
PO Box 39009
Elim, Alaska 99739

HATTENBURG & DILLEY
Engineering Consultants
3151 E. 64th
Anchorage, Alaska 99507

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PRELIMINARY GEOLOGIC RECONNAISSANCE POTENTIAL ROCK QUARRY SITES ELIM, ALASKA

INTRODUCTION

This report presents the results of our preliminary geologic reconnaissance of potential rock quarry sites located near Elim, Alaska. The purpose of this study was to evaluate the rocks in the area for potential uses and to provide recommendations for future development. This was a reconnaissance level study: more detail, site-specific studies at select locations are recommended before development of a particular site. Included in this report is a description of the study area, literature reviewed, the geology, field study, results of laboratory testing, and our recommendations about the materials encountered and for future work.

Authorization to proceed with this work was received from Mr. Luther Nagaruk of the City of Elim on August 28, 2000. Our work was conducted in general accordance with our proposal dated June 29, 2000.

SITE AND PROJECT DESCRIPTION

Elim is located on the Seward Peninsula approximately 90 miles east of Nome (Figure 1) along the north shore of Norton Sound. The study area encompasses approximately 160 square miles and extends south along the Darby Peninsula to Kalc Point, northeast to Moses Point and north and west to Kwiniuk River. The study area is bounded by the limits of the native corporation land.

As can be seen in Figure 1 and the photographs in Appendix A, the topography of the study area is rugged with rolling hills, and steep cliffs that form the coastline. The relief in the study area is approximately 2,075 feet with Haystack Mountain the highest point in the area. Vegetation consisted mainly of spruce trees with alder and willow located near riverbanks and tundra located at higher altitudes. Outcrops of the bedrock primarily occurred along the coasts and at the top of hills.

Observation of the study area was confined to the coastline, the Hot Springs trail, and the road to Moses Point. Limited access to the area consisted of two 4-wheeler trails and by boat along the coast. A two-lane, gravel road follows the coast from Elim, east to Moses Point.

LITERATURE REVIEW

Four reports were reviewed prior to the field study. The reports are listed in the reference section. These reports included three US Geological Survey (USGS) reports and one Alaska Department of Transportation (ADOT) report. A preliminary geologic map of a part of the Solomon Quadrangle and topographic maps for the area formed the basis for Figure 1. The other two USGS reports were a surficial geologic map and a report on the Bluff area. Although the Bluff area report is from outside the study area, reference is made to various rocks in the study area. Several additional reports have been written on the economic geology in the area, however these reports did not contain relevant data on potential quarry/borrow sources. The ADOT report was an engineering geology and soils report on the Elim Airport.

FIELD STUDY

The field study was conducted from September 6 to 9, 2000. Two major traverses were conducted to observe the geology and potential quarry sites; one by four wheelers on the trail to a hot springs, and the second by boat along the shoreline. The road to Moses Point was also driven. These traverses are shown on Figure 1.

Geology was observed and samples collected at each of the stops made during the traverses (Figure 1). Stops were made based on outcrop location, type of bedrock encountered, and access. Sample collection consisted of obtaining large pieces of the various rock types observed, as well as collecting gravel and smaller size beach sediment encountered at stops along the boat traverse and at Moses Point beach. Seven samples were collected with sample sizes ranging from about 20 pounds to about 45 pounds of rock and sediment.

The Hot Springs trail is approximately 8 to 9 miles long and occurs northwest of Elim and ends at a hot springs located on the northwest bank of the Kwiniuk River. Five stops were conducted on this traverse. The boat traverse was approximately 15 miles long in one direction, and consisted of six stops along the coastline from Elim to Kalc Point. A stop at the current borrow site along the road to Moses Point was made (Stop 1 in Figure 1), as well as observing the beach sediments at Moses Point.

GEOLOGY

The geology, from the literature and field observations, consists of three main rock types, granite, marble, and black schist, as well as sand and gravel sediment. The geologic units shown on Figure 1 consists of granitic rock, white, gray or black marble, graphite schist/black marble, and sand and gravel. Granite is Cretaceous in age and the marble ranges from Precambrian to Devonian in age. The black schist was not observed in the field, however it is shown on the preliminary geologic map. It is considered the same age as the older marble (Precambrian). Some of the material observed from the boat, along the coastline, appeared to be black marble was mapped on the USGS preliminary geologic map as graphite schist.

The granitic rock is located primarily in the western part of the study area and south to and including Darby Point. The granite outcropped to the west of a small tributary of Kwiniuk River along the Hot Springs trail and continued to occur to the main part of the river. Granite torrs (spires) occurred to the west and south along many of the hilltops in this area (Photograph 1, Appendix A). South of Portage Bay, granite outcrops were encountered along the coastline.

Based on the USGS map and observations, this granitic material consists of several rock types including migmitites, quartz monzonites, aplites, quartz latites, and granodiorites. Essentially all of these rock types are granitic in nature except for migmitites, which are cut by numerous granitic type rock bodies. The migmitites are generally mapped along the western edge of the study area. Engineering properties of the rock types are generally the same. These rocks are hard, weather resistant, and have high shear and compression strengths.

The granitic rock was primarily white and black, with large crystals of white and pink potassium feldspars. The large feldspars were up to an inch in length. The minerals that composed the granite were primarily quartz, potassium feldspars, and lesser amounts of biotite, calcium feldspars, and amphiboles. Photograph 2 in Appendix A shows the typical texture of the granitic material. It was generally medium to coarse-grained except for areas of finer-grained material that occurred along the coastline, particularly near the contact with marble. The finer-grained material still had minerals large enough to observed with the naked eye and usually did not contain pink potassium feldspars. Microfractures were not observed in the granitic rocks, however the large crystals of potassium feldspars may create areas of preferential weathering along the mineral boundaries.

Along the coastline, the granite was massive and created large boulders as rubble along the beaches and headland coasts (Photograph 3, Appendix A). At Kalc Point, the jointing appeared pervasive and occurred at angles of between 50 to 80 degrees with the horizontal. Large blocks of between 4 to 10 feet in diameter appeared to be common in the granite outcrops. The granite encountered along the Hot Springs trail was highly weathered due to its location along the top of the hills and vegetation growing on it. Weathering depths in granite are typically on the order of a few feet. At depth, the granite is probably massive.

Marble occurred along the coastline from Elim to just north of Portage Bay. In addition, marble occurred at Stop 1 along the road to Moses Point. Approximately the first six miles of the hot springs trail crossed the marble. As shown in Figure 1, some of what was considered marble in the field was preliminary mapped by the USGS as graphite/black schist with schistose marble. The predominantly white to gray marble is shown on Figure 1 by the red stripe area.

Away from the coastline, the marble weathered to form barren gray-colored hills as shown in Photograph 5 in Appendix A. A thick vein, about 20 feet wide of white quartz was encountered about one mile east of a small tributary of Kwiniuk River within the black marble/schist material. The black marble was thinly bedded (schistose texture) in some outcrops and more massive in others (Photograph 6, Appendix A). The thin beds were generally less than a few inches thick. It was softer than the white and gray marble, and in one locality contained fossils. Along the coastline, the white to gray marble was blocky to massive in size and joint sets were about 3 to 6 feet apart. Photographs 7 and 8 in Appendix A show the typical white marble coastline.

The white, gray to black marble is chiefly white to gray, massive, crystalline limestone, marble and dolomite. Marble is limestone that has been subjected to high temperatures. Dolomite is a limestone that contains magnesium as well as calcium. It is difficult to distinguish between these three rock types without detailed chemical analysis; therefore, it is referred to herein as marble. In general, the engineering properties of these rock types are similar. The marble is soft, typically can be carved with a knife, moderately weather resistant, and has moderate shear and compressive strengths.

The schist material is interbedded with and intimately associated with the black marble. According to the USGS preliminary mapping, it contains quartz, muscovite and graphite as well as calcium rich minerals. It is thinly bedded, black, and soft, similar to the black marble observed in the field. It is believed, due to contacts between the marble and schist observed by the USGS in other parts of Darby Mountains, that the schists underlie the marble.

Sand and gravel is shown on Figure 1 as yellow striped areas, and primarily occurred along river valleys and beaches. Moses Point beach is composed of sand and gravel due to its location at the mouth of Kwiniuk River. The sand and gravel was composed primarily of granitic material with up to about 30 percent gray marble particles. This is due to the more weather resistant nature of the granitic material and that the Kwiniuk River primarily drains the granitic material as oppose to the marble. Some of the granitic beaches along the coastline were composed of pebble size, rounded particles of granite. These beaches primarily occurred as small coves within the granitic cliffs. At larger beaches such as Portage Bay, sand was the predominant particle size. Along the marble beaches, sand and gravel size particles were about evenly split. The marble gravel was generally thin in one dimension and elliptical in shape.

LABORATORY TESTING

Laboratory tests conducted on the field samples included LA Abrasion, Sodium Sulfate Soundness tests, degradation, specific gravity, and grain size analyses. Alaska test methods T-13, AASHTO T-96, AASHTO T-104 were used to conduct these tests. Not all tests were conducted on all the samples. Seven samples were collected: three granite, two marble, and two sand and gravel. The granite and marble rock samples were combined into two samples, one granite and one marble in order to average the results of the testing. Moses Point sand was tested as a separate sample. Appendix B presents the laboratory testing reports. The following is a summary of the laboratory results.

TESTS		REQUIRED SPEC	GRANITE	MARBLE	MOSES POINT SAND
LA Abrasion Loss		<45%	47%	39%	31%
Sulfate Soundness		<6%	<1.0%	<2.0%	<1%
Degradation Value		>45	75	9	41
Specific Gravity		none	2.65	2.67	2.85
Grain Size		none			SW

The above results are discussed in the conclusion section of each of the specific material type. In general, the test results are what were anticipated from the field observations. The specific gravity results are typical of the material tested.

CONCLUSIONS

The development of a quarry/borrow site should consider geologic/engineering factors such as quality of the material, the size of the source, the type of construction material that can be developed from the source, and other factors. Economic and social factors should also be considered in the development of a site. These factors include but are not limited to the market for the material, competition, the infrastructure needed, the labor pool, fuel needs, environmental factors and other considerations. In general, the source material that was studied would provide several types of quality construction materials, however, the market, competition and the infrastructure needs may outweigh the quality of the source and should be seriously considered prior to future development. The scope of the following recommendations is primarily on the geologic/engineering factors of the studied material, but the market and infrastructure needs will be discussed in relation to the source development.

Granitic Material

With the vast quantity of granitic material, various quarry sites could be developed based on the market needs and where the quarry needs to be located. In general, the granite body extends from the coastline north for approximately 18 to 20 miles to the land boundary. The coastline may be the easiest place to develop a quarry so that there is easy access to transportation.

When considering the development of a quarry, the size of material that can be created either through drill and blasting or by rock cutting should be of primary importance. Riprap (large blocks of rock) could be created from the coastline granite particularly at Kalc Point. Blocks up to 10 feet in diameter were commonly observed in the cliffs and boulders along the coast were easily this size. It is unknown how the joints continue into the granite. If the joints die out into the body, then sizes may depend more upon on the quarry is developed as oppose to geological controls. The granite would in general be durable and weather resistant. The large crystals of feldspars may create areas of preferential weathering, however this was not observed in the field.

Aggregate for road, airport construction could be made from other areas along the coast particularly those areas with finer spacing of fractures within the granite. Depending upon the size of the aggregate need, beach sand and gravel could be used. Based on the laboratory results, the granite should make suitable aggregate. The LA abrasion loss tests were slightly out of specifications (47 percent to 45 percent), however, this may be due to the inclusion of the highly weathered granite from the Hot Springs trail area. The degradation values indicate that the granite would hold up well for use as aggregate.

Building stones may also be developed from this material. This would involve cutting of blocks and depending upon the need, polishing. Granite is hard and generally requires the use of diamond cutting blades. Polishing takes a longer time than with other rocks primarily due to its hardness. The pink, white and black granite with the large crystals would be particularly suited to this use.

Marble Material

Marble occurs along the coastline and north for about 12 to 15 miles. A majority of this material may include schist and be unusable. The white and gray marble is the more usable. Marble is softer and weathers faster than the granite, and although large blocks up to about 6 feet in diameter may be created, it should not be used as riprap material. Riprap is generally used as erosion protection. Photograph 8 shows how the marble weathers and it can be seen that the surf has eroded the marble. The granite has weathered into large boulders and the boulders are still intact. Marble and limestone may be used as building stones or aggregate. Since the marble is soft, it is easy to carve and cut into needed sizes. Also once polished the white and gray marble may be quite attractive. The black marble that is thinly bedded should be avoided for any type of use. It is soft and the thin beds would make material possible crumble and become unusable. The more massive black marble could be used, however, it may fall apart easier than the white and gray marble and care should be taken if developing this material.

Aggregate can be created from the marble such as at the borrow location at Stop 1 on the road to Moses Point. The aggregate may be softer and of small size as oppose to the granitic aggregate. The laboratory analyses indicate that the marble has very low degradation values but good LA abrasion loss numbers. The degradation value indicates how the marble would hold up to weather and erosion. If the marble was used as an aggregate, it would most likely become soft with time and will not be as durable as the granite.

Sand and Gravel Material

The vast quantities of sand at Portage Bay beach and Moses Point would provide valuable resources of aggregate. In addition, the numerous beaches could be developed for aggregate. The laboratory analyses of the sand and gravel indicated that the sand and gravel at Moses Point was a well graded sand. The sample had less than one percent fines. Material that contains less than about six percent fines is considered non-frost susceptible. The sand and gravel could be mixed with the marble for specific projects requiring more fines. The material in general would be suitable for aggregate use as a subbase or base course for roads.

Infrastructure Needs

A quarry/borrow source located along the coastline would require an infrastructure to support the operation. This infrastructure would include a dock facility for loading and unloading of equipment and the material; crushing and sorting facilities; facilities for personnel; and roads. Typical costs for dock facilities alone in western Alaska are from 2 to 5 million dollars. In addition to these facilities, power sources will be required for some of the equipment especially if crushing and sorting facilities are located at the site.

Quarry/borrow sources located within the hills along the hot springs trail would still require some infrastructure. Currently, the trail is only open to four wheelers, if a quarry/borrow source was developed along this trail, it would have to be upgraded for large haulers. Dock facilities may still be required to move the material out of Elim, as well as specialized equipment for the quarry/borrow source.

Development of quarry/borrow source along Moses Point road would reduce the road building costs however, moving the material out of Elim or Moses Point via a dock would still be needed. Specialized equipment may also be needed depending upon what type of source is developed.

Recommendations

The granite and marble sources have excellent potential for development of riprap, aggregate or building stones. Marble would not provide the best material for riprap however, it would be easier to work than the granite for building stones. The sand and gravel that is available at Moses Point and along the beach areas provide an excellent source for aggregate. The fine content of these materials is less than one percent, which may require the material to be mixed with finer material generated from the marble sources depending upon the use.

Although the rock and sediments observe would make excellent quarry/borrow sources, infrastructure needs and market demand may seriously impede the development of any of these sources. The aggregate sources of sand and gravel at Moses Point may provide the easiest way to develop a borrow source, however dock facilities would still be needed.

Prior to development of any of the sources on a large scale, we recommend that additional site-specific studies be conducted. Detailed studies of a specific area should be conducted in order to evaluate the full size of the potential site, and the quality of the material within the site. Depth of the rock material should be investigated, by drilling to evaluate the quality of the material, fracture patterns, and where the base of the material is located. In addition to these studies, economic, social and environmental issues should be considered prior to development.

LIMITATIONS

This report presents the results of our preliminary reconnaissance level study of potential quarry/borrow sources. No subsurface data was collected and the scope of work was broad in extent. As such, this report should not be construed as providing definitive information at any particular site, but rather provides a general overview of the material quality in the study area.

Recommendations provided in this report were based on observed rocks and sediments at specific locations during the field study. If a substantial amount of time passes between development of a quarry/borrow source and the issuance of this report, our recommendations should be reviewed.

We appreciate the opportunity of working with you on this project. If you have any questions, regarding the contents of this report, please do not hesitate to contact me at your convenience.

HATTENBURG & DILLEY, LLC

Lorie M. Dilley 11/10/00

Lorie M. Dilley, P.E., C.P.G.
Principal Geologist

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Alaska Department of Transportation and Public Facilities, Engineering Geology and Soils Report, Elim Airport, Project No. D-11711, August 1982.

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Kaufman, D.S., Surficial Geologic Map of the Solomon, Bendeleben, and Southern Part of the Kotzebue Quadrangles, Western Alaska, US Geological Survey, Miscellaneous Field Studies Map, 1986.

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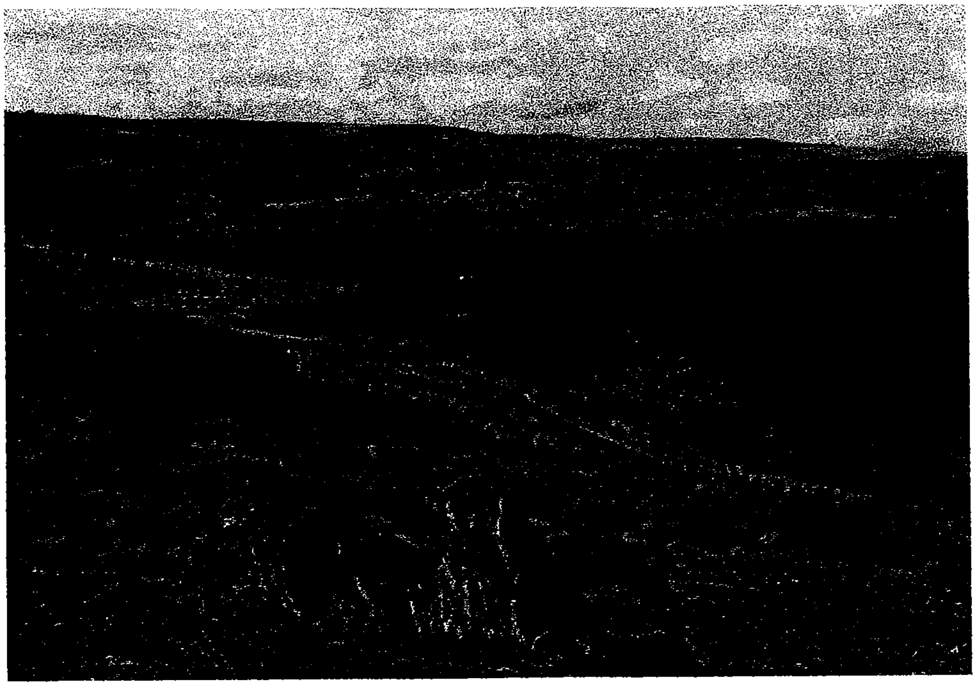
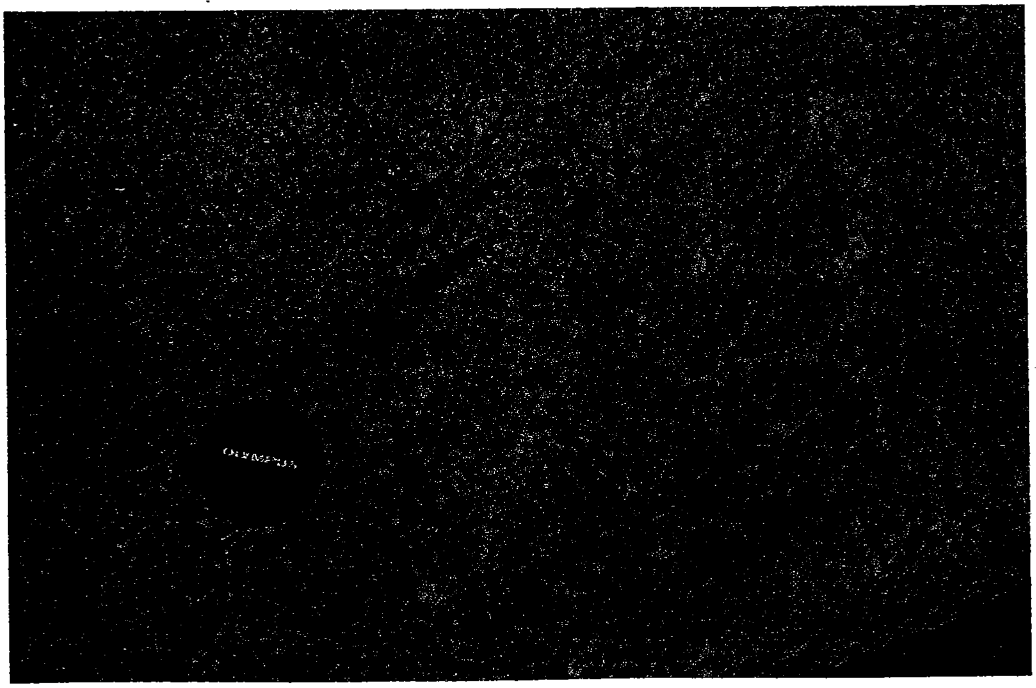
APPENDIX A

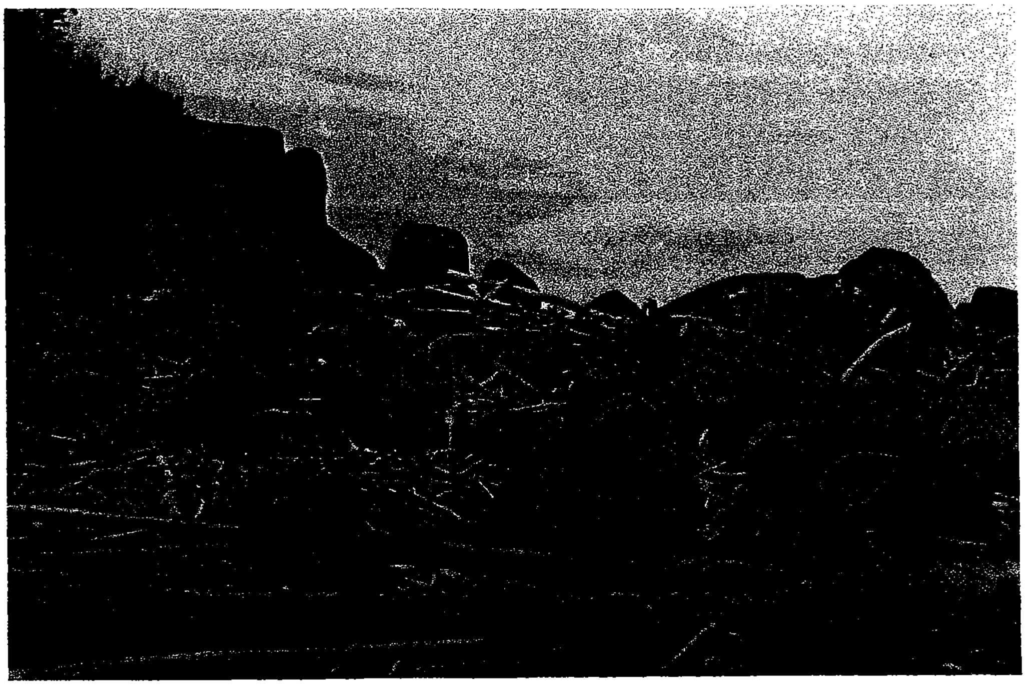
PHOTOGRAPHS OF THE SITE



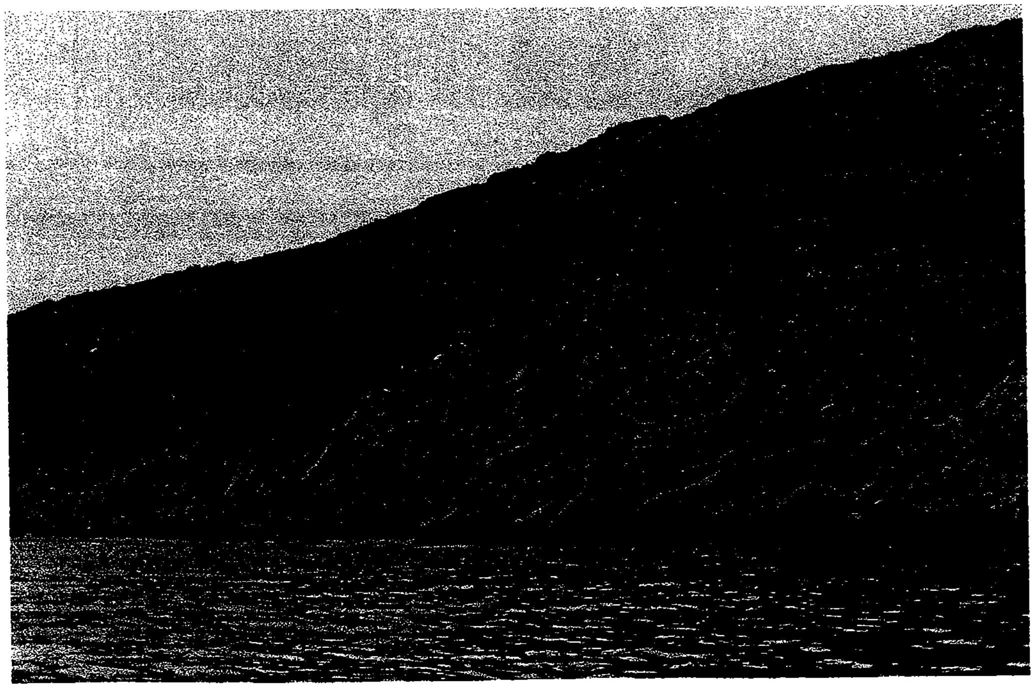
Photograph 1: Granite torrs occur throughout the hills north and west of Elim. Kwiniuk River seen in the background.



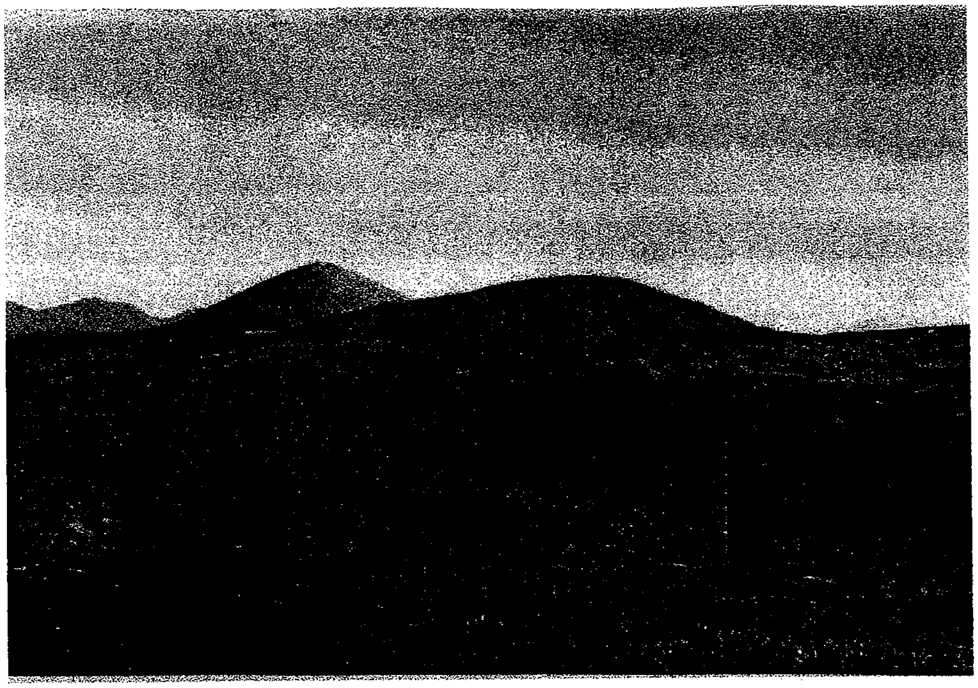
Photograph 2: Up close view of the granite. Notice the large pink and white feldspar crystals. The texture of the granite is coarse grain. Minerals include quartz, feldspars, biotite, and amphiboles.



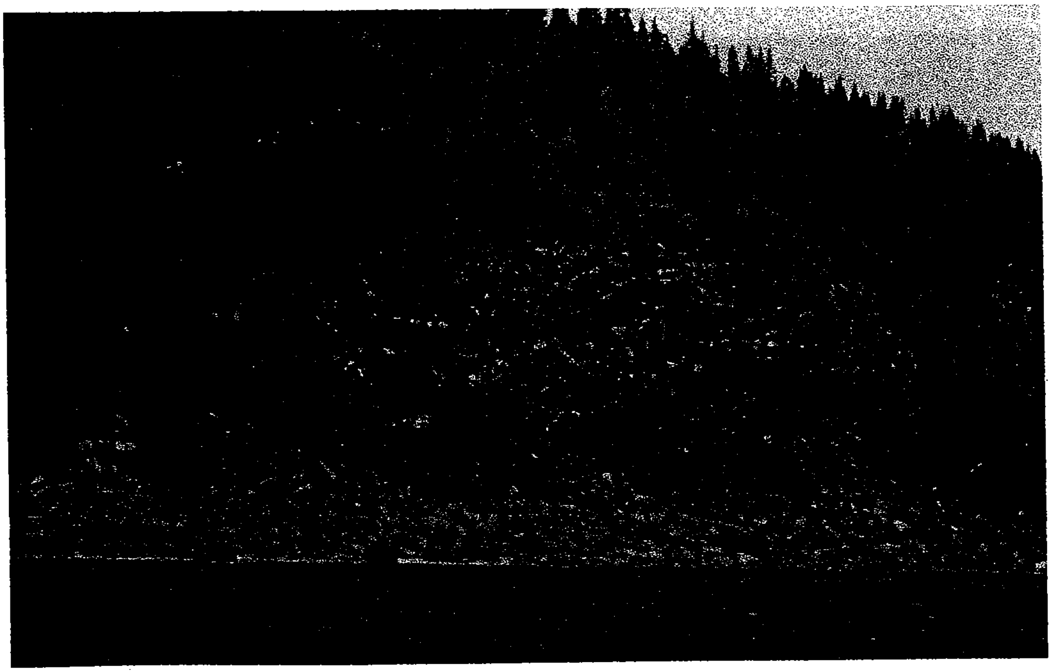
Photograph 3: Large granitic boulders occur along the coastline particularly near Portage Roadhouse. Boulders are greater than 10 feet in diameter and rounded from the surf.



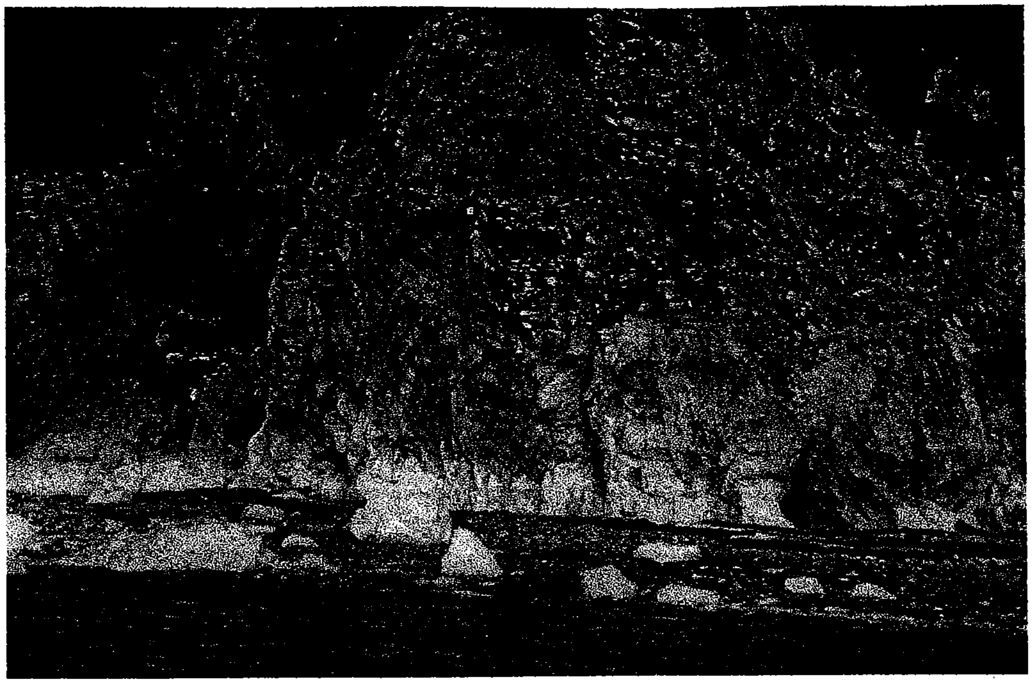
Photograph 4: Typical coastline along Kalc Point. Notice the gray weathering of the granitic material on the surface and the fracturing along the coast. Typical spacing between joints was 4 to 10 feet.



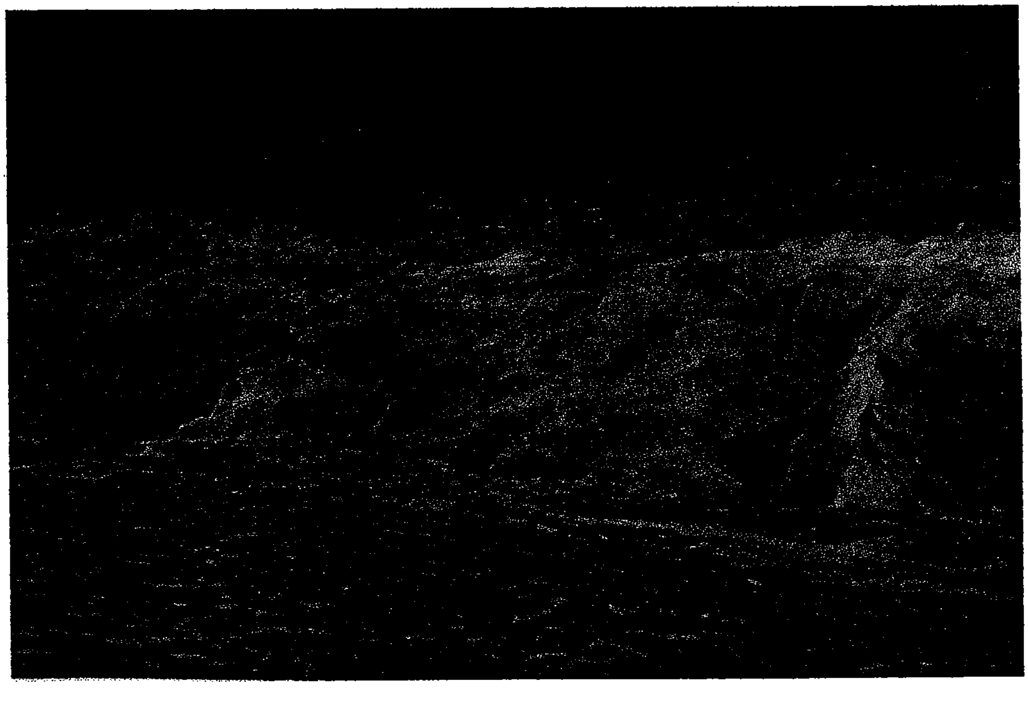
Photograph 5: Marble occurs as rounded, bare, gray-colored hills north and west of Elim. Trail in the foreground is the Hot Springs trail.



Photograph 6: Black marble occurs as thin layers interbedded with white marble and the schist. Notice the fine layering. Compare this photograph to the granite and white marble shorelines. Notice the talus and fine grain nature of this material.



Photograph 7: The white and gray marble was blocky and massive along the coastline. There is a general lack of joints within the marble.



Photograph 8: The white marble is easily eroded by wave action indicating a soft material. This material can be worked easier than the granitic material.

APPENDIX B

LABORATORY RESULTS

LABORATORY TEST REPORT

R&M CONSULTANTS, INC. 9101 VANGUARD DR. ANCHORAGE, ALASKA 99507 PH 907-522-1707

R&M PROJECT: 051003

CLIENT: Hattenburg and Dilley LLC
PROJECT: Geotechnical Investigation
CLIENT PROJECT: Elim, Alaska
CLIENT ADDRESS: 3151 E. 64th Ave, Anchorage, Alaska 99507
PROPOSED USE: Roadway Aggregate Investigation
SOURCE: Insitu
SAMPLED FROM: Granite Cale Point & Hot Springs
LOCATION: Rosemary Hill

SUBMITTED BY: Client
DATE SAMPLED: n/a
DEPTH: n/a

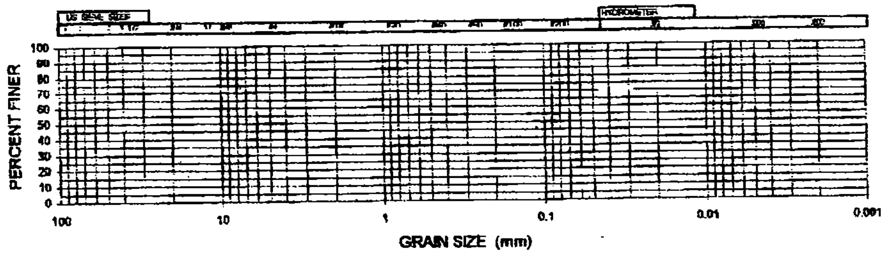
LAB NO.: 379-c
FIELD NO.: n/a
DATE REPORTED: 10/25/00
DATE RECEIVED: 9/14/00

GRAIN SIZE DISTRIBUTION		
SIEVE	% PASS	SPEC.
5"		
4"		
3"		
2"		
1 1/2"		
1"		
3/4"		
1/2"		
3/8"		
#4		
#8		
#10		
#16		
#20		
#30		
#40		
#50		
#60		
#80		
#100		
#200		
.02MM		
.005MM		
.002MM		

CLASSIFICATION			
	UNIFIED	AASHTO	FAA
% + 10			
% + 3			
% GRAVEL			
% SAND			
% SILT			
% CLAY			
FSV			
LL			
PL			
PI			
CLASS			

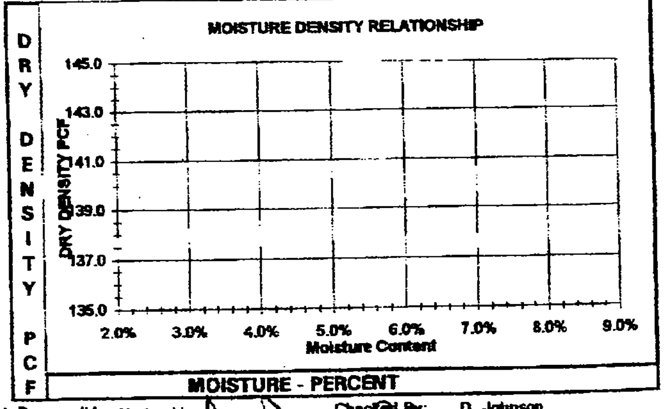
COMPACTION	
OPTIMUM MOISTURE:	
MIN. DRY DENSITY.	
MAX. DRY DENSITY:	
CORR. MAX. DRY DENSITY:	
% FRACTURE:	
METHOD:	
NATURAL DENSITY:	
NATURAL MOISTURE:	
WEIGHT LOOSE:	
WEIGHT RODDED:	

GRAIN SIZE DISTRIBUTION CHART



TOTAL WT. TESTED: 0 GMS.

COARSE	SPEC	FINE	SPEC	DELETERIOUS MAT.
				MINUS #200 MESH
				SOFT FRAGMENTS
				COAT & LIG. OR L.T.WT.PT.
				CLAY LUMPS
				STICKS & ROOTS
				FRIABLE PARTICLES
				THIN-ELONGATED
				ORGANIC COLOR
				FINENESS MODULUS
		1.0%	<6%	SULFATE SOUNDNESS
75	>45			DEGRADATION VALUE
0.860				ABSORPTION
2.589				SPG.-BULK
2.611				SPG.-BULK S.S.D.
2.648				SPG.-APPARENT



Tech Responsible: M. Arnolds
Checked By: D. Johnson

ORGANIC CONTENT %:
L.A. ABRASION LOSS %: 47 spec <45

Signed By:
Title: Laboratory Manager

R&M CLASSIFICATION:

REMARKS: Utilized AK DOT Standard Specifications for surface course
Alaska Test Method T-13, AASHTO T-96, AASHTO T-104

LABORATORY TEST REPORT

R&M
R&M CONSULTANTS, INC. 9101 VANGUARD DR. ANCHORAGE, ALASKA 99507 PH 907-522-1707

R&M PROJECT: 051003

CLIENT: Hattenburg and Dilley LLC
PROJECT: Geotechnical Investigation
CLIENT PROJECT: Elim, Alaska
CLIENT ADDRESS: 3151 E. 64th Ave, Anchorage, Alaska 99507
PROPOSED USE: Roadway Aggregate Investigation
SOURCE: Insitu
SAMPLED FROM: Portage Point Sand & Black Marble
LOCATION: n/a

SUBMITTED BY: Client
DATE SAMPLED: n/a
DEPTH: n/a

LAB NO.: 379-b
FIELD NO.: n/a
DATE REPORTED: 10/25/00
DATE RECEIVED: 9/14/00

GRAIN SIZE DISTRIBUTION

SIEVE	% PASS	SPEC.
5"		
4"		
3"		
2"		
1 1/2 "		
1"		
3/4"		
1/2"		
3/8"		
#4		
#8		
#10		
#16		
#20		
#30		
#40		
#50		
#60		
#80		
#100		
#200		
.02MM		
.005MM		
.002MM		

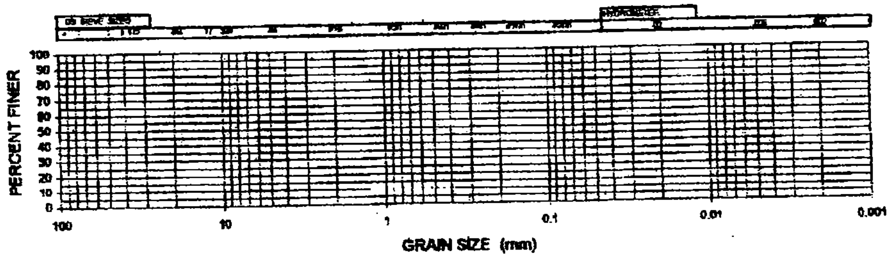
CLASSIFICATION

	UNIFIED	AASHTO	FAA
% + 10			
% + 3			
% GRAVEL			
% SAND			
% SILT			
% CLAY			
FSV			
LL			
PL			
PI			
CLASS			

COMPACTION

OPTIMUM MOISTURE:	
MIN. DRY DENSITY.	
MAX. DRY DENSITY:	
CORR. MAX. DRY DENSITY:	
% FRACTURE:	
METHOD:	
NATURAL DENSITY:	
NATURAL MOISTURE:	
WEIGHT LOOSE:	
WEIGHT RODDED:	

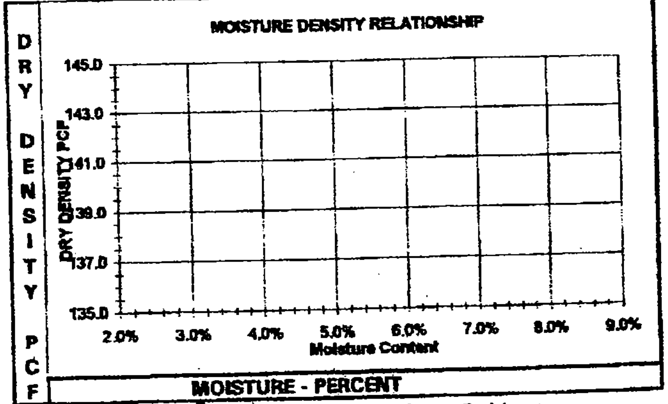
GRAIN SIZE DISTRIBUTION CHART



TOTAL WT. TESTED: 0 GMS.

COARSE	SPEC	FINE	SPEC	DELETERIOUS MAT.
				MINUS #200 MESH
				SOFT FRAGMENTS
				COAT & LIG. OR L.T.WT.PT.
				CLAY LUMPS
				STICKS & ROOTS
				FRIABLE PARTICLES
				THIN-ELONGATED
				ORGANIC COLOR
				FINENESS MODULUS
		2.0%	<6%	SULFATE SOUNDNESS
9	>45			DEGRADATION VALUE
1.786				ABSORPTION
2.545				SPG.-BULK
2.591				SPG.-BULK S.S.D.
2.667				SPG.-APPARENT

MOISTURE DENSITY RELATIONSHIP



Tech Responsible: M. Arnolds
Checked By: D. Johnson

ORGANIC CONTENT %:
L.A. ABRASION LOSS %: 39 spec <45

Signed By:
Title: Laboratory Manager

R&M CLASSIFICATION:

REMARKS: Utilized AK DOT Standard Specifications for surface course
Alaska Test Method T-13, AASHTO T-96, AASHTO T-104

Received Time Oct. 25. 3:36PM

LABORATORY TEST REPORT

R&M
R&M CONSULTANTS, INC. 9101 VANGUARD DR. ANCHORAGE, ALASKA 99507 PH 907-522-1707

CLIENT: Hattenburg and Dilley LLC
PROJECT: Geotechnical Investigation
CLIENT PROJECT: Elim, Alaska
CLIENT ADDRESS: 3151 E. 64th Ave, Anchorage, Alaska 99507
PROPOSED USE: Roadway Aggregate Investigation
SOURCE: Stop 1
SAMPLED FROM: Moses Point Sand
LOCATION: n/a

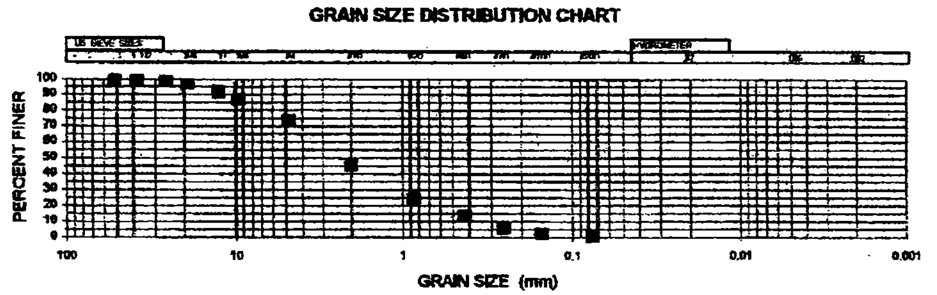
SUBMITTED BY: Client
DATE SAMPLED: n/a
DEPTH: n/a

R&M PROJECT: 051003
LAB NO.: 379-a
FIELD NO.: n/a
DATE REPORTED: 10/25/00
DATE RECEIVED: 9/14/00

GRAIN SIZE DISTRIBUTION		
SIEVE	% PASS	SPEC.
5"		
4"		
3"		
2"	100	
1 1/2 "	99	
1"	98	
3/4"	97	
1/2"	91	
3/8"	87	
#4	73	
#8		
#10	45	
#16		
#20	24	
#30		
#40	13	
#50		
#60	5.8	
#80		
#100	2.0	
#200	0.6	
.02MM		
.005MM		
.002MM		

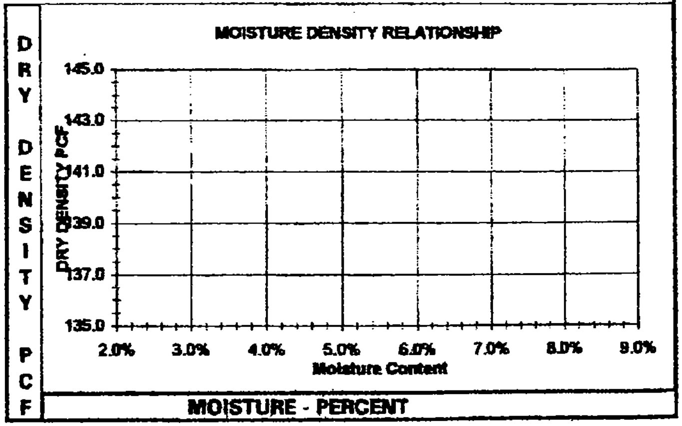
CLASSIFICATION			
	UNIFIED	AASHTO	FAA
% + 10			
% + 3			
% GRAVEL	26.8		
% SAND	72.6		
% SILT	0.6		
% CLAY			
FSV			
LL			
PL			
PI			
CLASS	SW		

COMPACTION	
OPTIMUM MOISTURE:	
MIN. DRY DENSITY.	
MAX. DRY DENSITY:	
CORR. MAX. DRY DENSITY:	
% FRACTURE:	
METHOD:	
NATURAL DENSITY:	
NATURAL MOISTURE:	
WEIGHT LOOSE:	
WEIGHT RODDED:	



TOTAL WT. TESTED: 10,235 GMS.

COARSE	SPEC	FINE	SPEC	DELETERIOUS MAT.
				MINUS #200 MESH
				SOFT FRAGMENTS
				COAT & LIG. OR L.T.WT.PT.
				CLAY LUMPS
				STICKS & ROOTS
				FRIABLE PARTICLES
				THIN-ELONGATED
				ORGANIC COLOR
				FINENESS MODULUS
1%	<8%			SULFATE SOUNDNESS
41	>45			DEGRADATION VALUE
0.458				ABSORPTION
2.813				SPG.-BULK
2.826				SPG.-BULK S.S.D.
2.849				SPG.-APPARENT

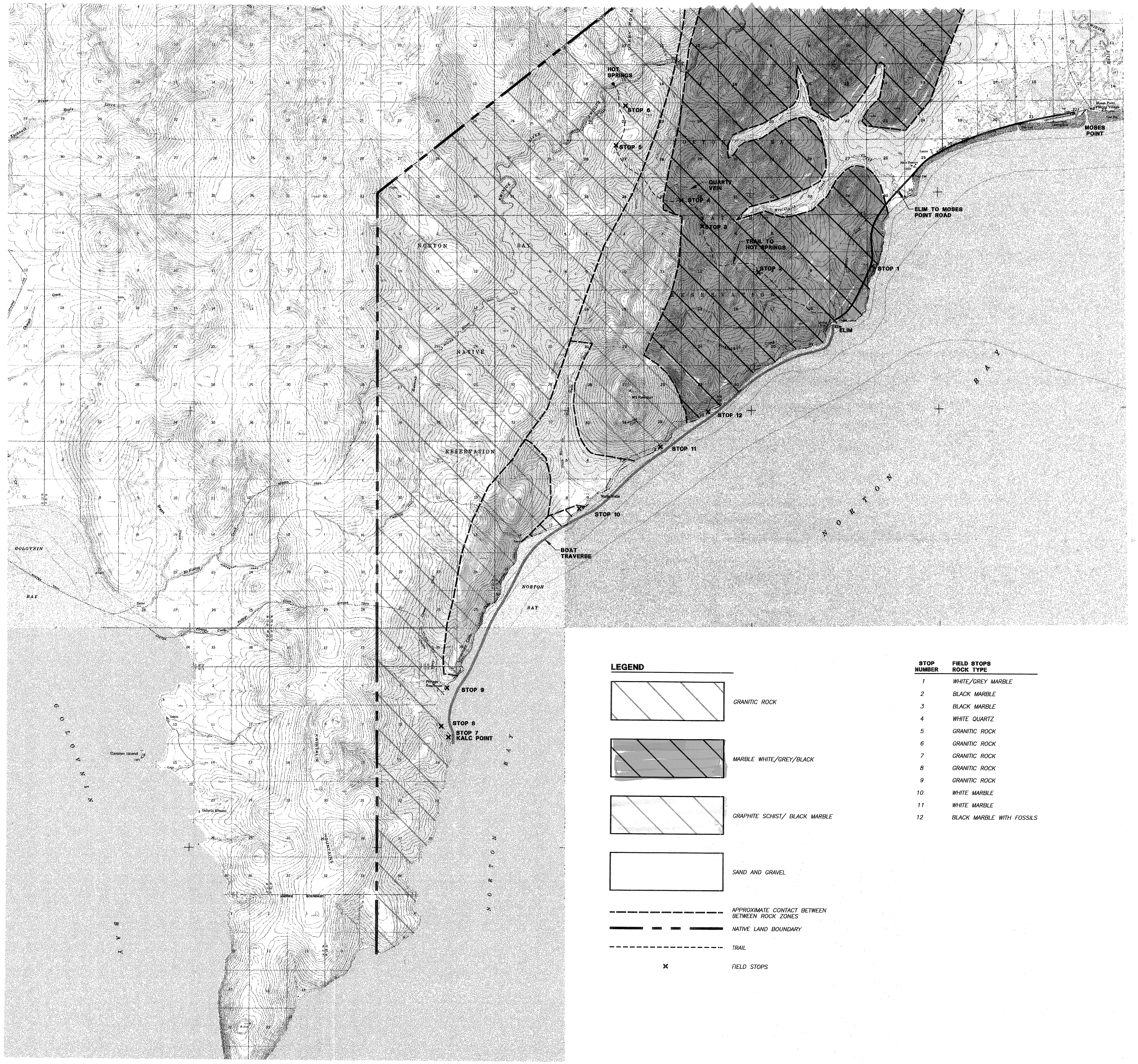


ORGANIC CONTENT %:
L.A. ABRASION LOSS %: 31 spec <45

Tech Responsible: E. Lindqui
Checked By: D. Johnson
Signed By:
Title: Laboratory Manager

R&M CLASSIFICATION: Sand, with some Gravel

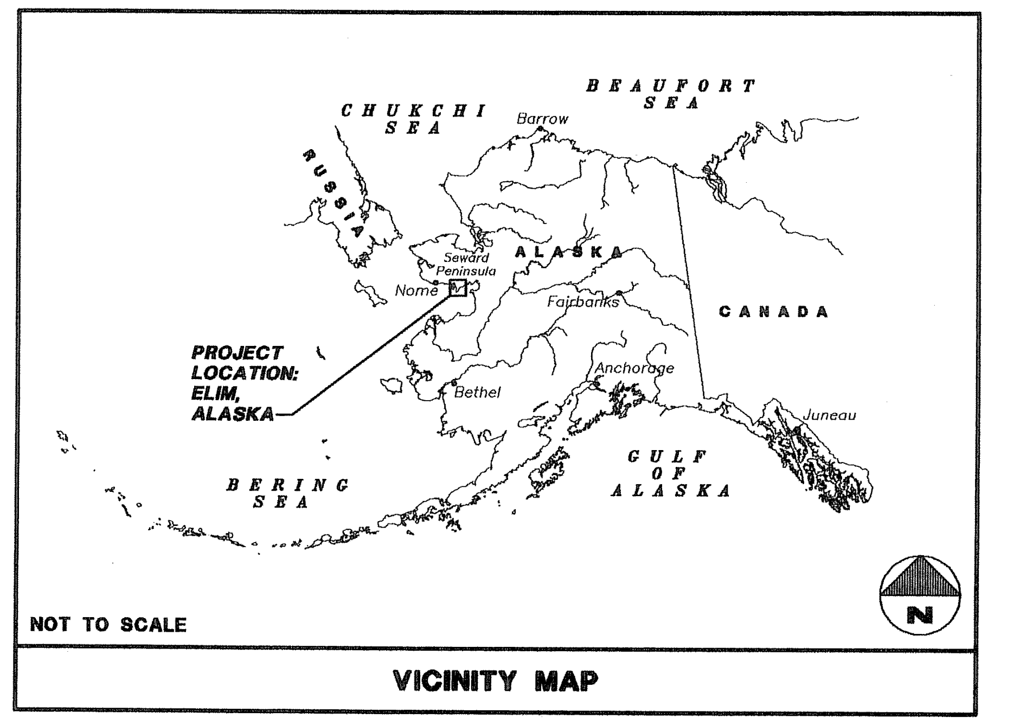
REMARKS: Utilized AK DOT Standard Specifications for surface course
Alaska Test Method T-13, AASHTO T-96, AASHTO T-104



LEGEND

▨	GRANITIC ROCK
▨	MARBLE WHITE/GREY/BLACK
▨	GRAPHITE SCHIST/ BLACK MARBLE
☐	SAND AND GRAVEL
– – – – –	APPROXIMATE CONTACT BETWEEN BETWEEN ROCK ZONES
▬ ▬ – ▬	NATIVE LAND BOUNDARY
- - - - -	TRAIL
×	FIELD STOPS

STOP NUMBER	FIELD STOPS ROCK TYPE
1	WHITE/GREY MARBLE
2	BLACK MARBLE
3	BLACK MARBLE
4	WHITE QUARTZ
5	GRANITIC ROCK
6	GRANITIC ROCK
7	GRANITIC ROCK
8	GRANITIC ROCK
9	GRANITIC ROCK
10	WHITE MARBLE
11	WHITE MARBLE
12	BLACK MARBLE WITH FOSSILS



VICINITY MAP

NOTES

1. APPROXIMATE CONTACTS BASED PRIMARILY ON U.S. GEOLOGICAL SURVEY OPEN FILE REPORT NUMBER 72–256, PRELIMINARY GEOLOGICAL MAP OF THE EASTERN SOLOMON AND SOUTHEASTERN BENDELEBEN QUADRANGLE, EASTERN SEWARD PENINSULA, ALASKA, BY T.P. MILLER, D.G. GRYBECK, R.L. ELLIOT, AND TRAVIS HUDSON, 1972.
2. GEOLOGIC UNITS ILLUSTRATE ARE BASED ON GEOLOGY AND ENGINEERING PROPERTIES AND MAY ENCOMPASS MORE THAN ONE ROCK TYPE. REFER TO TEXT FOR EXPLANATION.
3. MAPPING: USGS QUADRANGLES SOLOMON B–2, C–1, AND C–2

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 ▬▬▬ 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

FIGURE 1

CITY OF ELIM

ROCK QUARRY RECONNAISSANCE

RECONNAISSANCE GEOLOGIC MAP

ELIM, ALASKA

HATTENBURG and DILLEY, LLC

DATE: OCTOBER 2000	SCALE: 1" = 8000'
CHECKED BY: SLH	SHEET:
DRAWN BY: DAR	W.O. No:

PLOTTING DATE: 11/16/00 (09:04)
FIELD BOOK(S):
AUTOCAD DRAWING NAME: SOLOMON.DWG

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ANNEX B

Final Report on Results Geophysical Survey Report Navigation Improvement Feasibility Study, Elim, Alaska, Dated 4 November 2019

Report

Final Report on Results Geophysical Survey Report Navigation Improvement Feasibility Study, Elim, Alaska

Contract No. W911KB-17 D-0002, Delivery Order W911KB19F0113

Submitted to:

Mr. Rob Weakland
US Army Corps of Engineers - Alaska District
PO Box 6898
JBER, AK 99506-0898

Submitted by:

Golder Associates Inc.
2121 Abbott Road, Suite 100, Anchorage, Alaska, USA 99507

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19125762

November 4, 2019

Distribution List

3 Hardcopies + 6 CD

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GRAPHICS/IMAGES

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APPENDICES

1.0 INTRODUCTION

Golder Associates Inc. (Golder) is pleased to present the results of our nearshore marine geophysical survey for the Elim Navigation Improvement Feasibility Study. The project site is in the community of Elim, Alaska on the north shore of Norton Bay in the northeast corner of Norton Sound and approximately 95 miles east of Nome (Figure 1). The area of this investigation is approximately 4,000 feet along the shoreline and extends out approximately 2,000 feet offshore and a combination of two areas termed Elim Beach and Airport Point. Elim Beach is approximately 1,800 feet in length and composed of sands, gravel, cobbles and limestone bedrock outcrop at the surface (Figure 2) while Airport Point is southeast of the tank farm and State-operated Elim Airport and is primarily bedrock outcrop, boulders, and cobbles along shoreline but with a naturally deeper draft immediately off shore.

The Elim Navigation Improvement Feasibility Study includes evaluating the feasibility of installing a breakwater wall, jetty, and/or dock at one of these locations to increase navigation capabilities for small and medium size vessels and increase barge access for fuel and supplies to the community. Presence of rock along portions of the shoreline and just offshore indicate possible shallow depth to bedrock and bedrock removal may severely impact the cost of developing the selected project site.

1.1 Understanding of Project

The US Army Corps of Engineers (USACE) is selecting a preferred location for navigational improvement and developing the design for the project. Golder understands the placement of future navigational improvements may depend on sub-surface geologic conditions. Specifications for the type or placement of project features can be refined by understanding the thickness and lateral extent of the subsurface stratigraphy, particularly soft sediment, and the depth to the top of bedrock.

1.2 Scope of Work

The scope of work consisted of conducting both a shallow marine and onshore geophysical investigations to define subsurface conditions needed for project design. The marine geophysical data were acquired on a grid with pre-planned survey track lines that ran parallel and perpendicular to the shoreline (Figure 2). Details of the survey methods are presented in Section 3.0.

2.0 BACKGROUND DATA REVIEW

Limited historical geotechnical data was available for review prior to the field investigation. A multibeam survey was conducted for bathymetry earlier this year by eTrec, Inc. and earlier bathymetric data was presented by DOWL in 2012 (performed by Hughes and Associates; conducted from June 17 to June 22, 2012 using a ODOM ES3-M Multibeam Sonar System, with a 30 degree angle head) provided to Golder by USACE. Electronic copies of the 2012 bathymetric data and preliminary bathymetric data from 2019 were made available to Golder.

2.1 Geological Setting

The Elim area was mapped as Quaternary sediments and Younger metamorphosed sedimentary rocks (ymu) by Cass[1] in the 1950's, "sedimentary igneous or metamorphic rock" by Kaufman in 1986[2], and more recently mapped as Cretaceous-age carbonate-clast conglomerate, sandstone, and shale by Patton et. al. In 1981 a

---

[1] Cass, J.T., 1959, Reconnaissance geologic map of the Norton Bay Quadrangle, Alaska, USGS IMAP 286, 1:250000 scale.

[2] Kaufman, D.S., 1986. Surficial geologic map of the Soloman, Bendeleben and southern part of the Kotzebue quadrangles, western Alaska, USGS Miscellaneous Field Studies Map MF-1838-A.

surficial geology mapping area of coastal areas concluded the Elim shoreline is primarily pre-Quaternary rock Bedrock outcrops in the investigation area appear to be limestone and dolomite with lesser amounts of schist and marble folded within the outcrops. On shore, bedrock appears to be covered by relatively thin surficial deposits of alluvium, colluvium and windblown silt. Shannon and Wilson (S&W) conducted a geotechnical investigation in Elim for a proposed new High School in 1979. Given the elevation of the ground surface in the project area (~130 feet), it is believed that the 1970 investigation was performed in an area that may now be part of the existing runway. In the test pits, S&W reported approximately 1 foot of tundra/organics overlying 1 to 2.5 feet of eolian silt. Underlying the silt, S&W reported weathered bedrock becoming more competent with depth ranging from 3 to 7.5 feet below the existing ground surface. The depth of exploration ranged between 5 and 22 feet bgs (below ground surface) and S&W did not identify permafrost as part of their investigation.

3.0 GEOPHYSICAL SURVEY METHODS

The onshore geophysical survey was conducted in Elim on August 14 and again on August 17, 2019, by David Hrutfiord, project geophysicist and Connor Toth, a field geologist from Golder’s Redmond, Washington office. Field notes are presented in Appendix C.

The offshore geophysical survey was conducted in Elim on August 15 to August 17, 2019, by David Hrutfiord, Connor Toth, and Jessica Feenstra (geologist and geophysicist from Golder’s Anchorage office). A marine mammal observer (MMO; Chris Floyd, Biologist with US Army Corps of Engineers) was provided by USACE to observe and notify/stop work if any potential conflicts with wildlife and our survey efforts arise.

The onshore geophysical survey included collection of two seismic refraction lines along Elim beach and collection of two long transects of ground penetrating radar (GPR) data along approximately the same transects.

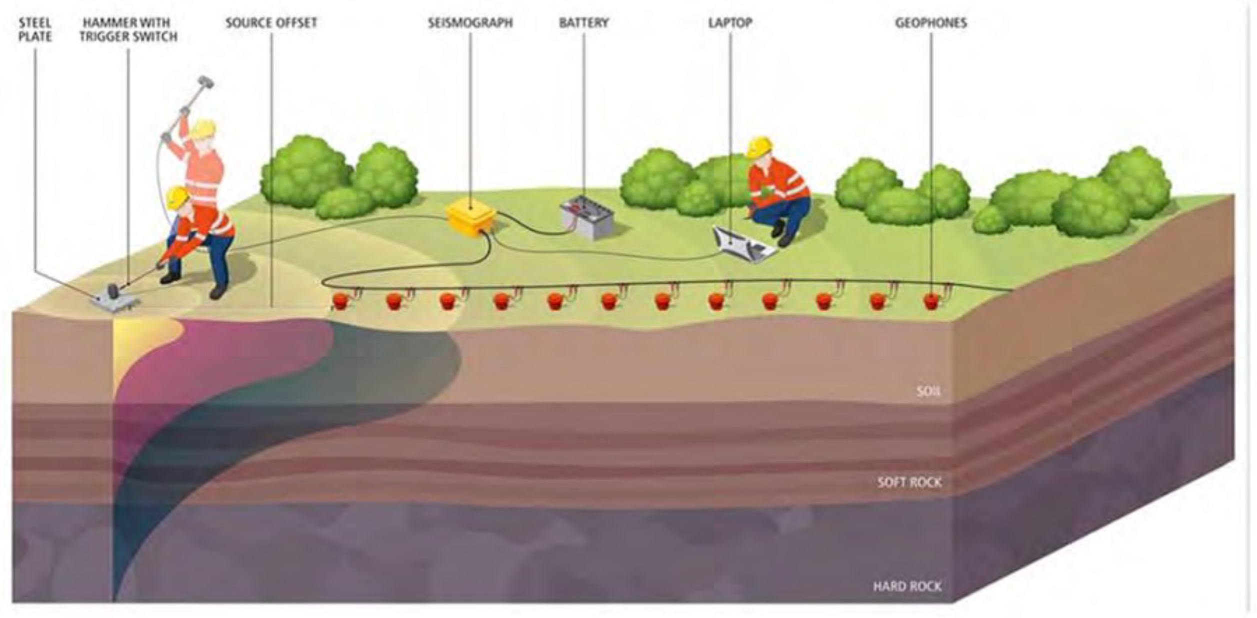
The methods used for the marine survey included a single-channel echosounder to measure the water depth, a sub-bottom profiler (SBP) to identify and map the thickness of fine-grained sediment, side scan sonar to map surficial features and a seismic reflection system to map the thickness of coarse-grained sediment and to determine the depth to the top of acoustic basement or interpreted top of bedrock.

3.1 Seismic Refraction

Two seismic refraction lines were collected along the beach. One at the top of the beach head, Line 1, and one just above the surf zone, Line 2 (blue lines in Figure 2). The two lines consist of multiple seismic spreads. Each spread was collected using 24 geophones at 10 foot spacing along the line. Data from each spread was collected before moving on to the next spread down the line.

Seismic refraction is the traditional method for mapping the thickness of overburden soils and depth to bedrock using a controlled energy source (hammer, blank shotgun shells, chemical explosives) to generate a seismic signal into the earth. The seismic signals are received by a series of geophones (24, for example) that are connected to a seismic cable laid on the ground in a linear manner. The geophones are placed several inches into the ground and spaced approximately 5 to 15 feet apart along the geophone cable.

The seismic energy source is discharged at several places along the array and off both ends of the array. The seismic wave front travels through the earth to the geophones. The geophones transfer the acoustic energy in the ground to an electric signal in the geophone cable. This process is illustrated in Graphic 3.1. The seismograph detects the arriving electric signals with respect to time and stores the records for future data processing. The seismic data is processed to determine the seismic velocity of the earth material through which the energy has traveled and to model the subsurface geology. The geophysical model depicts the earth in cross-sections showing the velocity and thickness of the subsurface layers below the seismic line.



Graphic 3.1: Seismic Refraction Survey Process

Seismic refraction often works well for characterizing subsurface conditions along a continuous profile when used in conjunction with other types of exploration methods. This method is well-suited for mapping both weathered bedrock and competent bedrock. In cases where no competent bedrock is detected, the seismic refraction method still provides valuable geotechnical information such as the variation in velocity structure, which is often a proxy for variation in geologic structure, or to document that no competent bedrock exists within the construction depths of the project. The depths to interpreted subsurface boundaries are generally accepted as accurate to within 15 percent of the true depths to the boundaries. In some cases where there are large velocity contrasts at sharp geologic boundaries and borehole test data are available for model calibration, it may be possible for seismic refraction interpretations to match geotechnical borings to within 5 to 10 percent. In cases where bedrock is very shallow, the expected resolution is related to the geophone spacing and is often limited to between 1 and 2 geophone intervals.

Overall, there is a decrease in the accuracy of the seismic refraction method with depth. This is often due to the natural variability within the shallow geologic layers. This effect can be minimized by using a combination of closely spaced geophones, long survey lines, and large numbers of shot points. In practice, this results in a survey design where the length of the geophone array is approximately five times longer than the expected depth to bedrock and the geophone spacing is one third of this depth. By using seismic refraction, complemented by traditional test borings, a more accurate subsurface characterization can be performed for a reduced cost, with far less uncertainty, and with a lower impact to the environment than drilling alone.

3.2 Ground Penetrating Radar

GPR data is collected by transmitting electromagnetic (radar) pulses into the ground from an antenna. Reflections of these pulses from subsurface features are produced where there is a contrast between the electrical properties of subsurface objects (e.g., the surrounding soil, buried utilities). Reflected electromagnetic pulses are received by the antenna, converted into an electric signal, and recorded by the GPR unit. The GPR unit compiles these pulses to produce an interpretive profile image of the subsurface beneath the path of the antenna.

The penetration depth of the GPR signal is a function of the antenna frequency and the conductivity of the subsurface material. As the frequency of the GPR antenna increases, the resolution (ability to detect small objects) increases, but the depth of subsurface penetration decreases. A lower frequency antenna is capable of greater subsurface penetration, but with reduced resolution. Materials that are electrically conductive, such as clay, tend to attenuate the GPR signal, resulting in a decrease in subsurface penetration.

Ground penetrating radar data were acquired along two transects on Elim Beach (green lines in Figure 2), along nearly the same locations as the seismic refraction lines.

3.3 Survey Vessel

The geophysical, navigational, and hydrographic instruments were installed on 40-foot vessel ‘Anchor Point’ owned by Adam Boeckmann of Nome, Alaska (Image 3.1). The vessel was operated by Mr. Boeckmann during the survey. The vessel was outfitted with fixed mounts on the starboard side for the seismic reflection system. The sub-bottom profiler transducer and echo sounder transducer were mounted off the port side. The side scan sonar was deployed from the bow and the seismic hydrophone was deployed off the starboard stern corner. The hydrophone was retrieved and deployed at the ends of each line to facilitate boat maneuvering. The navigational antenna for position acquisition were installed on the roof of the cabin, just forward of the side mounted transducers. Following installation of the instrumentation, all systems were calibrated according to manufacturer specifications.

Image 3.1: Survey Vessel

3.4 Navigation

The position of the survey vessel was determined with a differential global positioning system (DGPS). All data were collected in NAD83, and projected into Alaska State Plane Zone 7, US Survey Feet. Navigation data were acquired with a Trimble R8 real-time kinematic (RTK) receiver interfaced to an acquisition computer running HYPACK 2018 software, an industry standard navigation software package. The shipboard DGPS receiver and navigation software provided RTK-corrected latitude and longitude coordinates once per second with sub-foot accuracy. The position of the survey vessel was displayed in real-time on a monitor located at the helm in front of the survey vessel operator. This monitor also displayed additional navigation parameters, such as distance down line and distance off line, water depth, vessel speed and heading. This information enabled the vessel operator to pilot the boat along pre-plotted survey transects displayed on the monitor, in addition to viewing the location of completed transects.

3.5 Single Beam Echosounder System

The water depth data were acquired with a single beam Odom CV200 survey grade echosounder interfaced with a 200 kilohertz (kHz) transducer. The transducer was deployed from an over-the-side mount. Cross-checks and calibrations were performed by Golder as described in the International Hydrographic Organization S-44 standards and specifications. Standard "Bar Check" procedures were performed but were of marginal quality due to the motion of the boat. This procedure involves lowering a metal object (bar or plate) below the echosounder transducer to a known depth and then adjusting the velocity of sound on the instrument in order to obtain the correct depth measurement to the bar or plate. This procedure is repeated at several depths until the echosounder measurements are consistent for all depths. A standard velocity of 4,800 ft/sec. was used during the survey as this data was not intended to be used to chart the bottom, rather to be collected in conjunction with the SBP and seismic data to aid in determining seafloor depths along the track lines.

3.6 Sub-bottom Profiler System

A Datasonics Model SBT-2200 SBP system, using a 3.5 KHz transducer, was used to identify and determine the thickness of surficial deposits of fine-grained sediment. The system uses a single transducer/receiver to send and receive acoustic pulses directed at the seafloor. The acoustic pulses can penetrate tens of feet in homogeneous fine-grained sediment but are not able to penetrate dense sand or coarse-grained material. The reflections from the seabed and sub-bottom layers, that are acquired four times per second as the vessel travels along the survey transect, are displayed in real-time as a profile or vertical cross section on the digital acquisition system color monitor.

3.7 Seismic Reflection System

A Datasonics SPR-1200 low-frequency seismic reflection profiling system, referred to as a bubble pulser, was used to acquire information on the thickness of dense and coarse-grained, unconsolidated sediment and to identify the top of acoustic basement or bedrock. The data from this system was acquired simultaneously with the sub-bottom profiler data and displayed in real-time using the Chesapeake digital acquisition system. The digital acquisition system was interfaced with the navigation system to provide real-time position information on the acquired data. Table 3.1 below summarized the geophysical instrumentation used for this investigation and a schematic of the instrument setup is shown in Image 3.2.

3.8 Sidescan Sonar System

A GeoAcoustics dual frequency side scan sonar, operating at 100 KHz was used for this survey. The transducer was deployed off the bow of the boat. Data were set to collect a 50 meter per side swath width. The data were recorded using the Chesapeake acquisition system.

Table 3.1: Geophysical Instrumentation

Equipment	System	Application
RTK GPS	Trimble R8 with 35w UHF data radio	High-accuracy positioning
Precision Echosounder	Odom CV200, 24/200 KHz	Dual frequency, single-beam bathymetry
Sub-bottom Profiler	Datasonics Model SBT-2200 (3.5 to 12 KHz) with GeoAcoustics T135 transducer	Identify and map thickness of fine-grained sediment deposits
Seismic Reflection	Datasonics SPR-1200	Identify and map thickness of coarse-grained sediment and depth to top of till and/or bedrock
Side Scan Sonar	GeoAcoustics operated at 100 KHz	Side scan sonar seafloor coverage
Ground Penetrating Radar	Geophysical Survey Systems Model Utilityscan HS	Shallow bedrock subsurface shoreline investigation
Seismic Refraction System	Geometrics Model Geode Seismograph	Onshore depth to bedrock

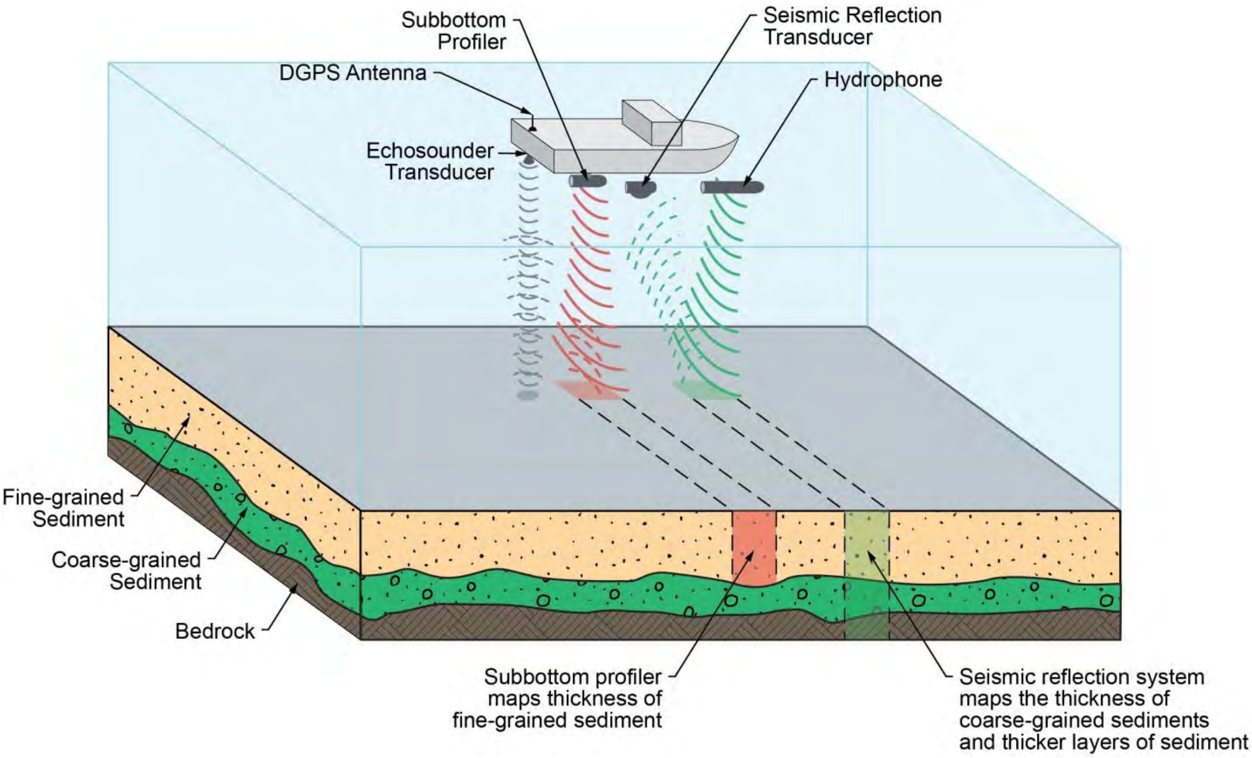


Image 3.2: Survey Instrumentation Schematic

4.0 GEOPHYSICAL DATA PROCESSING

4.1 Seismic Refraction

Seismic refraction data were processed using industry standard, commercially available SeisImager 2D PRO software from Geometrics Inc. The processing steps used to produce the 2-dimensional velocity models presented in the results section are provided below:

- Edit source and geophone locations
- Pick first arrival times
- Export file of first arrival times and geophone locations
- Generate initial velocity model-10 layers, 20-feet thick, constrained to 900-12,000 feet per second (fps)
- 2-dimensional inversion to determine velocity model
- Export model results as three-column data files containing x, z, and velocity
- Plot model results

Seismic refraction models are interpreted with respect to geologic conditions and based primarily on the seismic velocity structure. A typical range of seismic velocity values for weathered bedrock is 5,000-to-8,000 fps, while for competent bedrock the range is accepted as 8,000-to-16,000 fps. Weathered and fractured bedrock seismic velocity is often significantly lower than competent bedrock of the same type. These distinctions are the basis of our interpretations for overburden, weathered bedrock, and more competent bedrock for each of the seismic refraction models.

4.2 Ground Penetrating Radar

Golder collected GPR data along a total of five line segments ranging from approximately 183- to 1152-feet in length. GPR data was collected along each of the seismic refraction survey lines, using the four-wheel GPR cart. Figure 2 shows the approximate locations of the GPR lines in green.

GPR data was collected using a mid-frequency, 350-megahertz (MHz) GSSI UtilityScan radar system and was processed on a desktop computer using RADAN 7 software. GPR data was collected to a depth of approximately 18 feet-bgs

4.3 Marine Data

The marine data were collected and analyzed using HYPACK 2018 and Chesapeake Sonarwiz 5 for the bathymetry, sidescan, subbottom and seismic reflection data. A detailed discussion of the processing and analysis methods is discussed below.

4.4 Bathymetry Data

The digital bathymetric data were filtered for consistency and removal of anomalous values using Hypack single beam processing software. This software analyzes the data spatially and for signal quality on all survey lines. The sound-speed velocities used to calculate the water depths were based on the results of the bar-check calibration. The echosounder data were output as an ASCII XYZ file, which was then used to check SBP and seismic track line water depths. Bathymetric data collected during this investigation generally agrees with the preliminary multi-beam bathymetric data collected by Etrac, Inc. earlier in 2019. Bathymetric data collected during this investigation was not used for determining a new bathymetric surface. A mosaic contour map of 2012 and 2019 Etrac bathymetric data is presented in Figure 5.

4.5 Sub-bottom Profiler Data

Raw SBP data were imported into the Hypack system where a series of frequency and intensity filters were applied to increase prominence of subsurface acoustic reflectors. The data were then reviewed to determine the depth to the first acoustic horizon or reflector; interpreted to be the base of the surficial unconsolidated sediment. We interpret this top sub-bottom layer to be composed of material similar to that found along Elim Beach (namely coarse sand and gravel). Unconsolidated sediment thickness is determined by multiplying the compressional velocity of sound through sediment (5,500 feet per second [fps]) by the two-way travel time for an acoustic pulse to travel from the top of sediment to the top of the underlying interpreted consolidated and/or course-grained sediment or rock.

4.6 Seismic Reflection Data

The seismic reflection data were imported into the Hypack software system where a series of frequency and intensity filters were applied to increase prominence of acoustic reflectors. The data were then digitized and interpreted to determine the depth to the acoustic horizons or deeper reflectors interpreted to be the acoustic basement. The acoustic reflectors may be the base of the unconsolidated sediments, a paleo seafloor, or glacial till while the acoustic basement is interpreted to be top of bedrock. The basement is the deepest layer detected on the seismic reflection records that is not a multiple reflector.

Multiple reflectors are ‘layers’ that appear in the data but are produced by ringing of the outgoing acoustic pulse between the seafloor and surface. This ringing can occur many times but are characteristically found at multiples of the bathymetric depth. Multiples can also occur between interbedded layers but are very rarely detected due to the lower energy source.

The sediment thickness and depth to the top of bedrock was determined by multiplying the compressional velocity of sound through sediment (estimated at 5,500 fps) by the two-way travel time for an acoustic pulse to travel from the top of sediment to the top of acoustic basement. A database of sediment thickness was then generated, and these values were used to produce an isopach map of the sediment including coarse-grained sediments over the acoustic basement interpreted to be the top of bedrock.

5.0 GEOPHYSICAL SURVEY RESULTS

5.1 Onshore Seismic Refraction

As discussed in the method description, subsurface material properties can be interpreted based on compressional seismic velocity. Without nearby borehole information to correlate to, any material descriptions (i.e. lithology) are based solely on velocity structure. Seismic refraction results for each line of data collected are shown in Figure 3. For each line, the velocity models are plotted using colored contours between 900 and 12,000 fps with a contour interval of 100 fps. Cool colors (e.g., blue and green) represent relatively low seismic velocity (colluvium, alluvium, and highly weathered bedrock) while hot colors (e.g., orange and red) represent relatively high seismic velocity (bedrock).

There are three distinct layers of subsurface material interpreted in the models presented here with a further distinction provided relative to rippability. These layers are:

- Soil/soft alluvium that is easily rippable
- Hard alluvium/weathered rock that is easily rippable
- Fresh to weathered rock that is marginally to non-rippable

A velocity contrast at 5,000 fps is used to delineate softer and harder alluvium which grades into weathered rock. From the perspective of planning and cost assessment for excavations, rippability is a critical element in excavation costs. Ability to excavate or “rip” the material is highly dependent on equipment-specifications.

Topography along SL-1 (Seismic Line 1), collected furthest from the water, is mostly flat and bedrock was visibly outcropping approximately 80 feet to the east and 5 feet to the west. The seismic velocity model shown in the top panel of Figure 3 is interpreted to indicate softer sediments (shown in blue and dark green) are 0 to 9 feet in thickness. Dense and/or hard alluvium is interpreted to range from 3 to 7 feet thick. Very dense material that is difficult to rip appears to be no deeper than 12 feet below ground surface (bgs) along all of SL1 and is as little as 3 feet bgs along the eastern portion of SL-1 which includes a creek crossing at approximately 1,000 feet line distance.

SL-2 (Seismic Line 2) was collected near the high-water mark and is flat (Figure 2). Bedrock outcrops from the western end of SL-2 and is visible sporadically to the large rocks outcropping at the west end of Elim Beach. The seismic velocity model for SL-2, shown in the lower panel of Figure 3, is interpreted to indicate softer sediments (shown in blue and dark green) which are 0 to 5 feet in thickness; with very dense, difficult to rip material from approximately 5 to 10 feet bgs. A photograph of the rock outcrops (provided in the RFP as Figure 4) is shown in

Figure 3 and the geographic position provided on the photo is shown in Figure 2. Similar rock outcrops were observed along the length of the western portion of Elim Beach during the seismic refraction field investigation and it was decided that no further refraction data was needed to determine depth to rock in these areas.

5.2 Ground Penetrating Radar

GPR data were collected to determine if shallow bedrock could be imaged and mapped onshore; particularly along Elim Beach. Scaled graphic images of the GPR data (radargrams) are shown in Figure 4. A GPR contact is apparent in the radargrams and is shown in brown on all panels of Figure 4. It is assumed this contact is correlated to the seismic contact between softer (slower velocity) materials near the surface and harder (higher velocity) materials at depth. If this GPR contact is confirmed to be a rock surface, GPR data indicate pockets of bedrock within the 5 to 10 feet of GPR signal penetration observed along the Elim Beach shoreline. Deeper penetration was not possible due to GPR signal attenuation from saline soils at greater depths.

5.3 Sub-bottom Profiling Survey

Figure 2 (trackline map) includes labeled number of each marine trackline. Graphic images of the processed SBP records along each line are presented in Appendix B. The line/file name is shown in the lower right, and cross line locations depicted along each record. While picks of acoustic reflectors were made electrically, a graphic connection between reflectors in the SBP and seismic reflection (bubble pulser) datasets and interpreted geologic cross sections is shown in Figure 10.

A thin layer of unconsolidated material is interpreted to exist across most of the site generally ranging from 3 to 7 feet thick. An isopach map of the unconsolidated sediment is presented in Figure 6 and is interpreted to be the thickness of sand and gravel. Sub-bottom profiling penetration was limited to this layer of material which indicates deeper material is more consolidated and/or very course materials (cobbles and boulder). It is assumed either harder, dense/consolidated sediments or a weathered bedrock layer lay above the bedrock.

Interpreted geologic cross sections were generated for twenty transects within the Elim Beach and Airport Point investigation areas. A transect location map is presented as Figure A-1 in Appendix A with interpreted geologic cross sections presented in subsequent Appendix A figures. For each interpreted geologic cross section (Figures A-2 through A-9) the Y-axis is elevation MLLW, based on the 1983-2001 tidal epoch, with the assumption that the bathymetric elevations provided by others in 2012 and 2019 have the same datum. The top of each section is an arbitrary zero cutoff for the top of water at mean low water level. The bathymetric surface was used to drape interpreted thickness of other geologic contacts shown in Figures A-2 through A-9 to maintain the same vertical datum.

5.4 Seismic Reflection Survey

The seismic reflection records suggest a deeper (than seen in the SBP data) second acoustic reflector exists. This layer is a mostly continuous deeper reflector that is the acoustic basement. This reflector may be a glacially-smoothed bedrock surface or a paleo seafloor that has solidified or is armored with hard enough material that the acoustic signal was not able to penetrate further. When the onshore seismic refraction results are considered, it can be assumed that this reflector is mostly a rock surface. Interpreted depth to the acoustic basement (in feet below seafloor) is shown in Figure 7 and ranges from less than two feet near onshore bedrock outcrops at Airport Point to nearly 22 feet offshore of the eastern end of Elim Beach. The elevation (relative to mean lower low water; MLLW) of the deepest reflector is shown in Figure 8. The acoustic basement is shown as the lowest layer in interpreted geologic cross sections presented in Appendix A figures (Y-axis is elevation MLLW).

5.5 Sidescan Sonar Survey

Sidescan sonar (SSS) data were acquired with Chesapeake software, and processed using Hypack software. The side scan sonar data were processed to generate a mosaic acoustic image of the seabed showing outcrops and seabed forms (Figure 9). The seabed showed few features away from shore. There were only a couple locations were outcrops or boulders were noted away from the shoreline.

6.0 CONCLUSIONS

Onshore, bedrock appears to be very shallow close to visible outcrops (such as RFP Figure 4, shown in Figure 3 of this report). Similar rock outcrops were observed along the length of the western portion of Elim Beach during the seismic refraction field investigation and, where seismic refraction data was collected along Elim Beach, sediment thickness appears limited to approximately 12 feet near the middle of Elim Beach. GPR data along Elim Beach indicate a geologic contact that may represent either the contact between softer/less dense sediment and more dense sediment or weathered rock. The GPR contact is somewhat discontinuous but generally less than 8 feet bgs.

Offshore, interpreted depth to the acoustic basement or potentially competent rock varies at this site. The site appears to have a thin layer of soft material up to seven feet thick in the un-scoured offshore area. Side scan imagery indicates that there are large boulders or outcrops along the shoreline of Airport Point but few features away from shore at either Airport Point or along Elim Beach. Bedrock depths appear variable; with a few outcrop exposures appearing at the seabed near the Airport Point shoreline to approximately 36 feet below sea level offshore.

Figures 6 and 7 present the interpreted thicknesses of geologic layers from on shore to off shore with the transition between the on shore and off shore datasets being interpreted as relatively smooth. Based on the geologic history of glacial deposition and erosion, as well as current coastal processes, it is reasonable to assume the sediment layering and bedrock geometry does not vary significantly from where geophysical data does exist.

Because the subbottom profiling and seismic reflection data did not yield conclusive sediment type identification of unconsolidated material, it is recommended that a jet probing investigation be conducted over the potential footprint(s) of any navigational improvement structures. While 3 to 7 feet of unconsolidated material is interpreted to exist across most of the site, sub-bottom profiling penetration was limited to this layer of material which indicates deeper material is more consolidated and/or hard. The lack of acoustic reflectors in SBP data at depth suggests hard rock-like material or rock may be very shallow. The marine seismic reflection data suggest the deeper material is more consolidated and/or hard but does not provide an estimate of rippability. Jet probing and/or drilling would provide geotechnical information necessary to further the design of any navigational improvements at Elim.

7.0 LIMITATIONS

This report has been prepared exclusively for the USACE for use in design of the proposed navigation improvements. If there are significant changes in the nature, design, or location of the facilities, we should be notified so that we may review our conclusions and recommendations considering the proposed changes and provide a written modification or verification of the changes.

There are possible variations in subsurface conditions between explorations and also with time. Therefore, inspection and testing by a qualified geotechnical engineer should be included during construction to provide corrective recommendations adapted to the conditions revealed during the work. In addition, a contingency for unanticipated conditions should be included in the construction budget and schedule.

Golder geophysical services were conducted in a manner consistent with the level of care and skill ordinarily exercised by other members of the geophysical community currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services. Echosounding, sidescan sonar, sub-bottom, ground penetrating radar, and seismic refraction / reflection profiling are remote sensing geophysical methods that may not detect all surface or subsurface features of interest or concern. Furthermore, it is possible that interpreted subsurface may, upon intrusive sampling, prove to have been misinterpreted and or a different material type than that observed onshore. The geotechnical work program followed the standard of care expected of professionals undertaking similar work in the State of Alaska under similar conditions. No warranty expressed or implied is made.

Thank you for the opportunity to assist the USACE during the feasibility phase of the Elim navigational improvement project. If you have questions, please contact us at 907-344-6001.

Golder Associates Inc.

Peter E. Fahringer, LG, PGp	Mark R. Musial, PE
Associate, Senior Geophysicist	*Principal, Senior Geotechincal Engineer*

PEF/MRM/mlp

https://golderassociates.sharepoint.com/sites/111347/project files/6 deliverables/final report/19125762 elim geophysical survey final-11.4.19.docx

FIGURES

REGIONAL MAP

ALASKA MAP

(NOT TO SCALE)

NOTES:

1. MAP DATUM: NAD83, ALASKA STATE PLANE ZONE 7 US SURVEY FEET.
2. MAP SOURCES: GOOGLE, 2019 (LOCAL AREA), ALASKA CRUISE AND TOURS (ALASKA MAP).

CLIENT
USACE-ALASKA DISTRICT

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-01
PREPARED	DEH
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

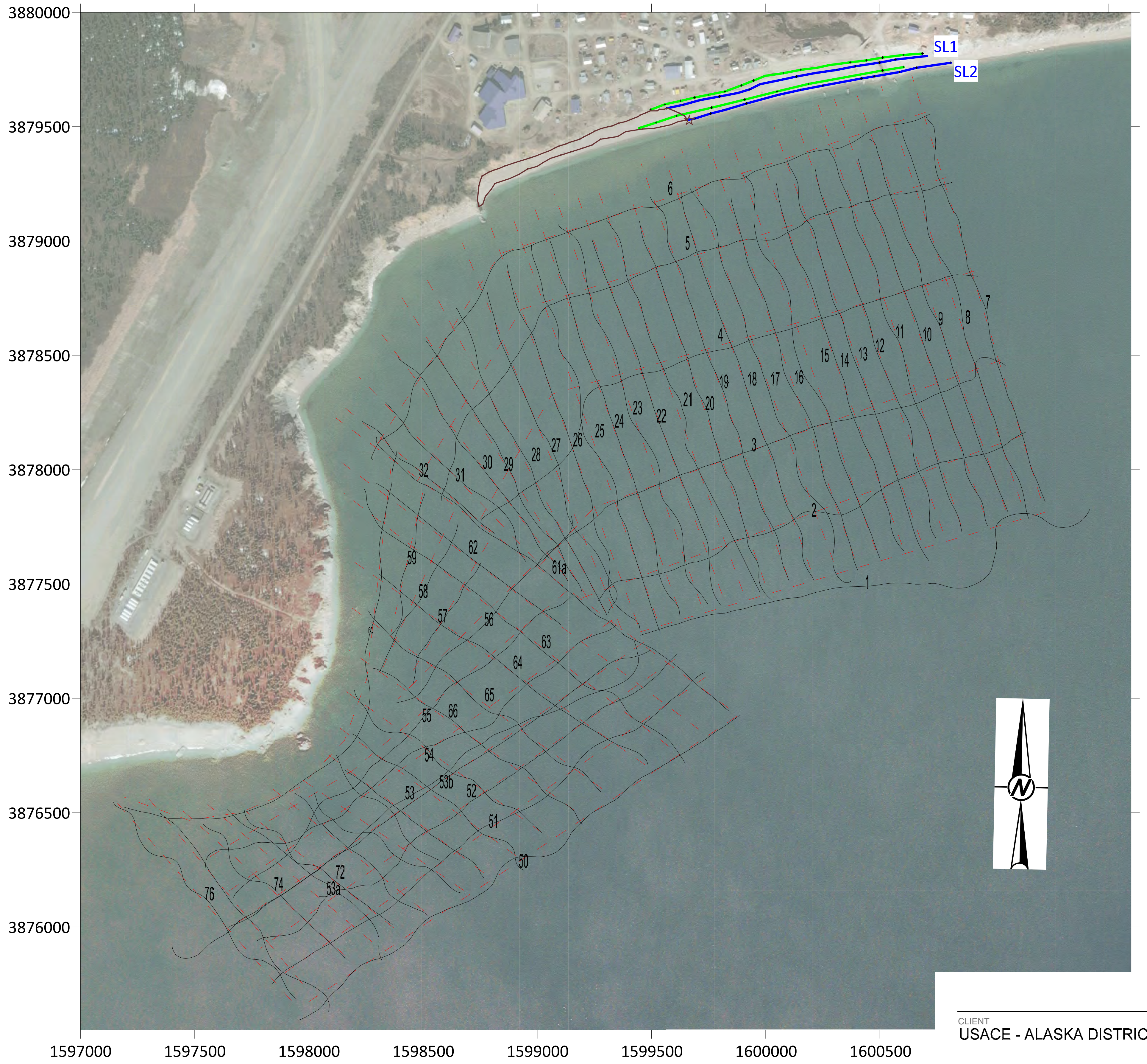
PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

TITLE
SITE LOCATION MAP WITH SURVEY AREA

PROJECT No.	REV	FIGURE
19125762	0	1

19125762 Figure 1.srf | revised: November 01, 2019

0 1 inch IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



LEGEND:

— SURVEY TRACKLINE

- - - PLANNED TRACKLINE

— SEISMIC LINE

— GPR LINE

☆ RFP FIGURE 4
BEDROCK OUTCROP

⬭ AREA OF OUTCROP
NOTED IN FIELD

GRAPHIC SCALE IN FEET

0 500 1000 1500 2000

NOTES:
1. MAP DATUM:
Horizontal is NAD83, Epoch 2002.00, AK SPC Zone 07, U.S. Survey Feet
2. MAP SOURCE: ESRI WORLD IMAGERY

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USACE - ALASKA DISTRICT

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PREPARED	DEH
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

TITLE
TRACKLINE MAP
ELIM BEACH AND AIRPORT POINT

PROJECT No. 19125762
REV 1
FIGURE 2

19125762 Figure 2.srf | revised: November 01, 2019

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1 inch
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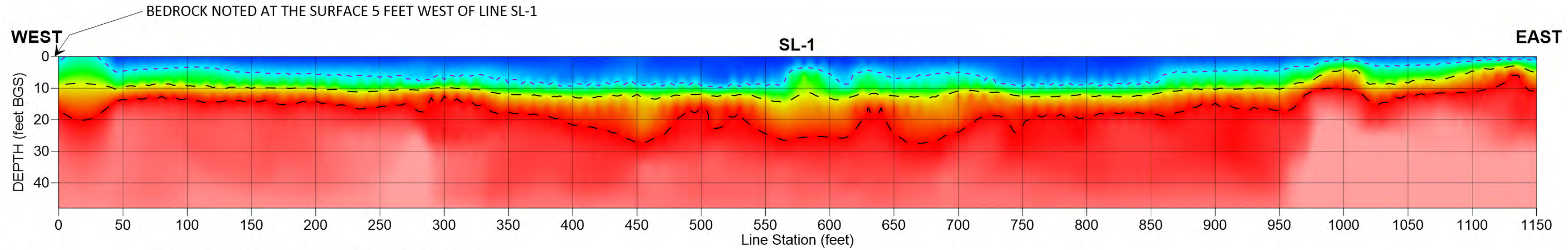
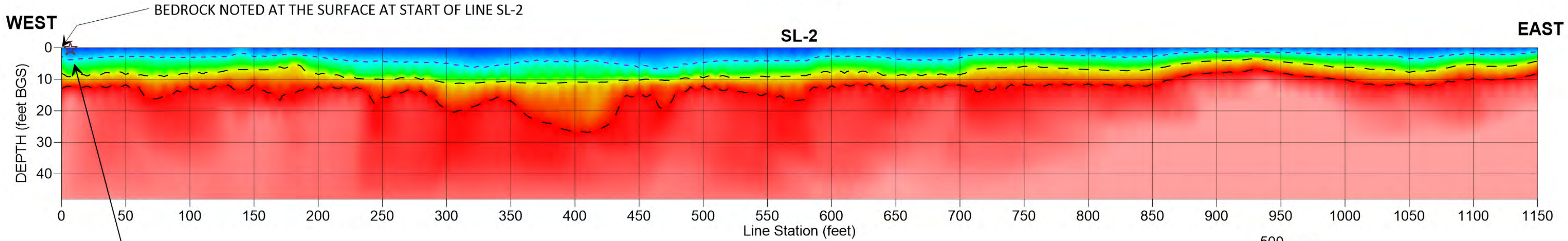
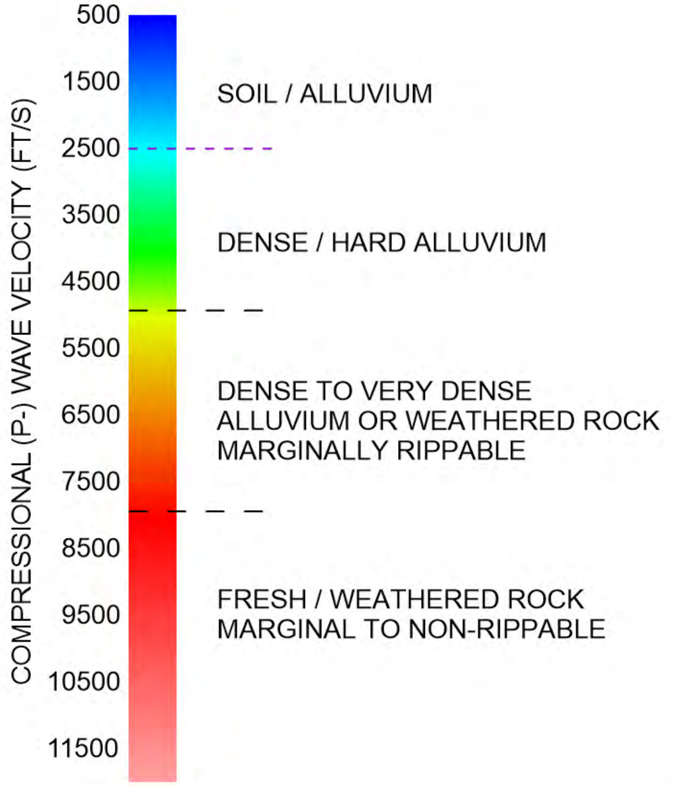

BEDROCK NOTED AT THE SURFACE 5 FEET WEST OF LINE SL-1


BEDROCK NOTED AT THE SURFACE AT START OF LINE SL-2

RFP FIGURE 4: BEDROCK OUTCROP



NOTES

1. Seismic refraction data collected in August 2019 using a 24-channel, Geometrics Geode seismograph, 4.5 Hz geophones & 8-lb hammer source.
2. Seismic data processed and analyzed using OYO SeisImager and Surfer software.
3. Survey objective to map thickness and determine relative strength of surfical sediments.

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PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

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GOLDER

YYYY-MM-DD	2019-11-01
PREPARED	DEH
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

TITLE
ELIM BEACH
SEISMIC REFRACTION VELOCITY MODEL

PROJECT No. 19125762
REV 2
FIGURE 3

19125762 Figure 3.srf | revised: November 01, 2019

1 inch

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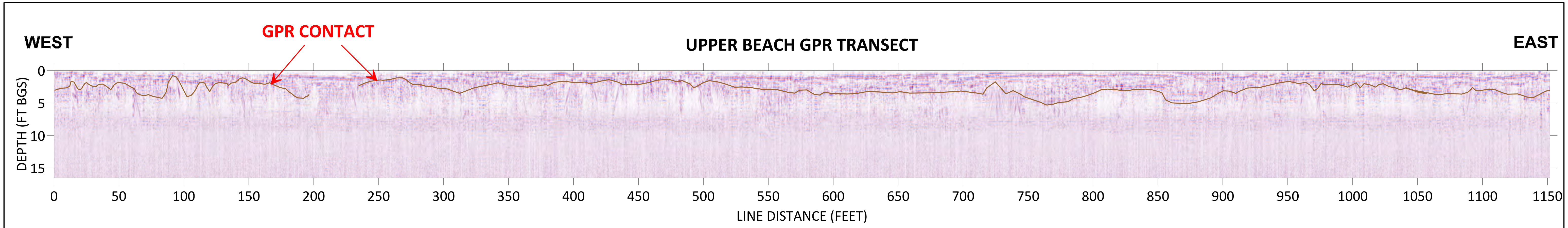

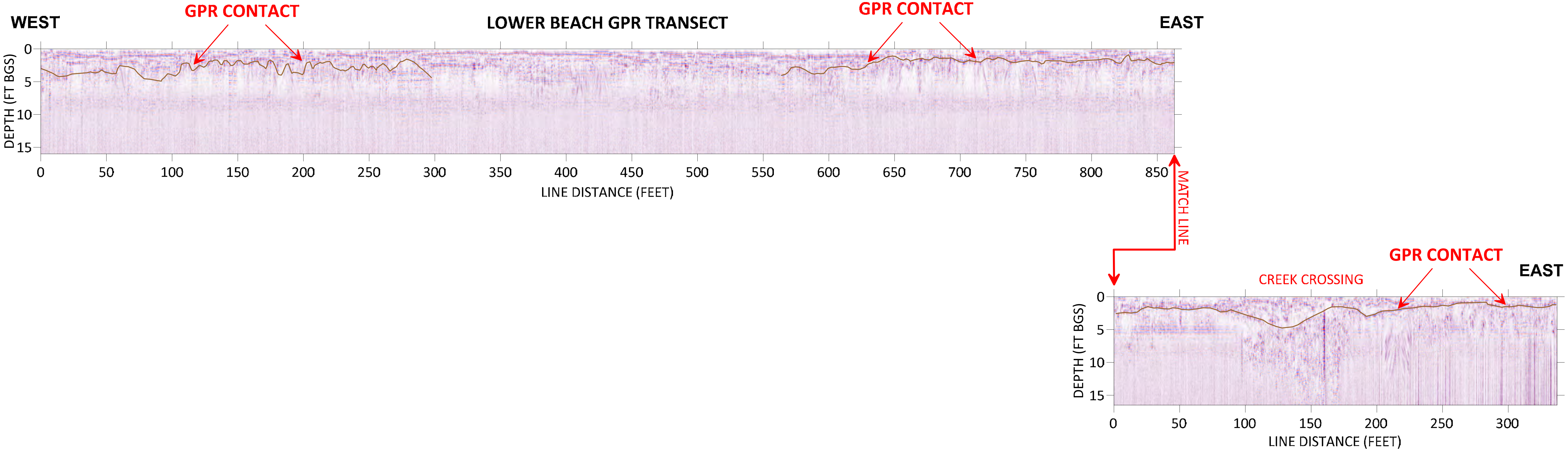

NOTES

1. GPR data collected in August 2019 using a GSSI UtilityScanHS (hyperscan), 350 MHz center frequency and four-wheel rugged card.
2. GPR data processed and analyzed using RADAN 7.1 and Surfer software.
3. Survey objective to map thickness and determine geometry of contact.

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PREPARED	DEH
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

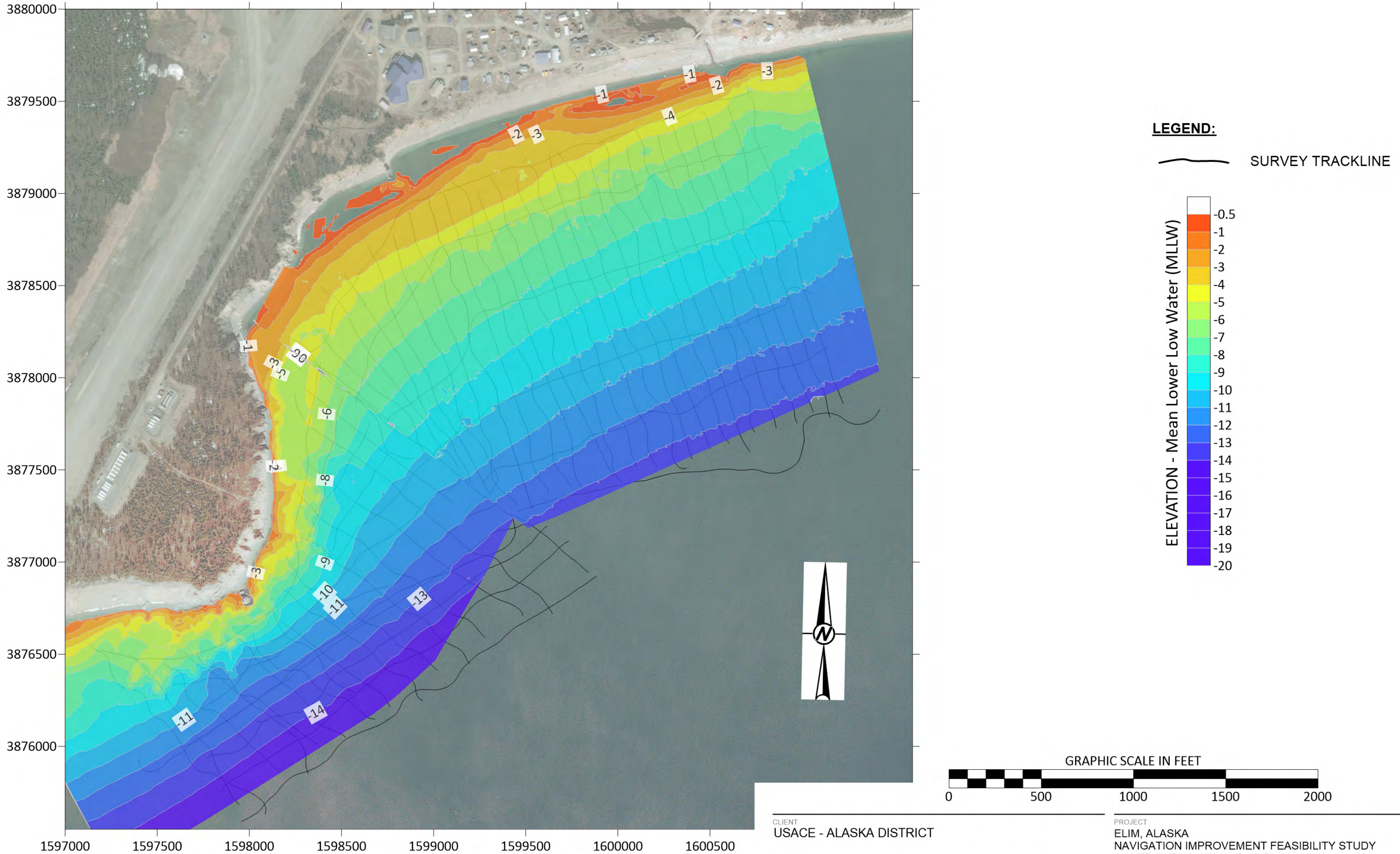
TITLE
ELIM BEACH
GPR PROFILES

PROJECT No.	REV	FIGURE
19125762	0	4

19125762 Figure 4.srf | revised: November 01, 2019

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 1 inch



NOTES:

1. MAP DATUM: Horizontal is NAD83, Epoch 2002.00, AK SPC Zone 07, U.S. Survey Feet
   Elevations are Mean Lower Low Water (MLLW) based on the 1983-2001 tidal epoch in U.S. Feet.
2. MAP SOURCE: ESRI WORLD IMAGERY

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DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

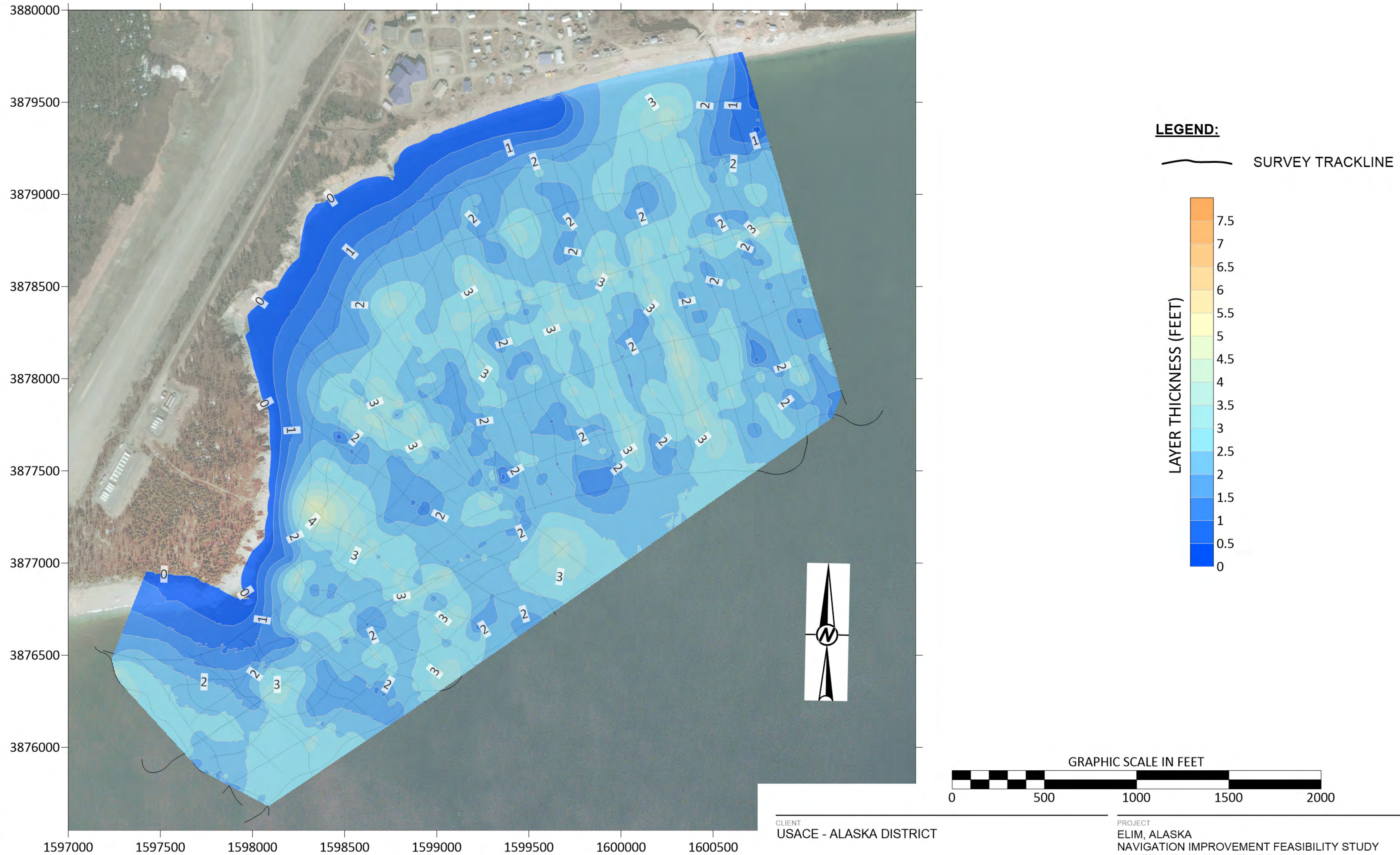
PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

TITLE
BATHYMETRY (BY OTHERS, 2012 & 2019)
ELIM BEACH AND AIRPORT POINT

PROJECT No. 19125762
REV 1
FIGURE 5

19125762 Figure 5.srf | revised: November 01, 2019

0
1 inch
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



NOTES:
1. MAP DATUM:
   Horizontal is NAD83, Epoch 2002.00, AK SPC Zone 07, U.S. Survey Feet
2. MAP SOURCE: ESRI WORLD IMAGERY

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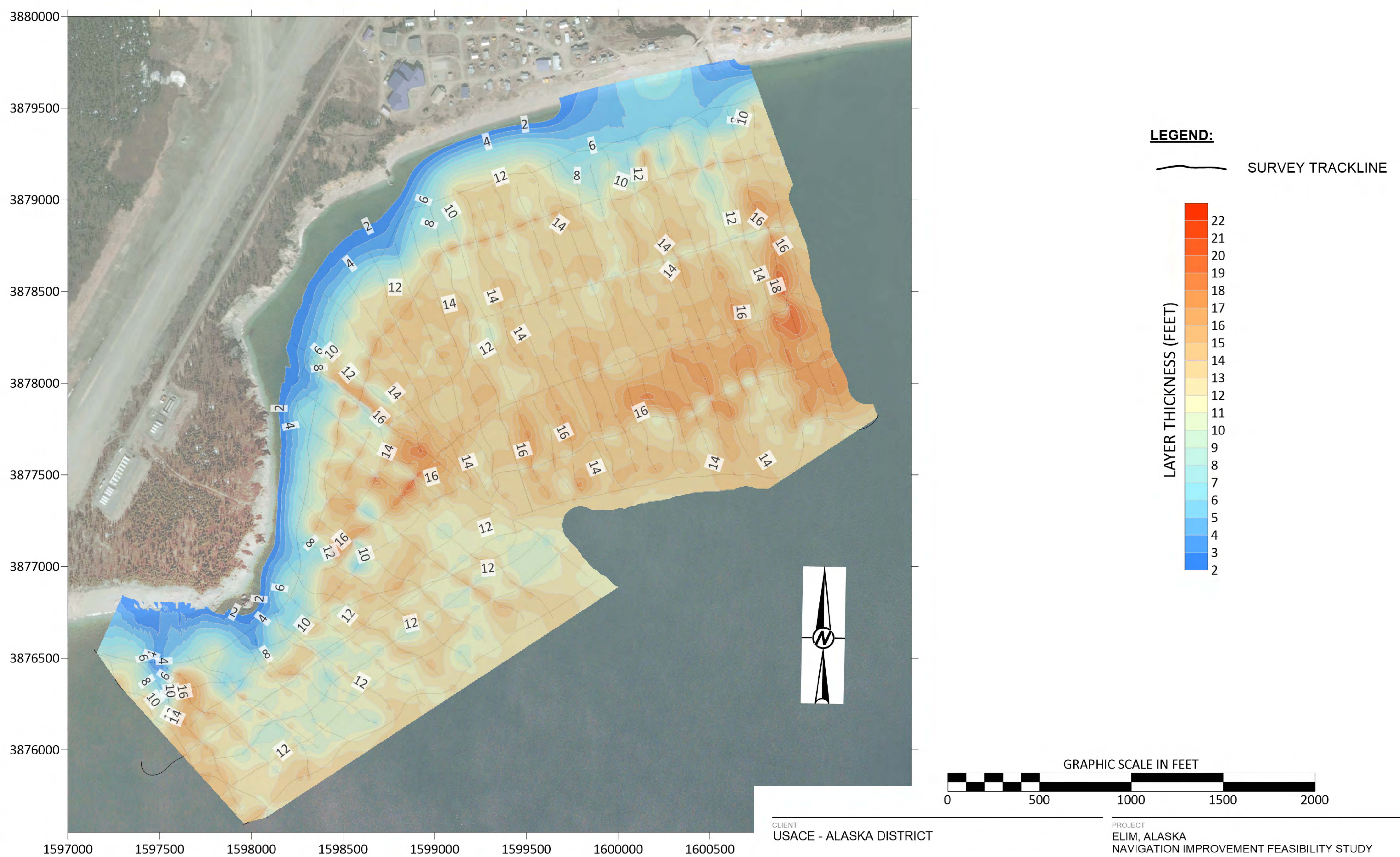
PREPARED	DEH
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

TITLE
UNCONSOLIDATED LAYER THICKNESS
ELIM BEACH AND AIRPORT POINT

PROJECT No. 19125762
REV 1
FIGURE 6

19125762 Figure 6.srf | revised: November 01, 2019

0 1 inch IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



NOTES:

1. MAP DATUM:
   Horizontal is NAD83, Epoch 2002.00, AK SPC Zone 07, U.S. Survey Feet
2. MAP SOURCE: ESRI WORLD IMAGERY

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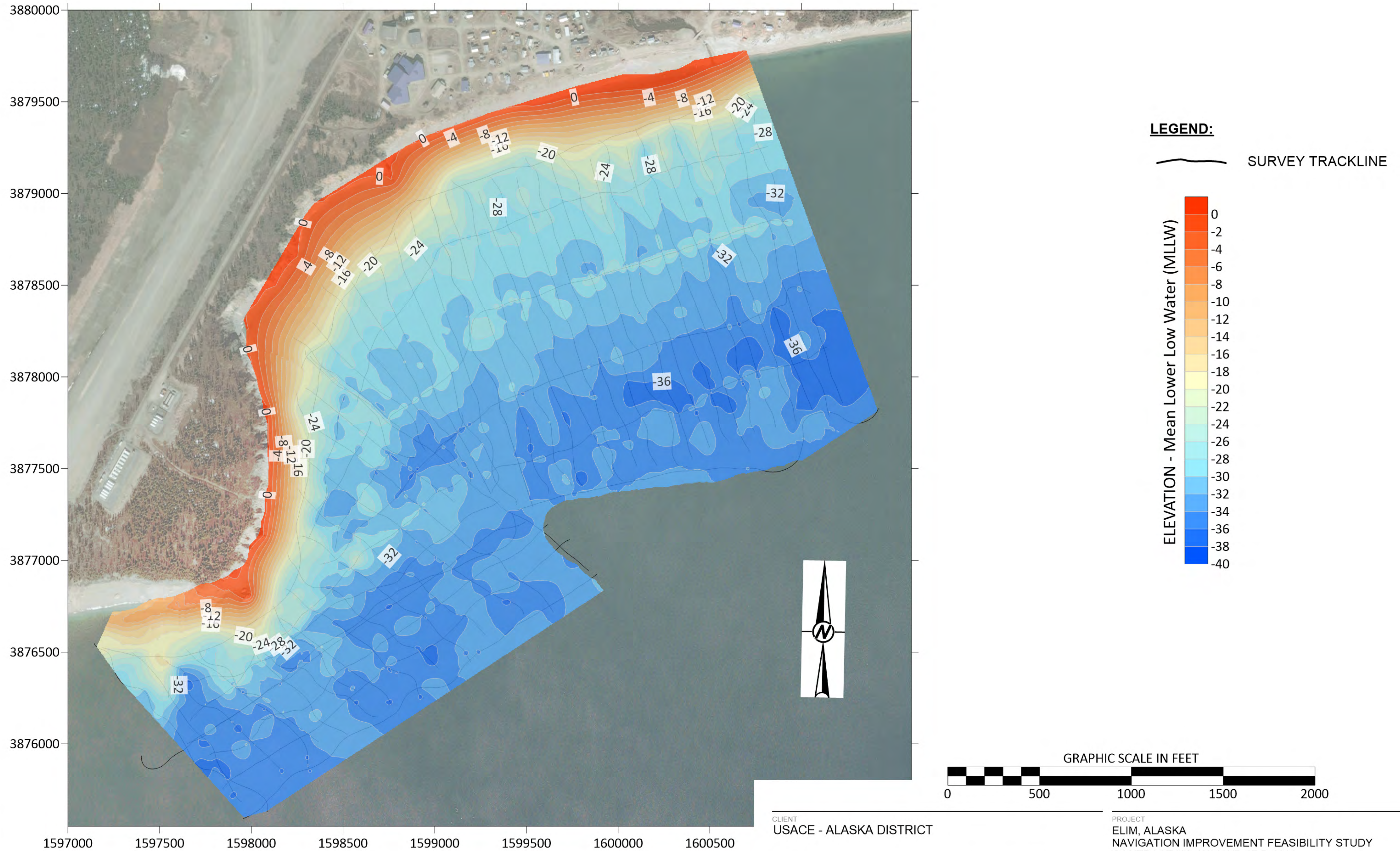
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

TITLE
DEPTH TO ACOUSTIC BASEMENT
ELIM BEACH AND AIRPORT POINT

PROJECT No. 19125762
REV 1
FIGURE 7



NOTES:
1. MAP DATUM:
Horizontal is NAD83, Epoch 2002.00, AK SPC Zone 07, U.S. Survey Feet
2. MAP SOURCE: ESRI WORLD IMAGERY

CLIENT
USACE - ALASKA DISTRICT

PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-01
PREPARED	DEH
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

TITLE
ACOUSTIC BASEMENT ELEVATION
ELIM BEACH AND AIRPORT POINT

PROJECT No.
19125762

REV
1

FIGURE
8

NOTES:

1. MAP DATUM: Horizontal is NAD83, Epoch 2002.00, AK SPC Zone 07, U.S. Survey Feet
2. MAP SOURCE: ESRI WORLD IMAGERY
3. SIDESCAN DATA SHADED LIGHT INDICATES HIGH AMPLITUDE RETURN, DARK IS LOW AMPLITUDE RETURN.

CLIENT
USACE - ALASKA DISTRICT

PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-01
PREPARED	DEH
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

TITLE
SIDESCAN MOSAIC
ELIM BEACH AND AIRPORT POINT

PROJECT No.	REV	FIGURE
19125762	0	9

1 inch

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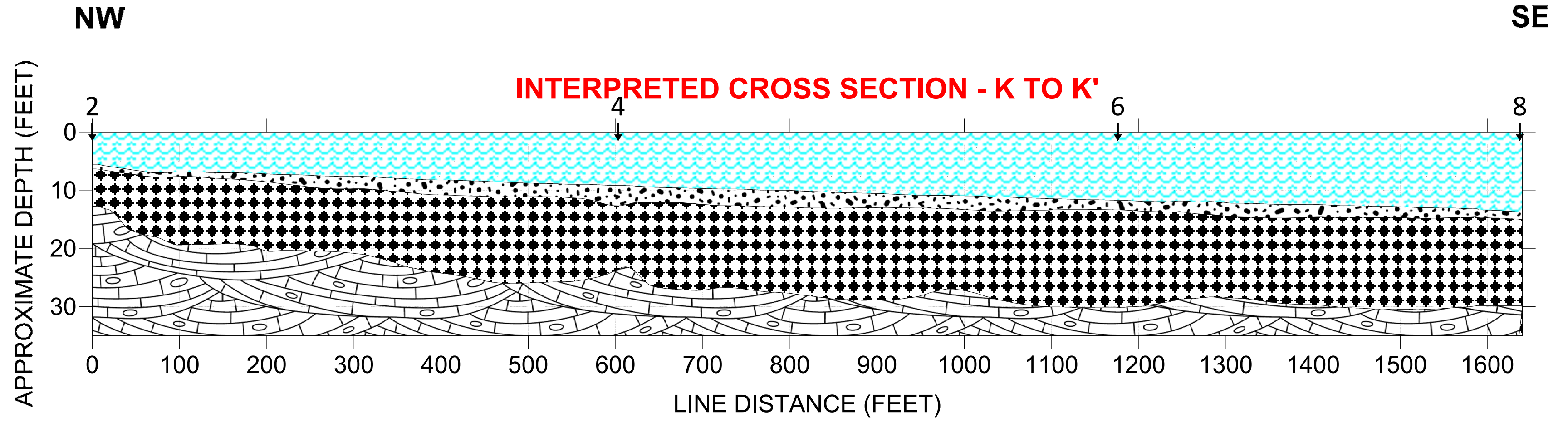
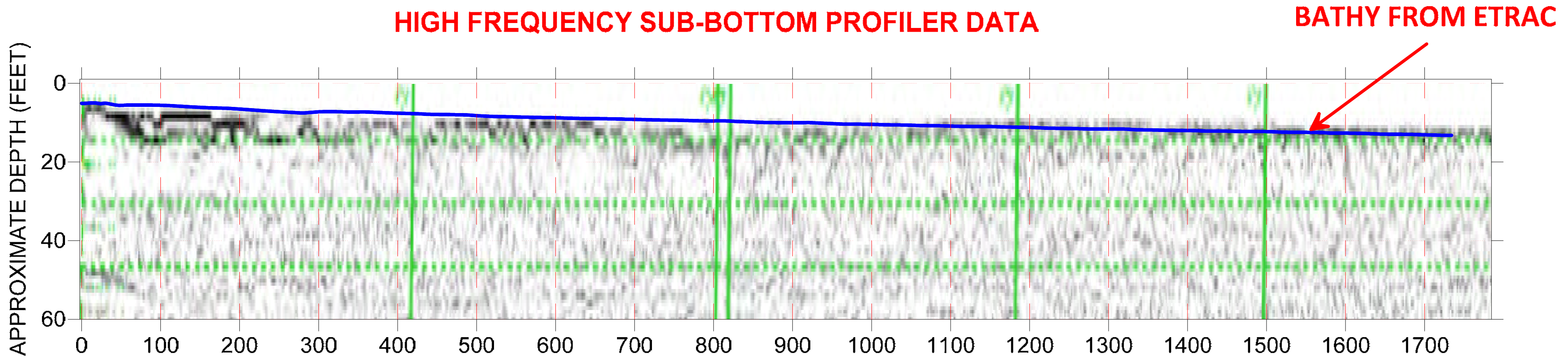
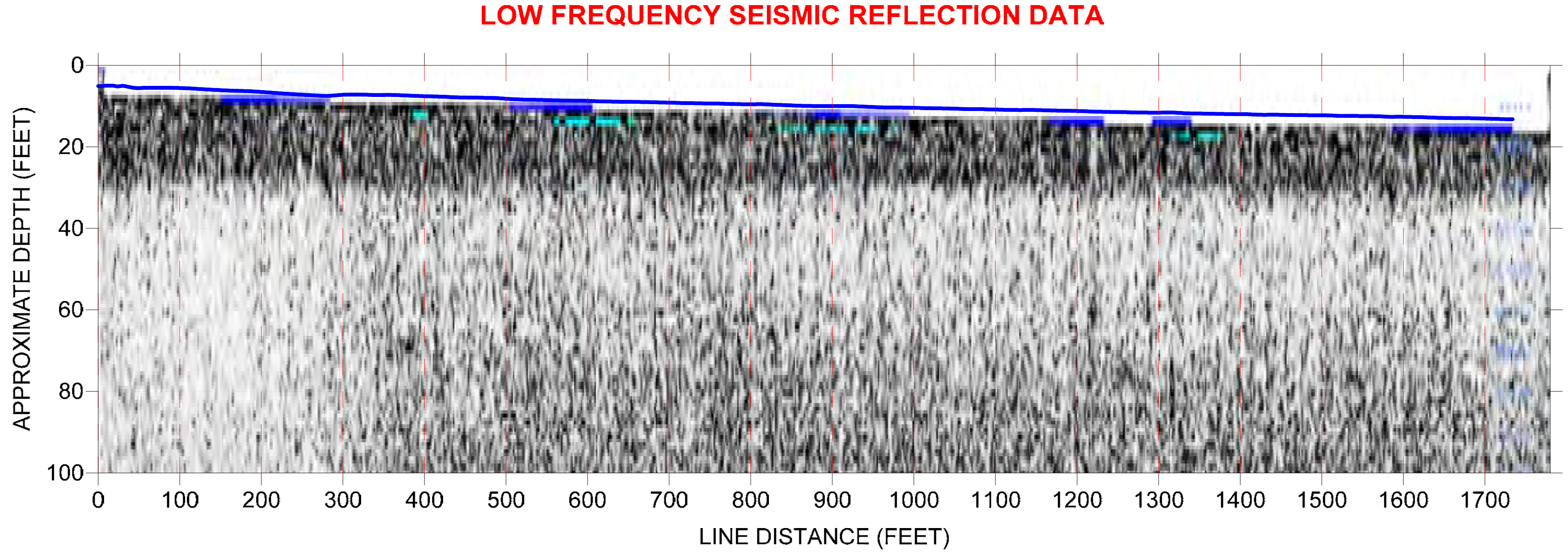
19125762 Figure 5.srf | revised: November 01, 2019



LEGEND

- WATER
- SAND/SILT/GRAVEL LOOSE TO MEDIUM DENSE
- METACALCARIOUS ROCK





NOTES:

1. DEPTH DETERMINED USING 4,890 fps WATER VELOCITY
2. HIGH FREQUENCY SUB-BOTTOM DATA ACQUIRED WITH DATASONICS SBT-2200
3. LOW FREQUENCY SEISMIC REFLECTION DATA ACQUIRED WITH DATASONICS SPR-1200

CLIENT
USACE - ALASKA DISTRICT

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-01
PREPARED	DEH
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

TITLE
ELIM BEACH TRACKLINE 7 EXAMPLE
NEAR CROSS-SECTION K-K'

PROJECT No.	REV	FIGURE
19125762	0	10

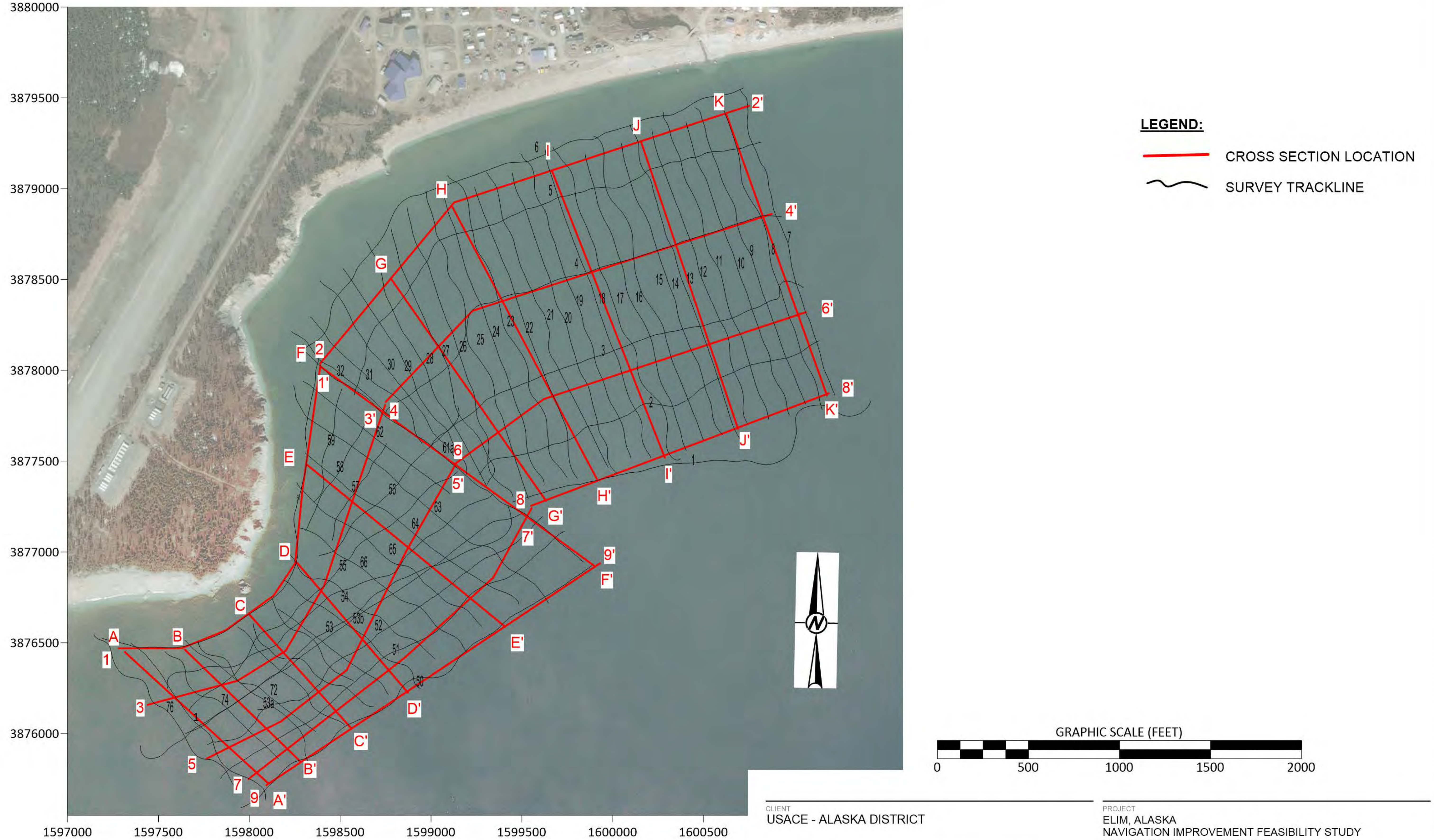
19125762 Figure 10.srf | revised: November 01, 2019

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

1 inch
0

APPENDIX A

Interpreted Geologic Cross Sections



NOTES:
1. MAP DATUM:
   Horizontal is NAD83, Epoch 2002.00, AK SPC Zone 07, U.S. Survey Feet
2. MAP SOURCE: ESRI WORLD IMAGERY

CLIENT
USACE - ALASKA DISTRICT

PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

CONSULTANT
GOLDER

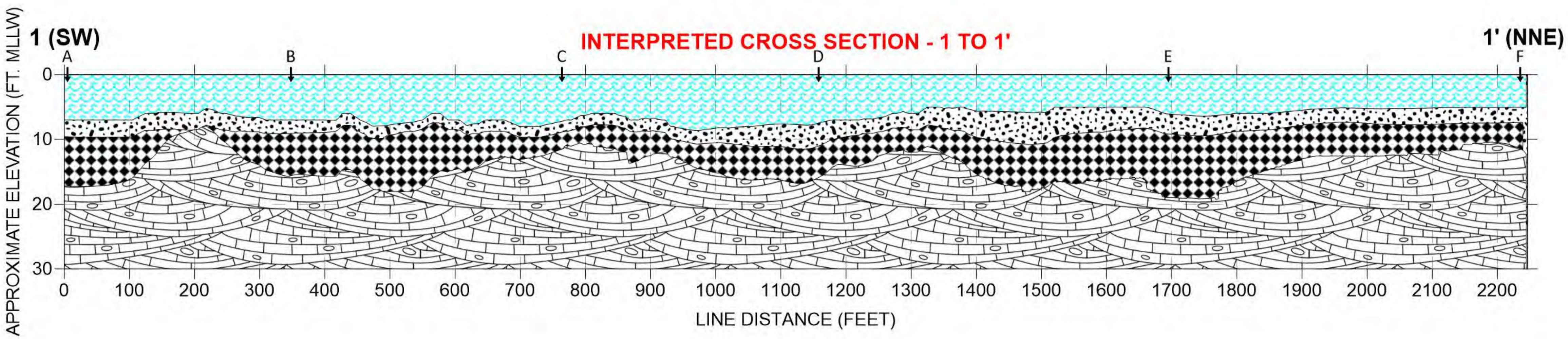
YYYY-MM-DD	2019-11-01
PREPARED	DEH
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

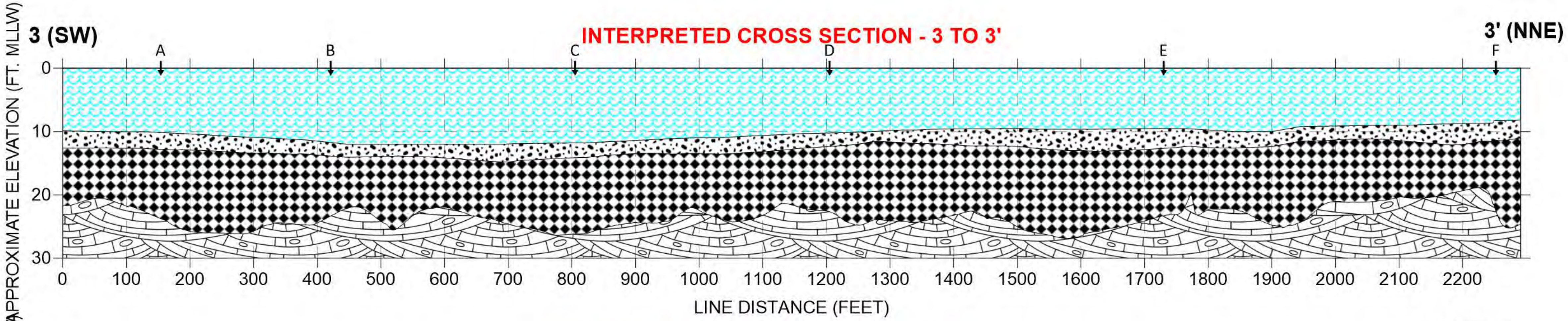
TITLE
INTERPRETED GEOLOGIC CROSS SECTION MAP
ELIM BEACH AND AIRPORT POINT

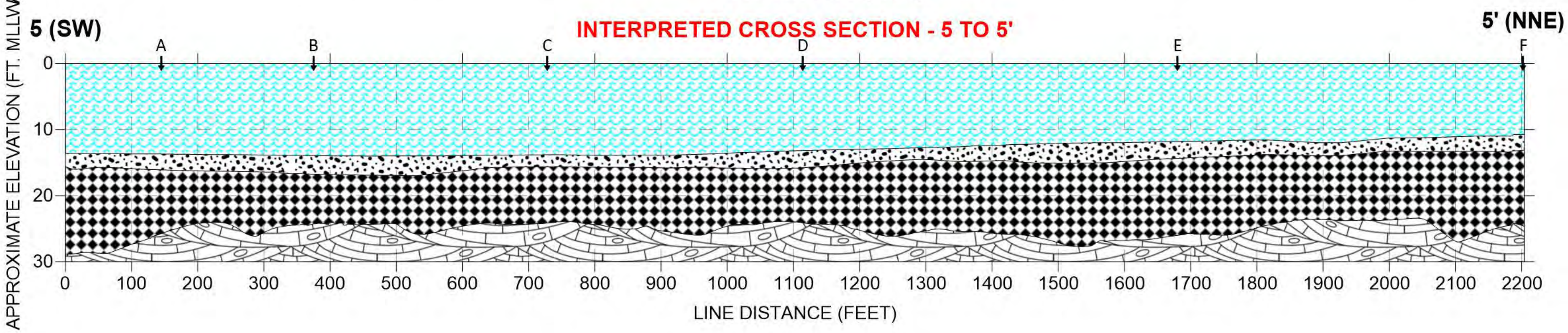
PROJECT No. 19125762
REV 1
FIGURE A-1

19125762 Figure A-1.srf | revised: November 01, 2019

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
1 inch
0


INTERPRETED CROSS SECTION - 1 TO 1'


INTERPRETED CROSS SECTION - 3 TO 3'


INTERPRETED CROSS SECTION - 5 TO 5'

LEGEND

▨ WATER

⁙ SAND/SILT/GRAVEL LOOSE TO MEDIUM DENSE

▦ DENSE/CONSOLIDATED SEDIMENTS OR WEATHERED ROCK

▤ ACOUSTIC BASEMENT (METACALCARIOUS ROCK?)

NOTES:

1. SUBSURFACE DEPTHS DETERMINED USING 5,000 fps SEDIMENT VELOCITY
2. HIGH FREQUENCY SUB-BOTTOM DATA ACQUIRED WITH DATASONICS SBT-2200
3. LOW FREQUENCY SEISMIC REFLECTION DATA ACQUIRED WITH DATASONICS SPR-1200
4. COMPOSITE BATHYMETRY FROM OTHERS (2012 and 2019)

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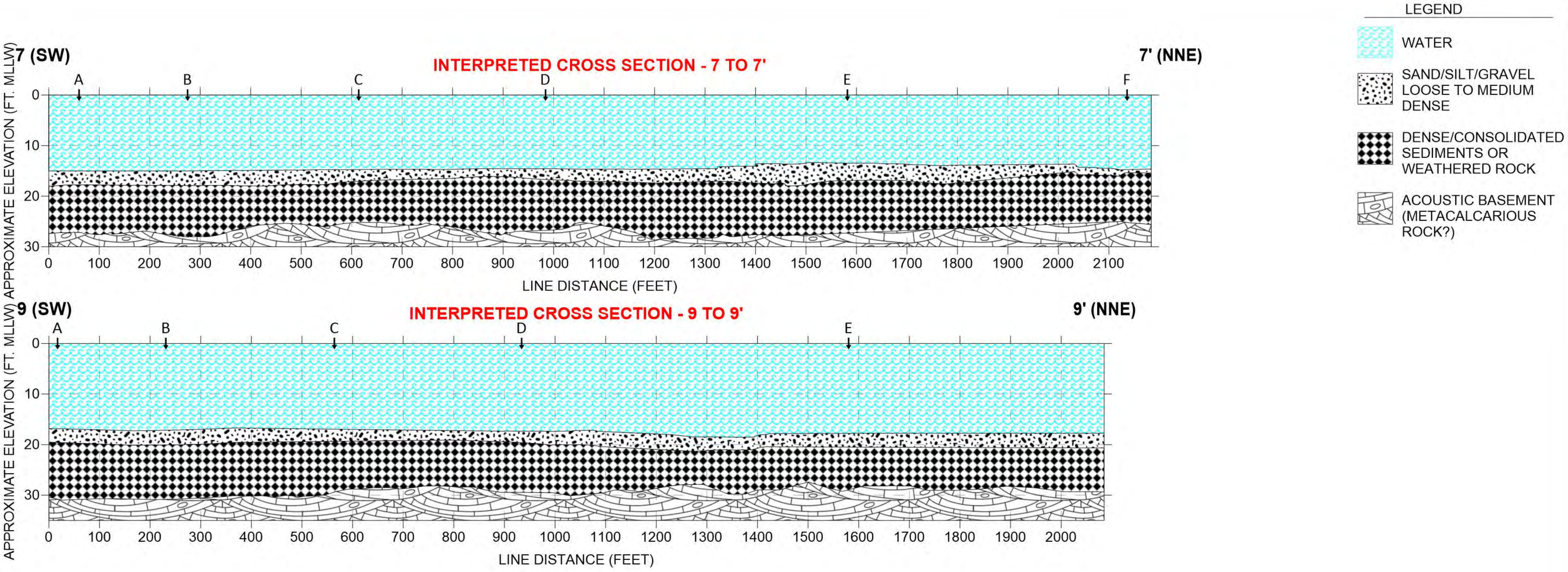
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

TITLE
AIRPORT POINT CROSS SECTIONS
1, 3, AND 5

PROJECT No. 19125762
REV 1
FIGURE A-2



NOTES:

1. SUBSURFACE DEPTHS DETERMINED USING 5,000 fps SEDIMENT VELOCITY
2. HIGH FREQUENCY SUB-BOTTOM DATA ACQUIRED WITH DATASONICS SBT-2200
3. LOW FREQUENCY SEISMIC REFLECTION DATA ACQUIRED WITH DATASONICS SPR-1200
4. COMPOSITE BATHYMETRY FROM OTHERS (2012 and 2019)

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REVIEW	PEF
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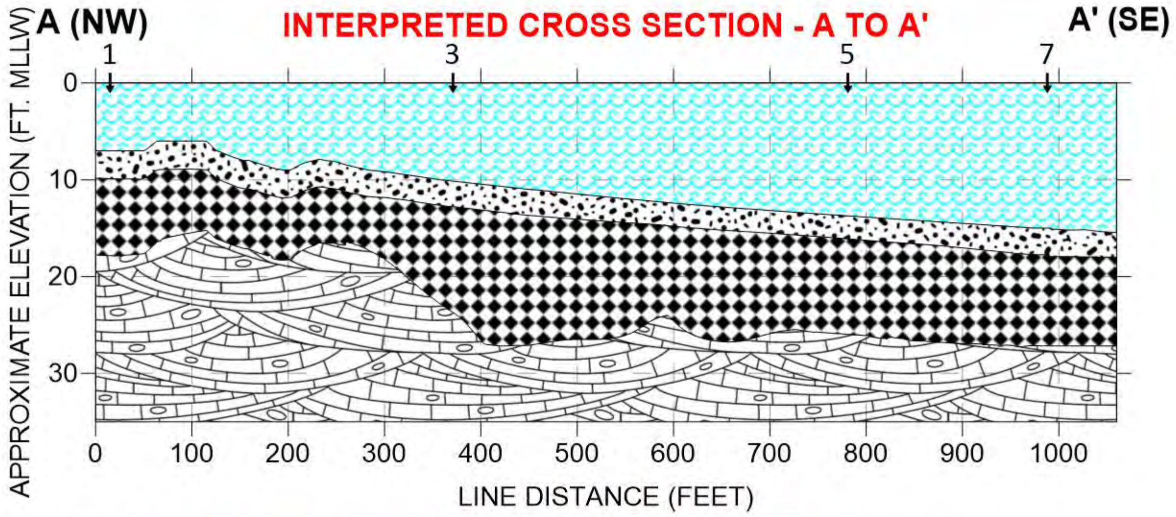
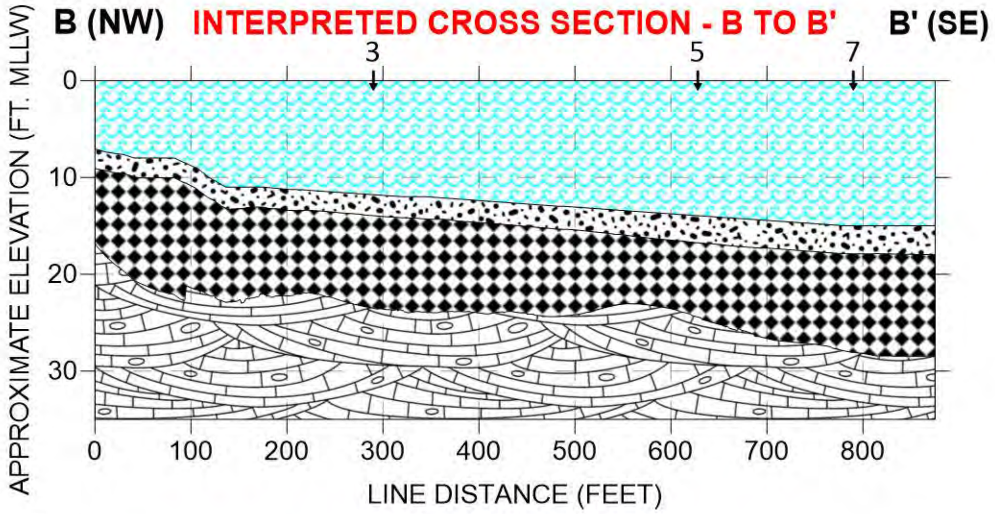
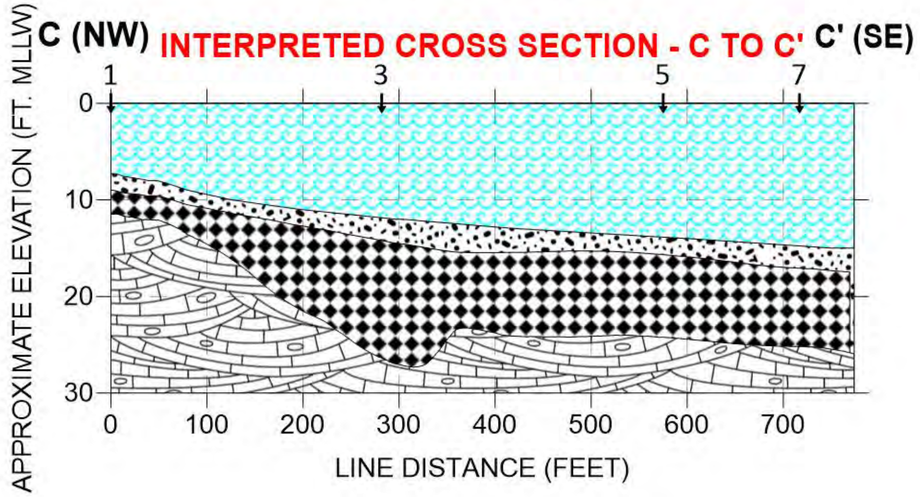
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

TITLE
AIRPORT POINT CROSS SECTIONS
7 AND 9

PROJECT No. 19125762
REV 1
FIGURE A-3


INTERPRETED CROSS SECTION - A TO A'


INTERPRETED CROSS SECTION - B TO B'


INTERPRETED CROSS SECTION - C TO C'

LEGEND

▨	WATER
▨	SAND/SILT/GRAVEL LOOSE TO MEDIUM DENSE
▨	DENSE/CONSOLIDATED SEDIMENTS OR WEATHERED ROCK
▨	ACOUSTIC BASEMENT (METACALCARIOUS ROCK?)

NOTES:

1. SUBSURFACE DEPTHS DETERMINED USING 5,000 fps SEDIMENT VELOCITY
2. HIGH FREQUENCY SUB-BOTTOM DATA ACQUIRED WITH DATASONICS SBT-2200
3. LOW FREQUENCY SEISMIC REFLECTION DATA ACQUIRED WITH DATASONICS SPR-1200
4. COMPOSITE BATHYMETRY FROM OTHERS (2012 and 2019)

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USACE - ALASKA DISTRICT

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PREPARED	DEH
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

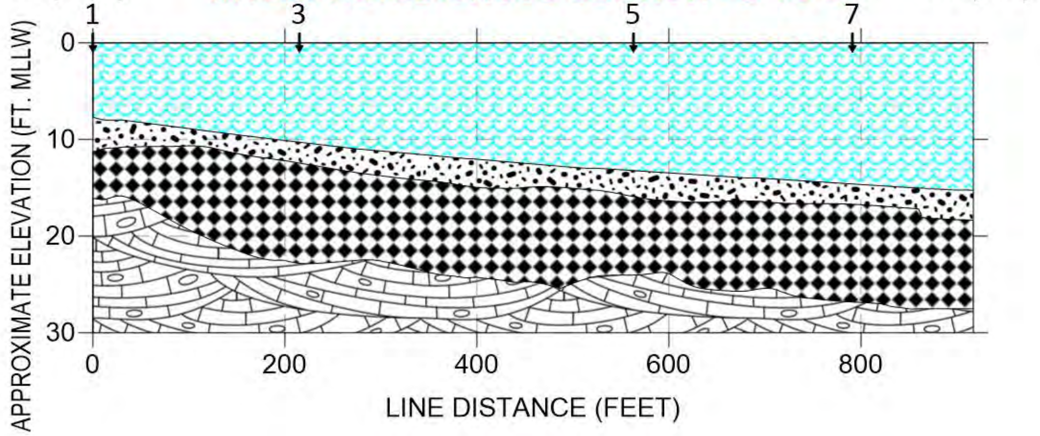
TITLE
AIRPORT POINT CROSS SECTIONS
A, B, AND C

PROJECT No.	REV	FIGURE
19125762	1	A-4

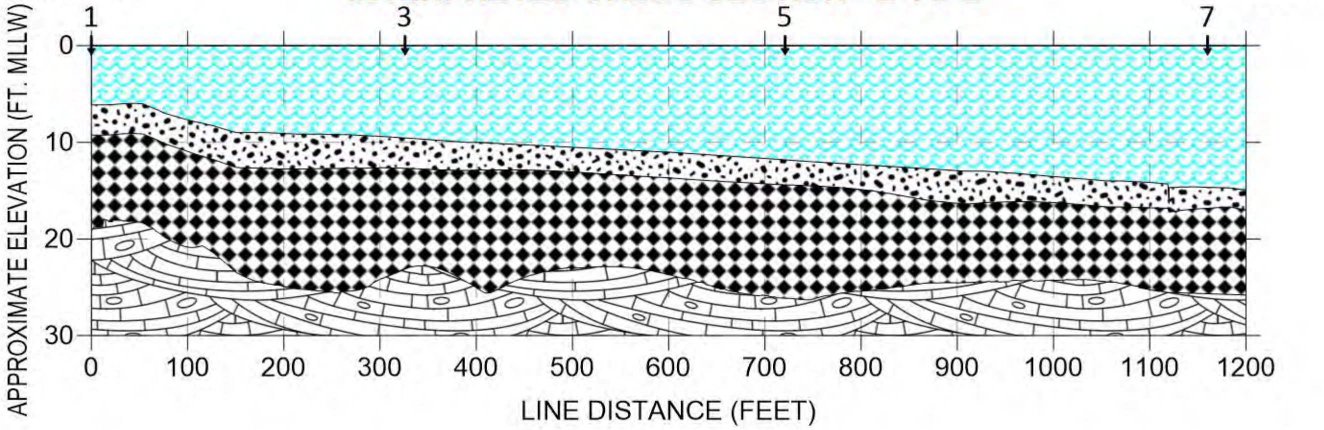
19125762 Figure A-4.srf | revised: November 01, 2019

1 inch
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

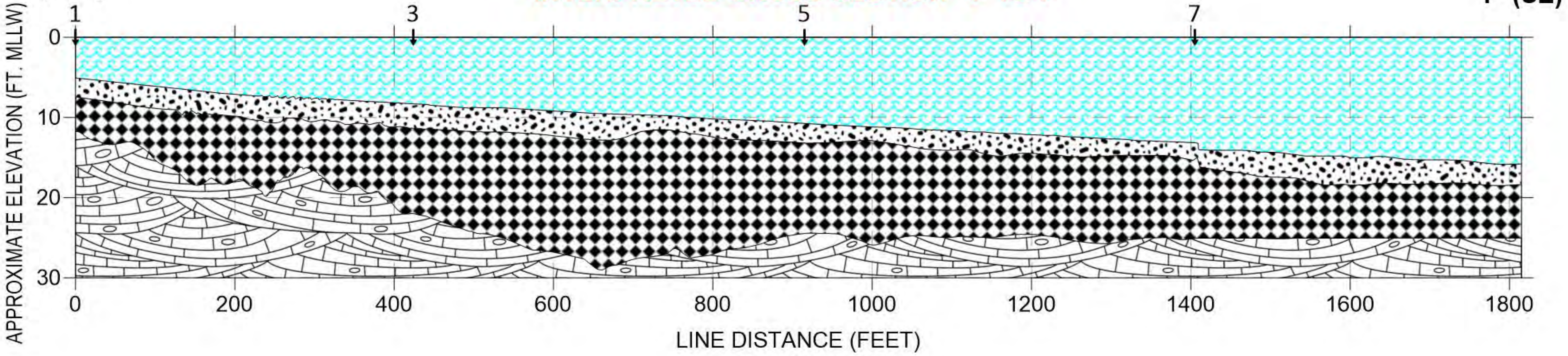
INTERPRETED CROSS SECTION - D TO D'



INTERPRETED CROSS SECTION - E TO E'



INTERPRETED CROSS SECTION - F TO F'



LEGEND

- ▨ WATER
- ▨ SAND/SILT/GRAVEL LOOSE TO MEDIUM DENSE
- ▩ DENSE/CONSOLIDATED SEDIMENTS OR WEATHERED ROCK
- ▨ ACOUSTIC BASEMENT (METACALCARIOUS ROCK?)

NOTES:

1. SUBSURFACE DEPTHS DETERMINED USING 5,000 fps SEDIMENT VELOCITY
2. HIGH FREQUENCY SUB-BOTTOM DATA ACQUIRED WITH DATASONICS SBT-2200
3. LOW FREQUENCY SEISMIC REFLECTION DATA ACQUIRED WITH DATASONICS SPR-1200
4. COMPOSITE BATHYMETRY FROM OTHERS (2012 and 2019)

19125762 Figure A-5.srf | revised: November 01, 2019

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DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

TITLE
AIRPORT POINT CROSS SECTIONS
D, E, AND F

PROJECT No. 19125762
REV 1
FIGURE A-5

LEGEND

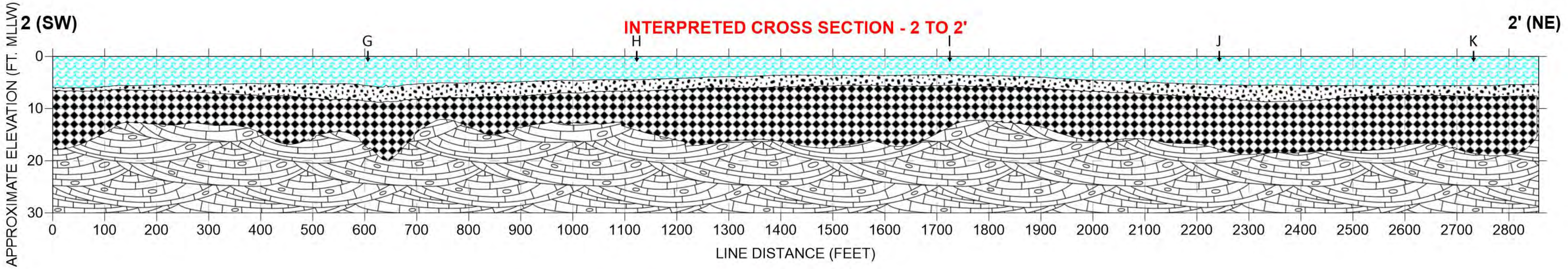
▨ WATER

▨ SAND/SILT/GRAVEL LOOSE TO MEDIUM DENSE

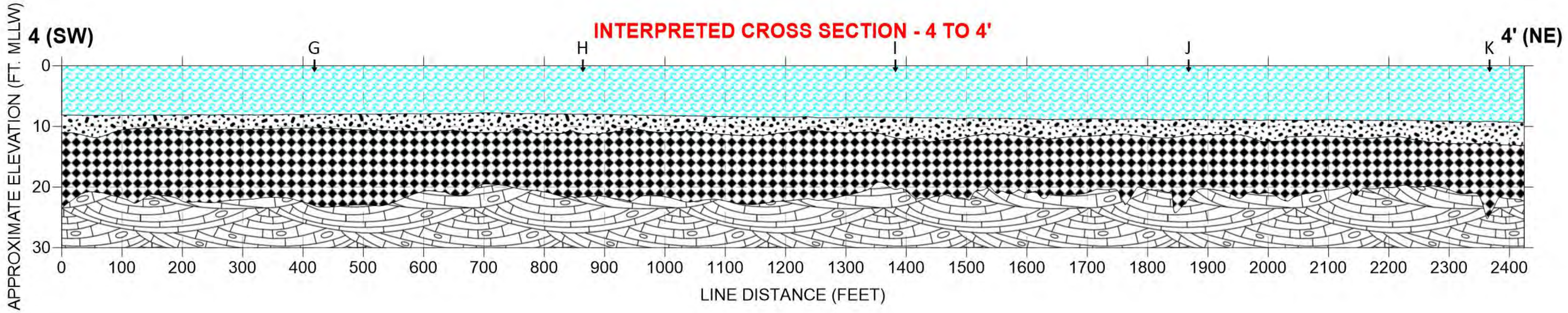
▨ DENSE/CONSOLIDATED SEDIMENTS OR WEATHERED ROCK

▨ ACOUSTIC BASEMENT (METACALCARIOUS ROCK?)

INTERPRETED CROSS SECTION - 2 TO 2'



INTERPRETED CROSS SECTION - 4 TO 4'



NOTES:

1. SUBSURFACE DEPTHS DETERMINED USING 5,000 fps SEDIMENT VELOCITY
2. HIGH FREQUENCY SUB-BOTTOM DATA ACQUIRED WITH DATASONICS SBT-2200
3. LOW FREQUENCY SEISMIC REFLECTION DATA ACQUIRED WITH DATASONICS SPR-1200
4. COMPOSITE BATHYMETRY FROM OTHERS (2012 and 2019)

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YYYY-MM-DD	2019-11-01
PREPARED	DEH
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

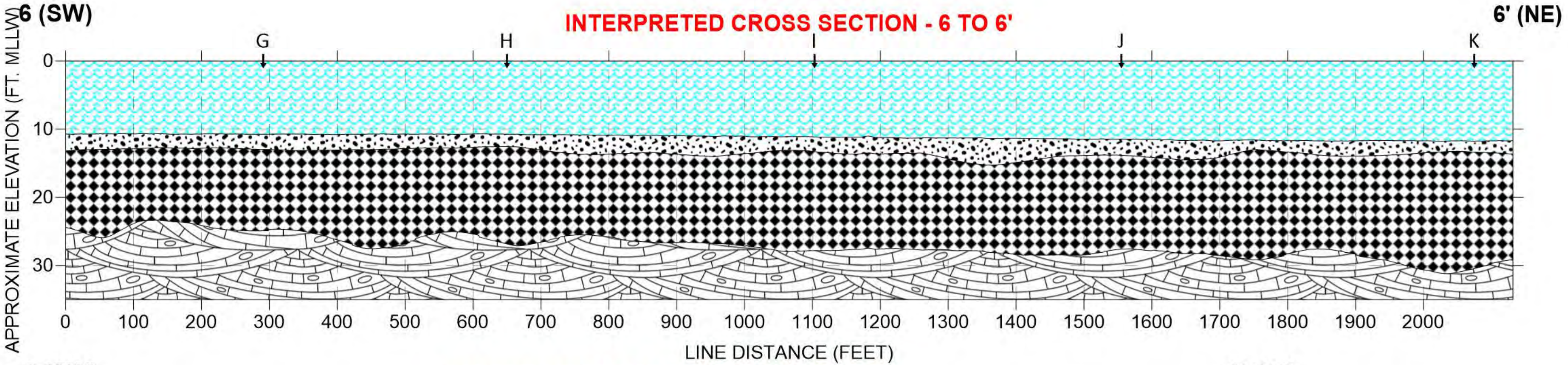
TITLE
ELIM BEACH CROSS SECTIONS 2 AND 4

PROJECT No.	REV	FIGURE
19125762	1	A-6

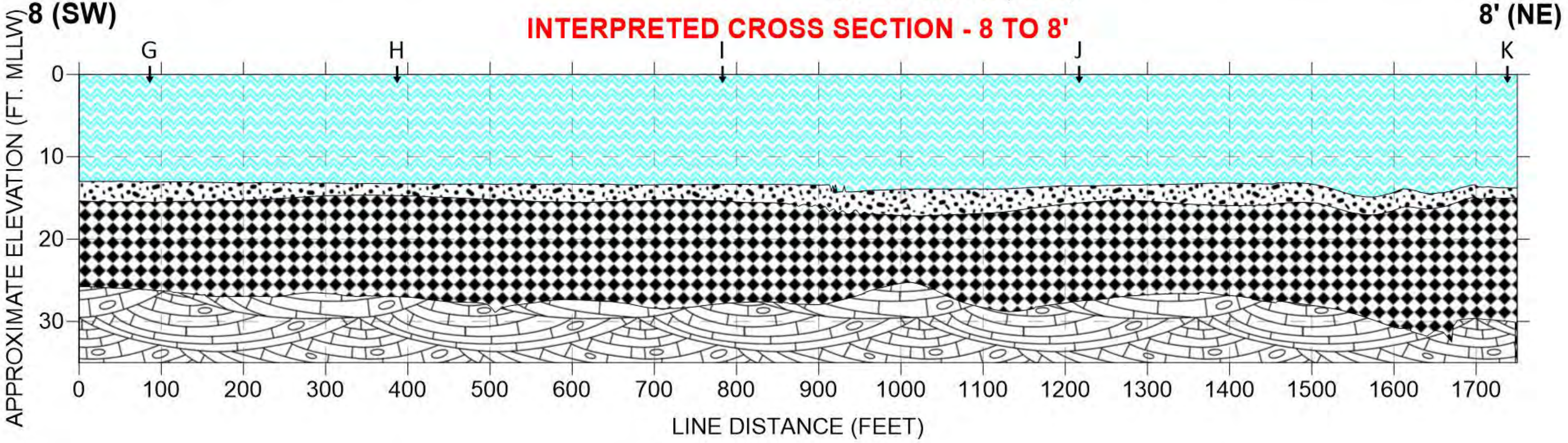
LEGEND

- ▨ WATER
- ▨ SAND/SILT/GRAVEL LOOSE TO MEDIUM DENSE
- ▨ DENSE/CONSOLIDATED SEDIMENTS OR WEATHERED ROCK
- ▨ ACOUSTIC BASEMENT (METACALCARIOUS ROCK?)

INTERPRETED CROSS SECTION - 6 TO 6'



INTERPRETED CROSS SECTION - 8 TO 8'



NOTES:

1. SUBSURFACE DEPTHS DETERMINED USING 5,000 fps SEDIMENT VELOCITY
2. HIGH FREQUENCY SUB-BOTTOM DATA ACQUIRED WITH DATASONICS SBT-2200
3. LOW FREQUENCY SEISMIC REFLECTION DATA ACQUIRED WITH DATASONICS SPR-1200
4. COMPOSITE BATHYMETRY FROM OTHERS (2012 and 2019)

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DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

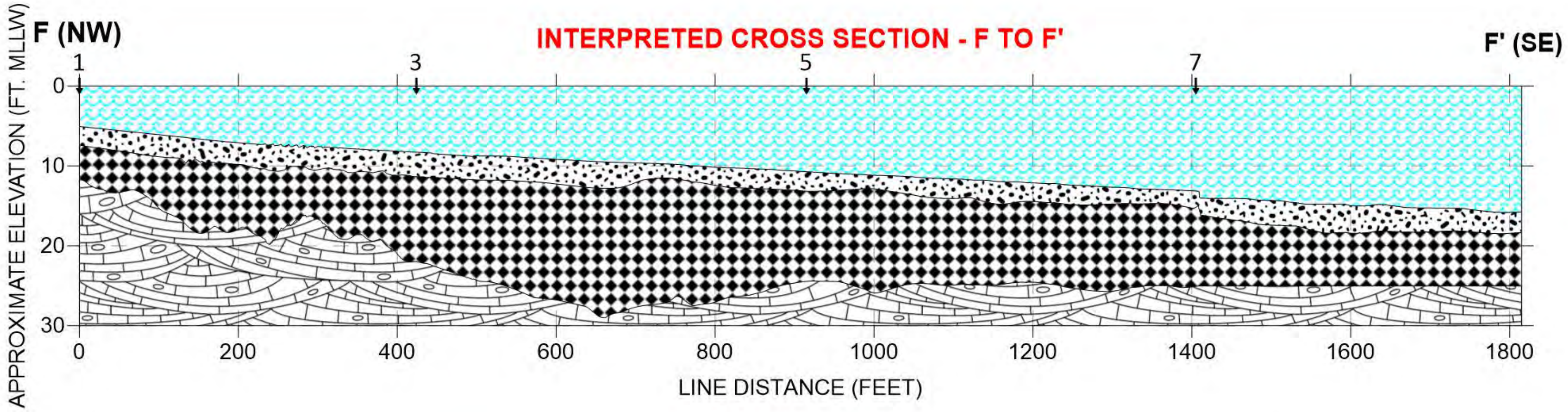
TITLE
ELIM BEACH CROSS SECTIONS
6 AND 8

PROJECT No.
19125762

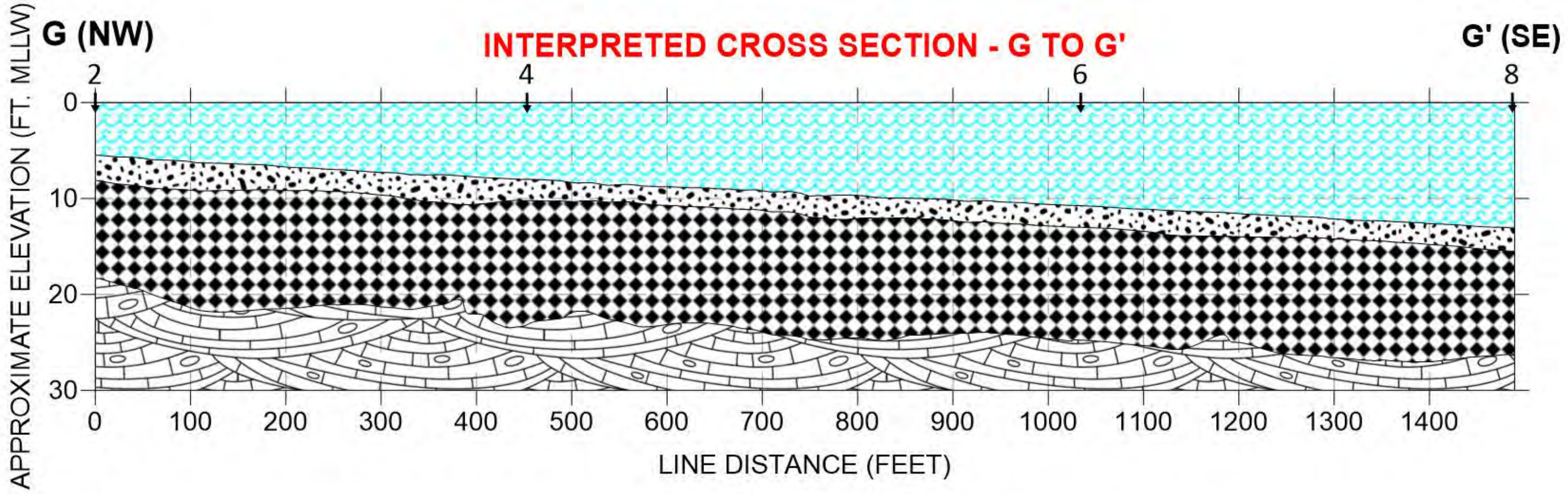
REV
1

FIGURE
A-7

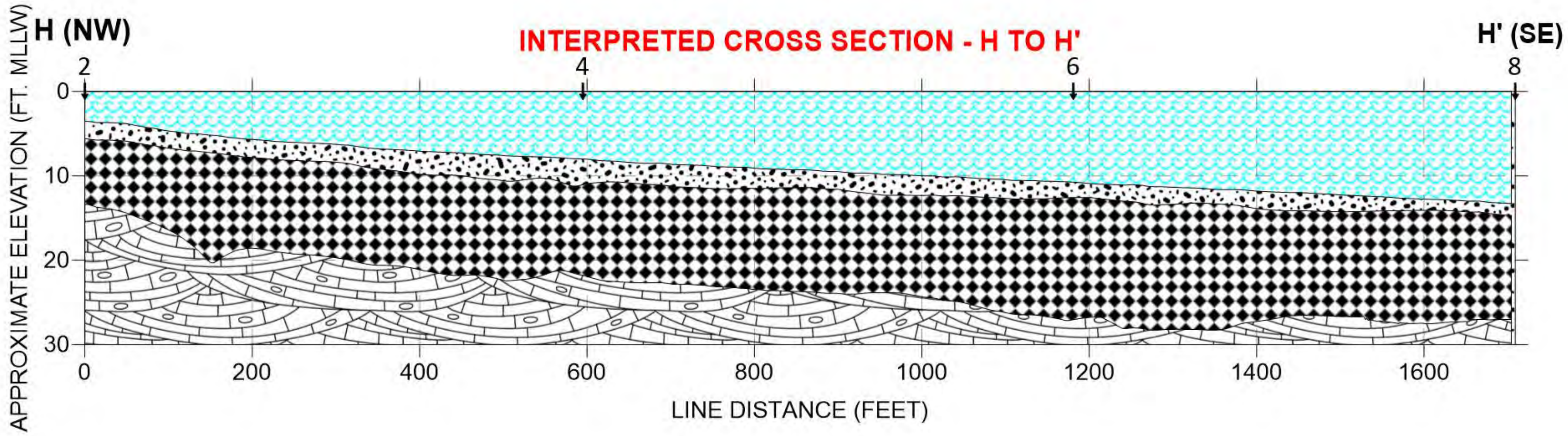
INTERPRETED CROSS SECTION - F TO F'



INTERPRETED CROSS SECTION - G TO G'



INTERPRETED CROSS SECTION - H TO H'



LEGEND

- ▒ WATER
- ⁘ SAND/SILT/GRAVEL LOOSE TO MEDIUM DENSE
- ▦ DENSE/CONSOLIDATED SEDIMENTS OR WEATHERED ROCK
- ▨ ACOUSTIC BASEMENT (METACALCARIOUS ROCK?)

NOTES:

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3. LOW FREQUENCY SEISMIC REFLECTION DATA ACQUIRED WITH DATASONICS SPR-1200
4. COMPOSITE BATHYMETRY FROM OTHERS (2012 and 2019)

19125762 Figure A-8.srf | revised: November 01, 2019

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PREPARED	DEH
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

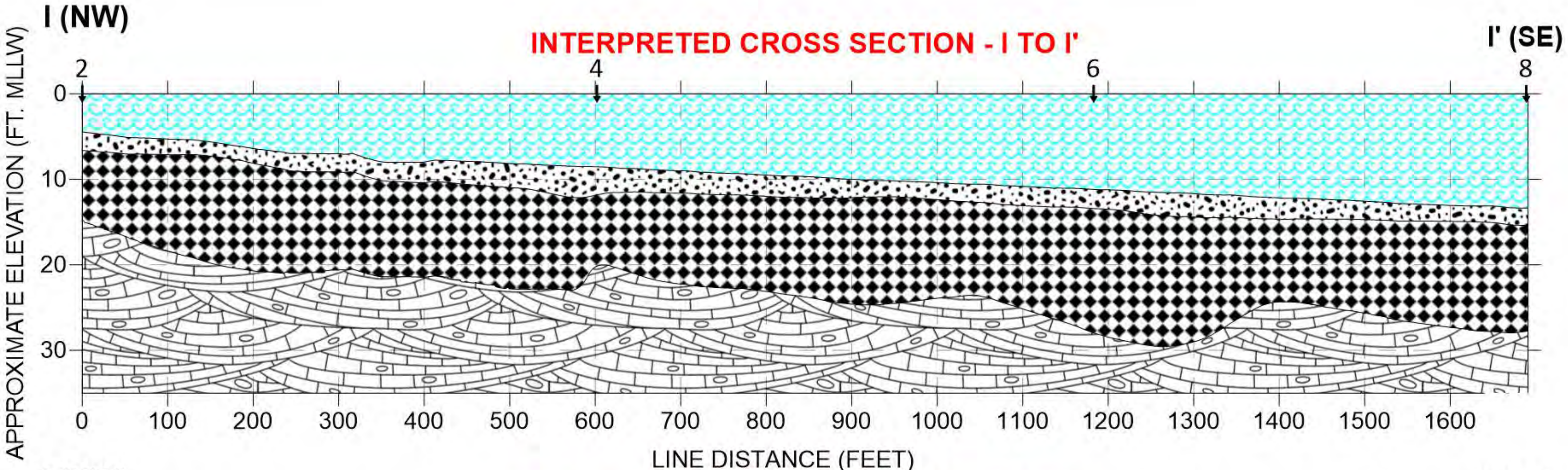
TITLE
ELIM BEACH CROSS SECTIONS
F, G, AND H

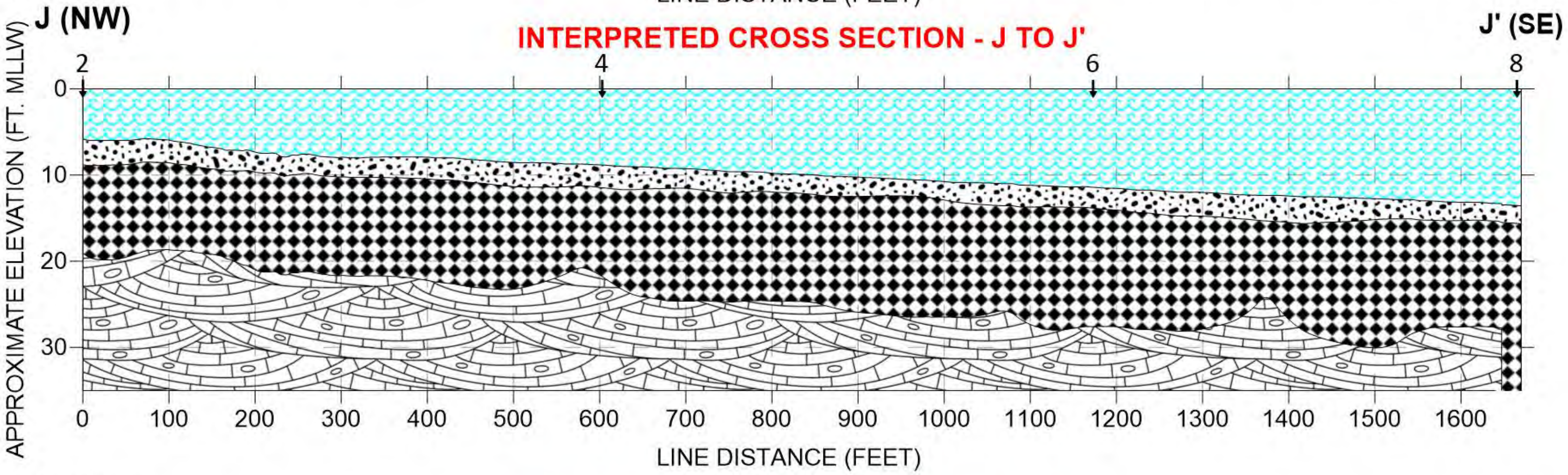
PROJECT No.
19125762

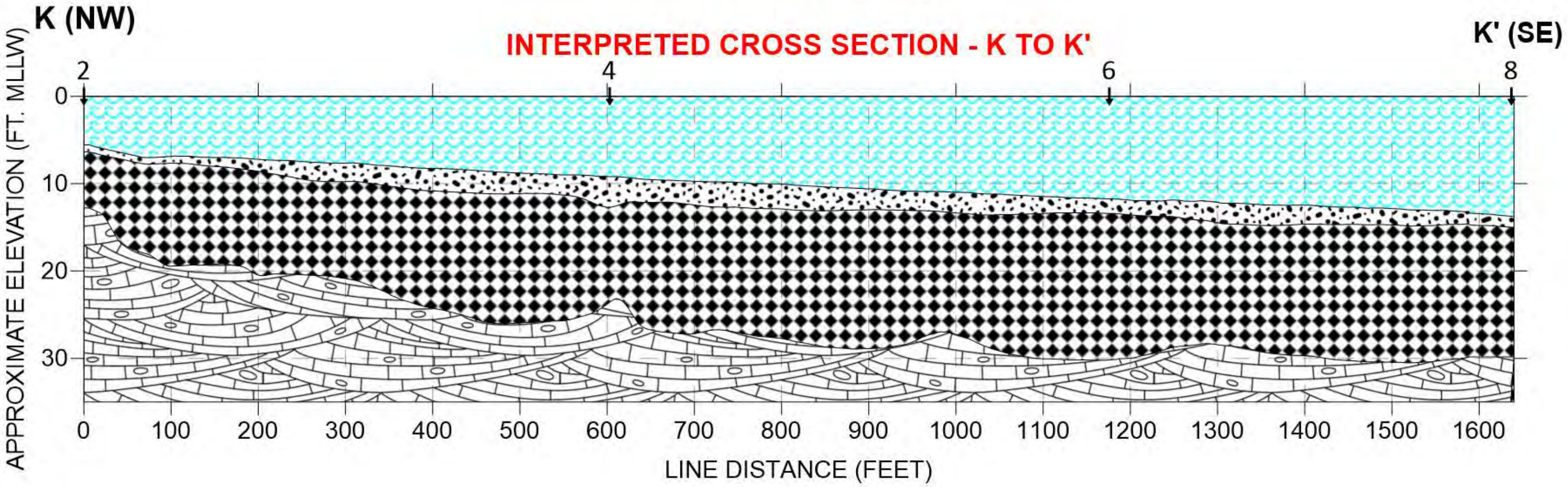
REV.
1

FIGURE
A-8

1 inch
0
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B


INTERPRETED CROSS SECTION - I TO I'


INTERPRETED CROSS SECTION - J TO J'


INTERPRETED CROSS SECTION - K TO K'

LEGEND

- ▒ WATER
- ░ SAND/SILT/GRAVEL LOOSE TO MEDIUM DENSE
- ▦ DENSE/CONSOLIDATED SEDIMENTS OR WEATHERED ROCK
- ▨ ACOUSTIC BASEMENT (METACALCARIOUS ROCK?)

NOTES:

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3. LOW FREQUENCY SEISMIC REFLECTION DATA ACQUIRED WITH DATASONICS SPR-1200
4. COMPOSITE BATHYMETRY FROM OTHERS (2012 and 2019)

19125762 Figure A-9.srf | revised: November 01, 2019

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YYYY-MM-DD	2019-11-01
PREPARED	DEH
DESIGN	DEH
REVIEW	PEF
APPROVED	MRM

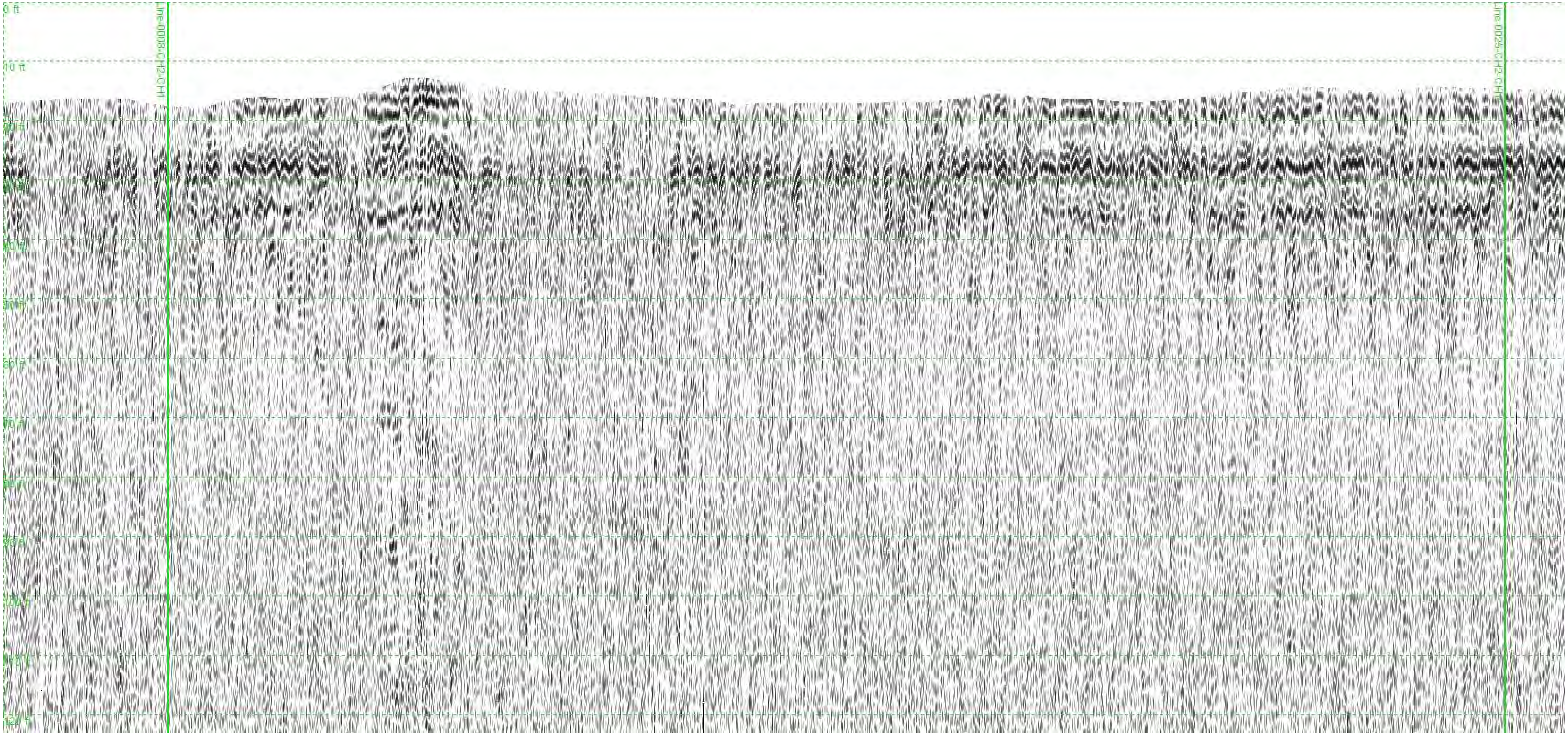
PROJECT
ELIM, ALASKA
NAVIGATION IMPROVEMENT FEASIBILITY STUDY
CONTRACT NO. W911KB-17 D-0002

TITLE
ELIM BEACH CROSS SECTIONS
I, J, AND K

PROJECT No.	REV	FIGURE
19125762	1	A-9

APPENDIX B

Graphic Images of Processed Seismic Reflection Records



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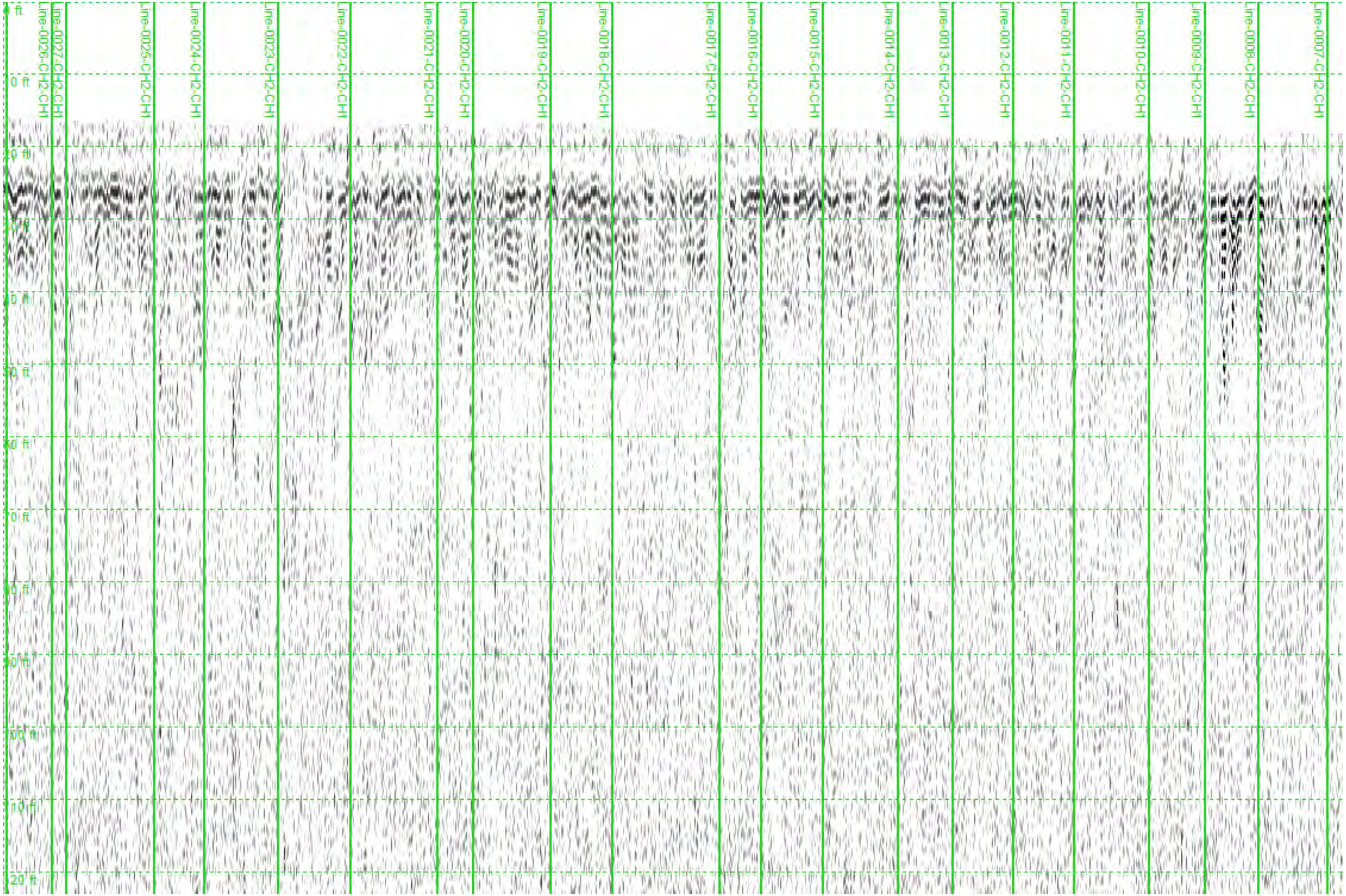

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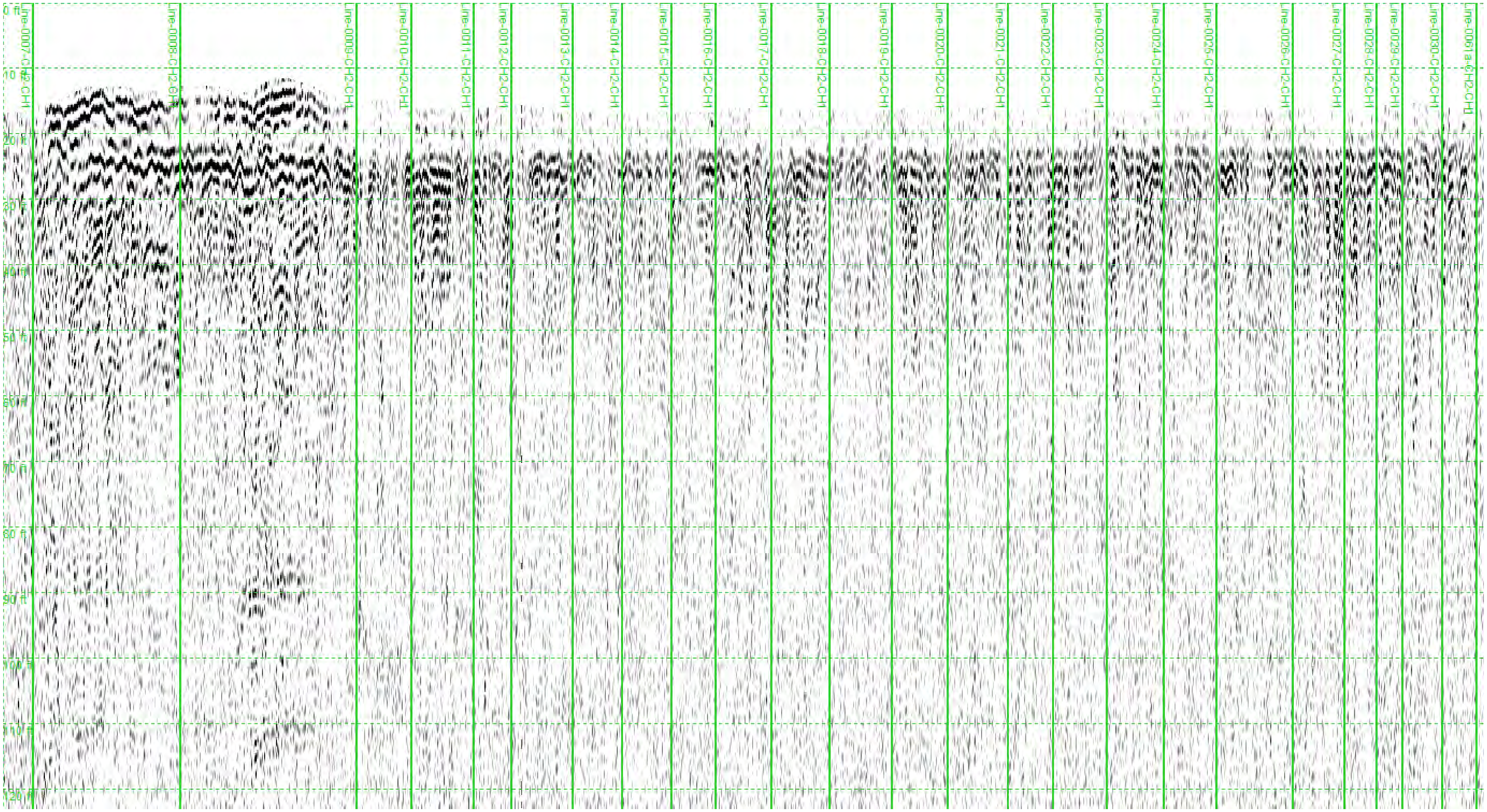

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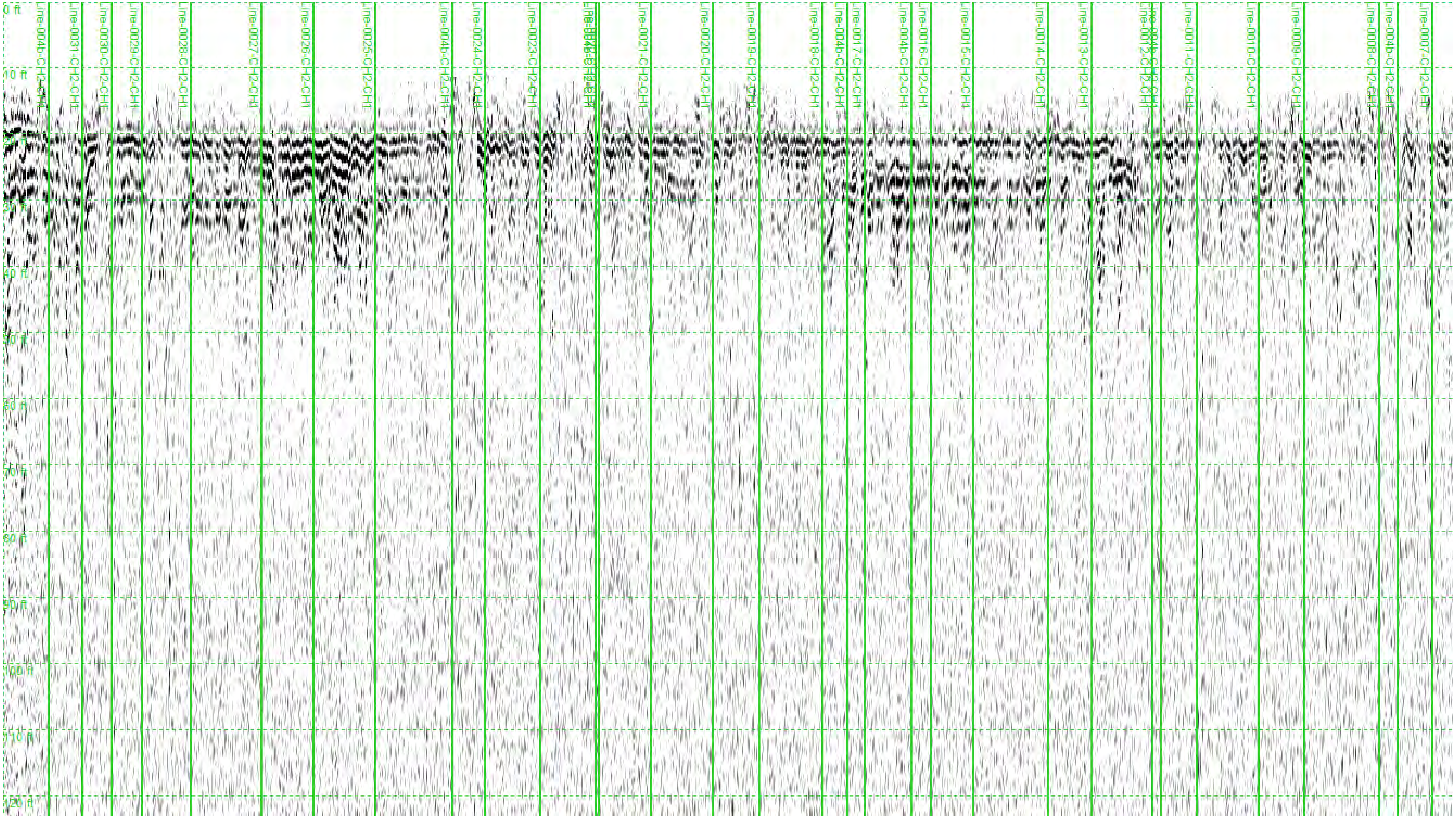

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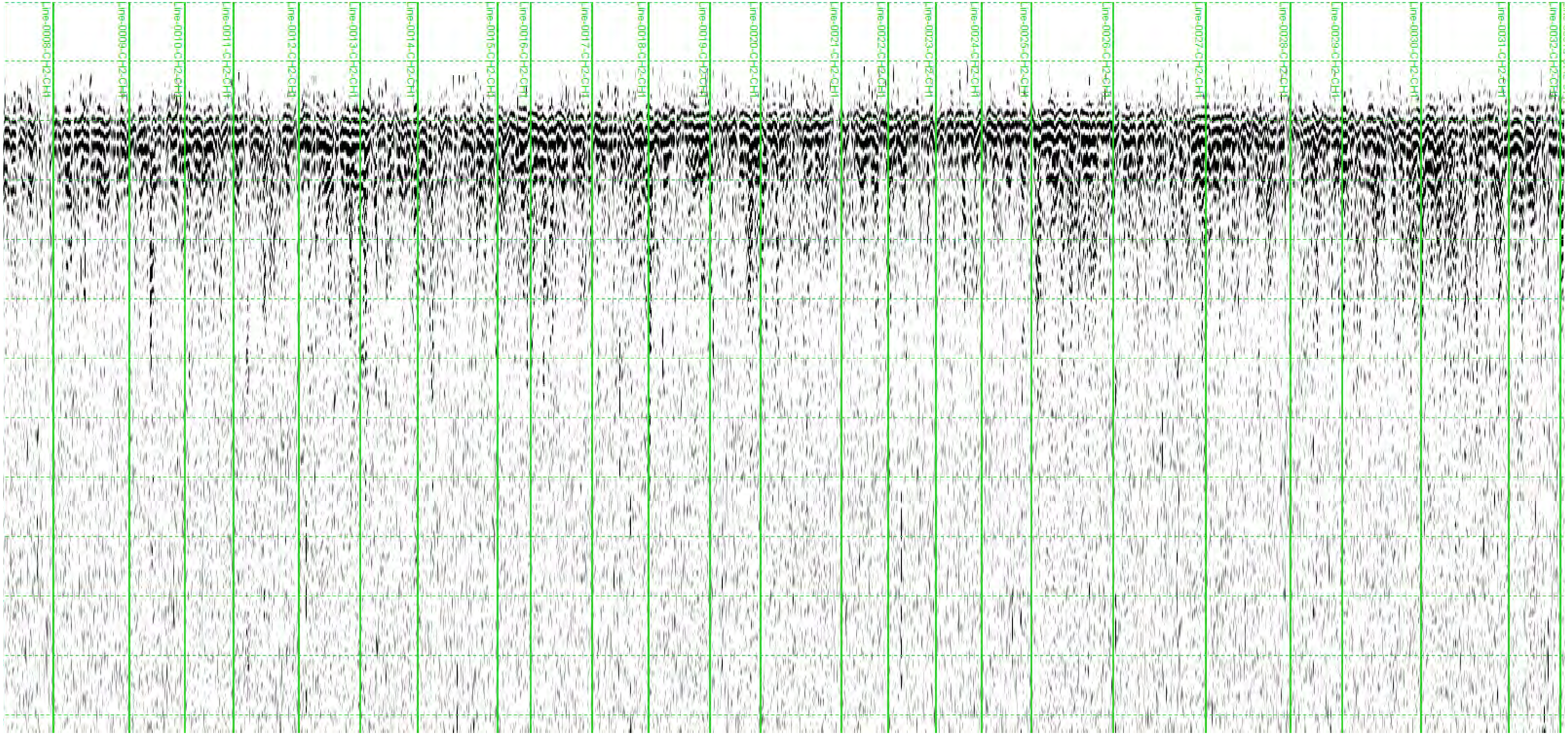

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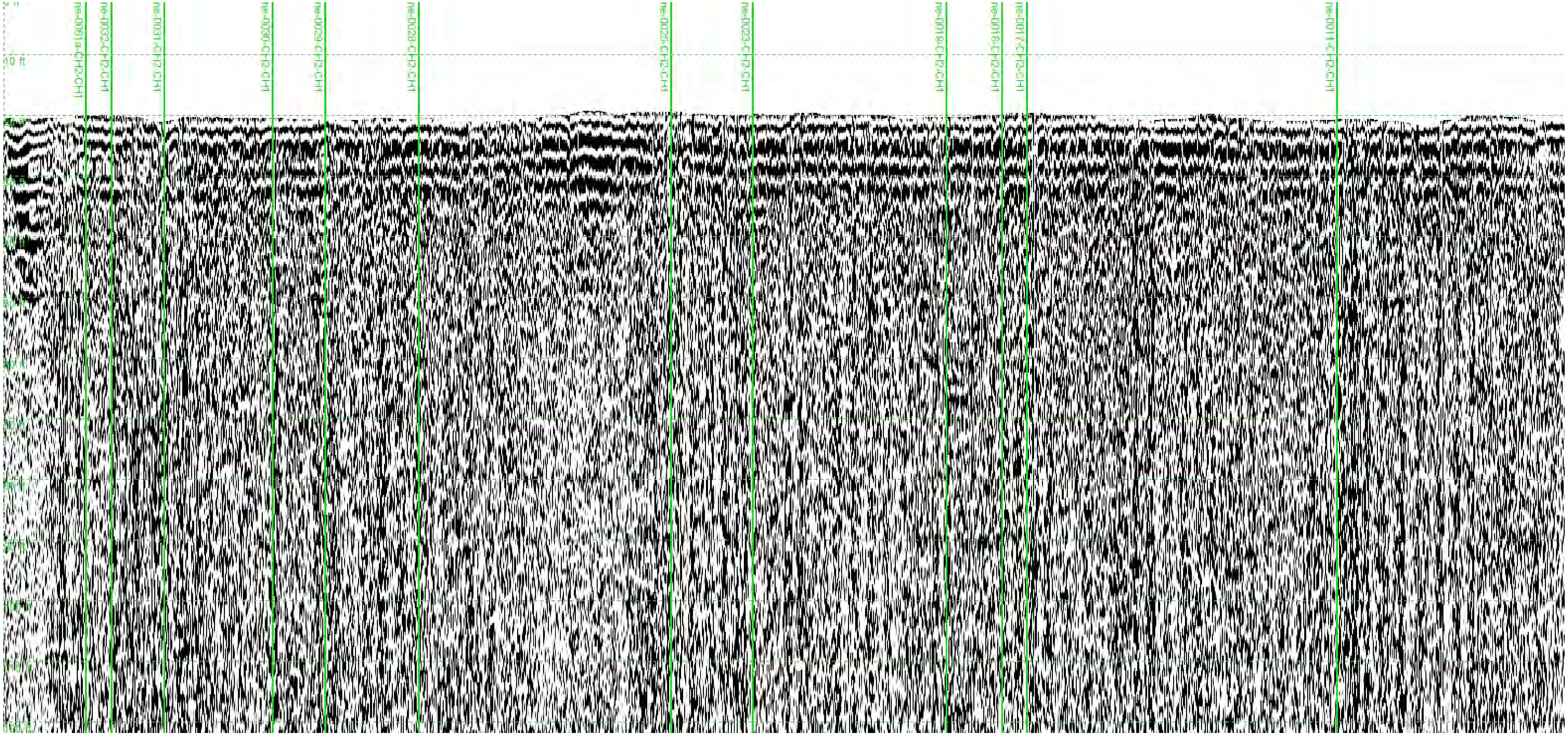

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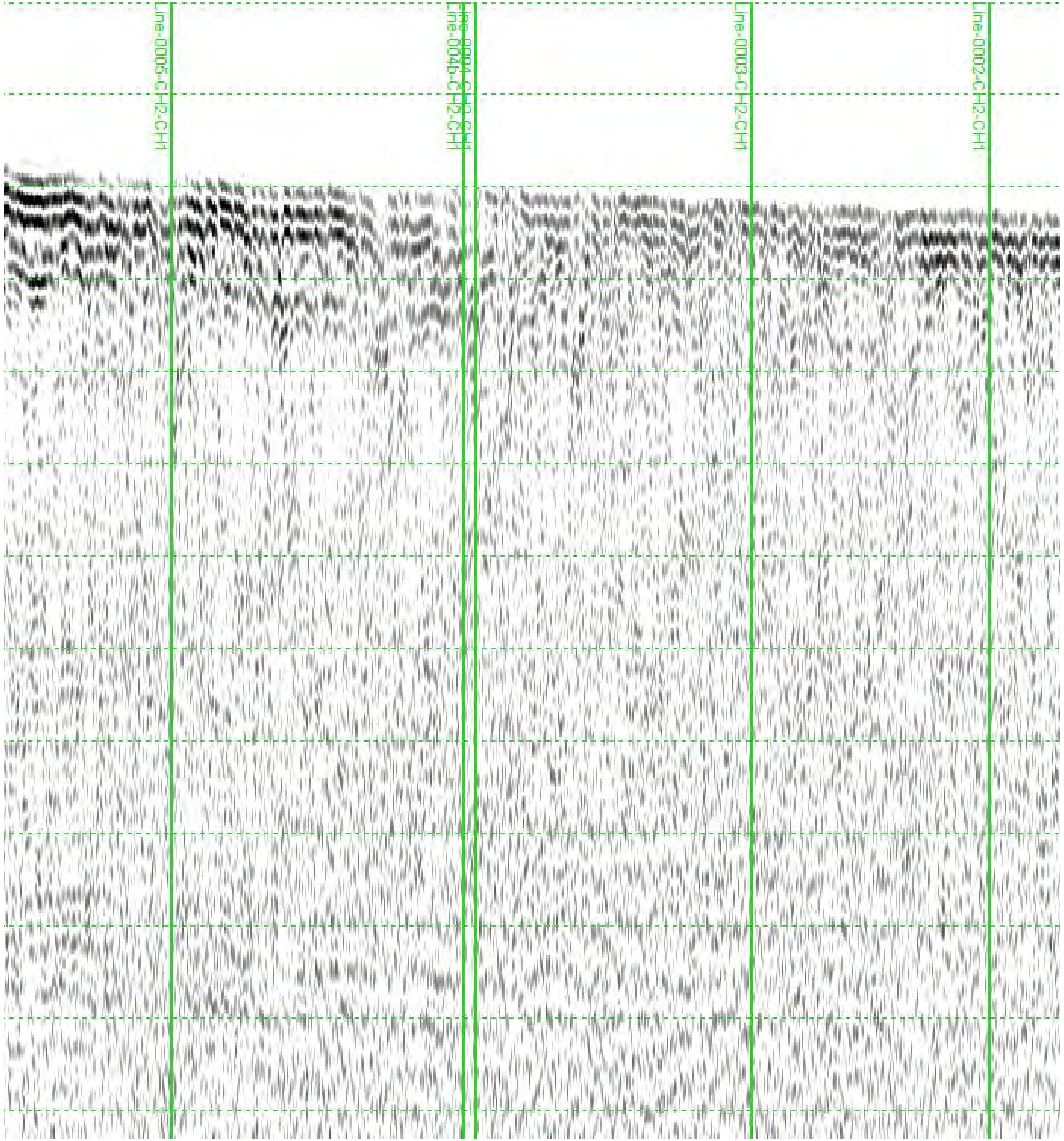

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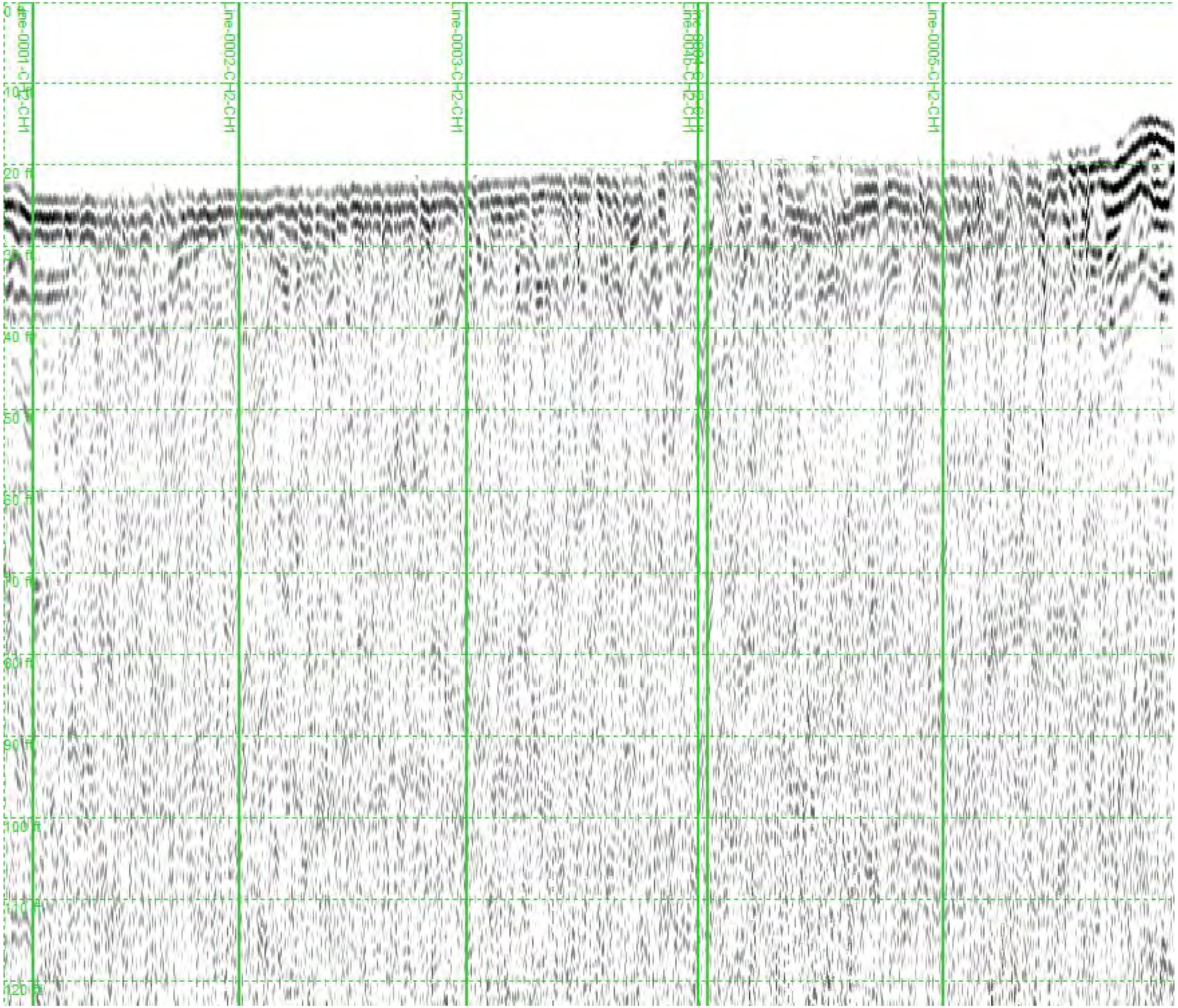

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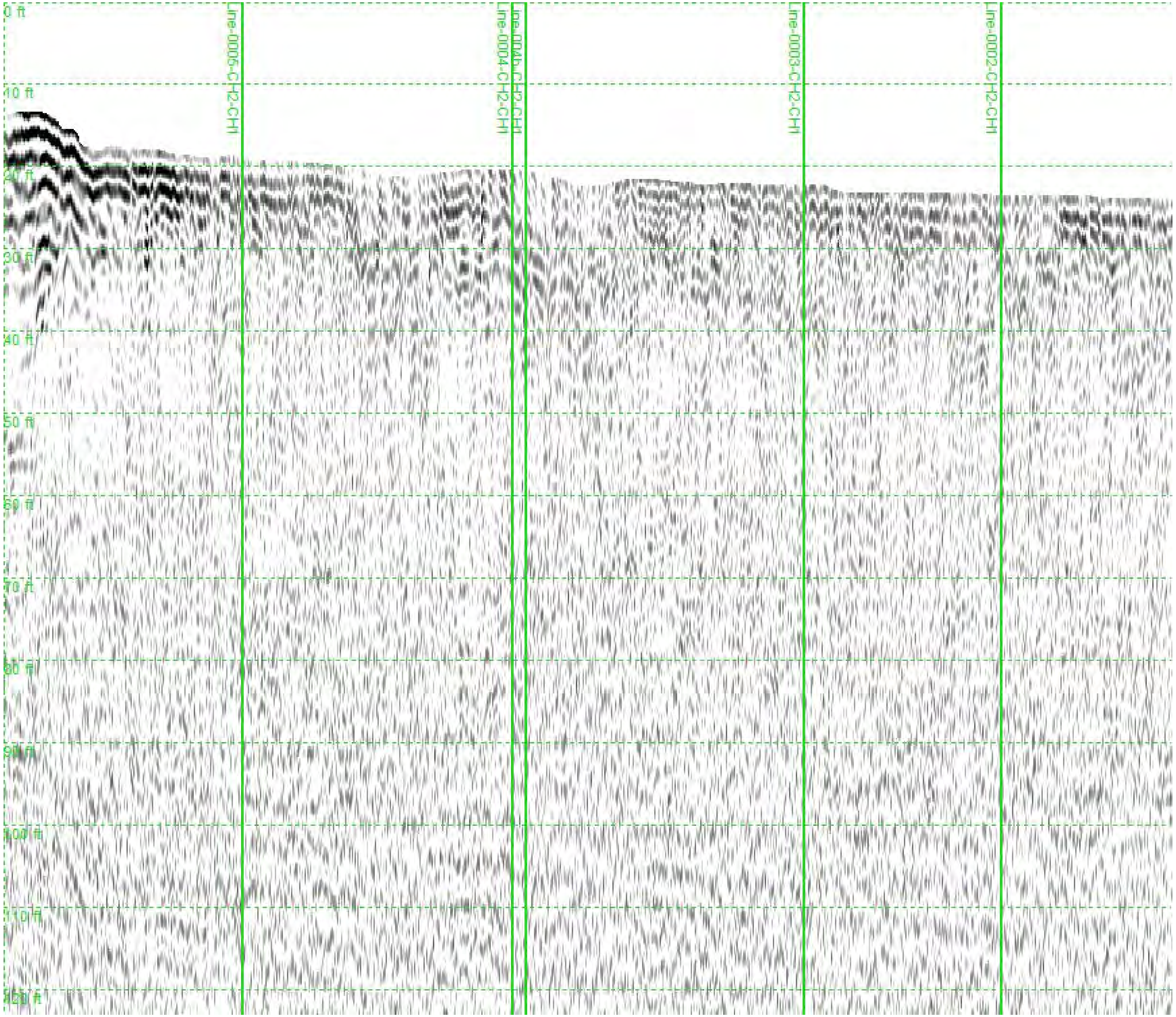

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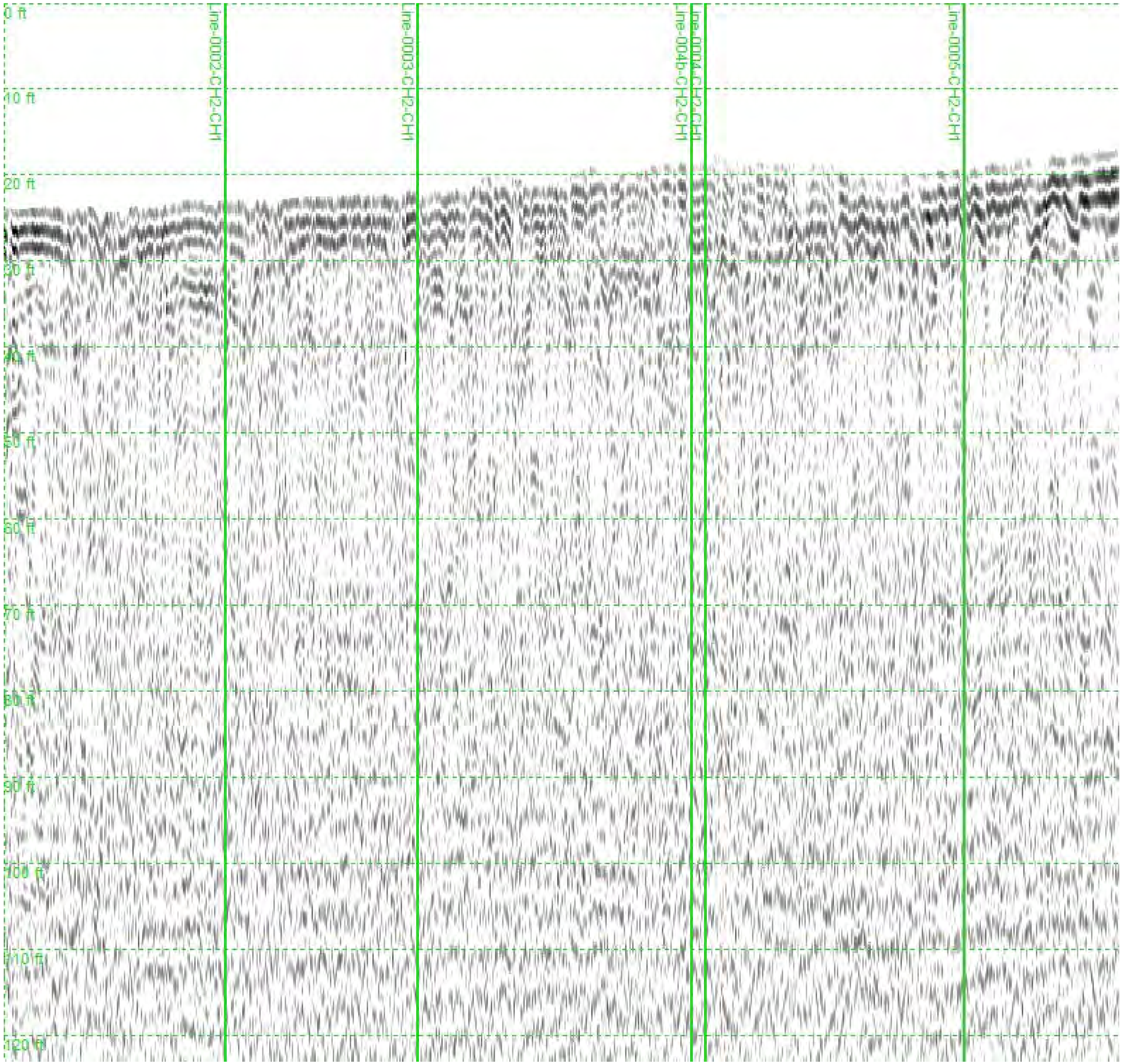

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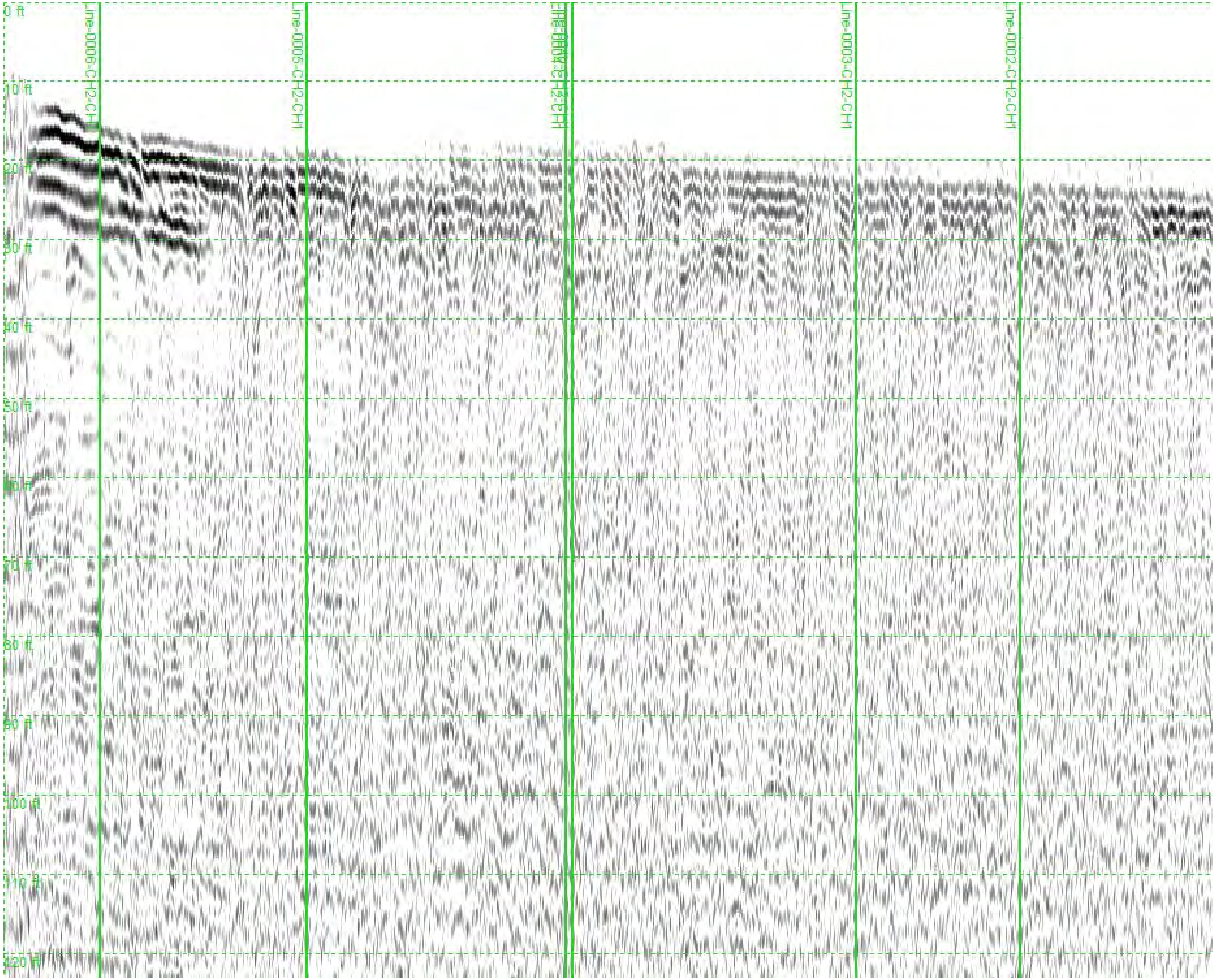

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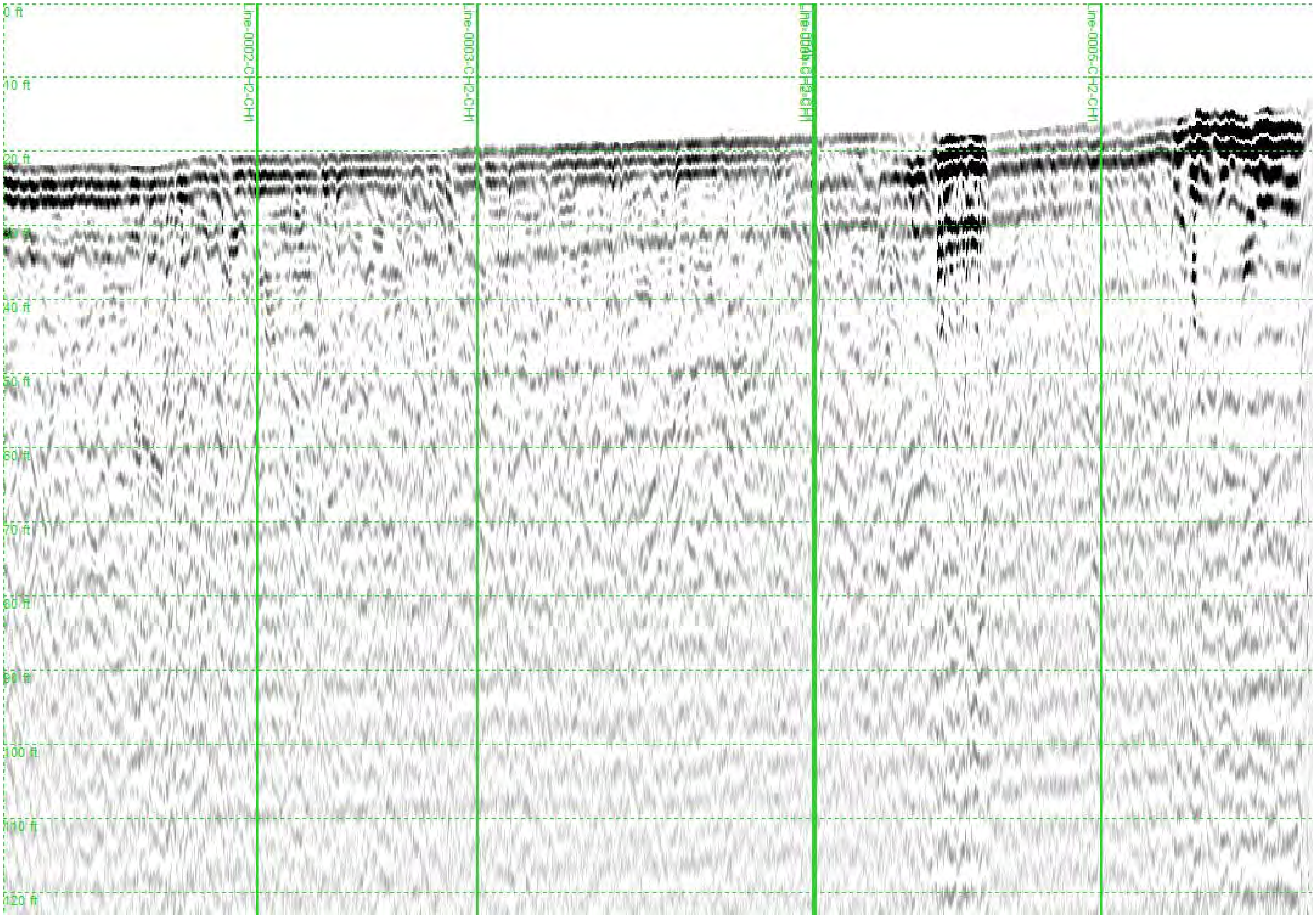

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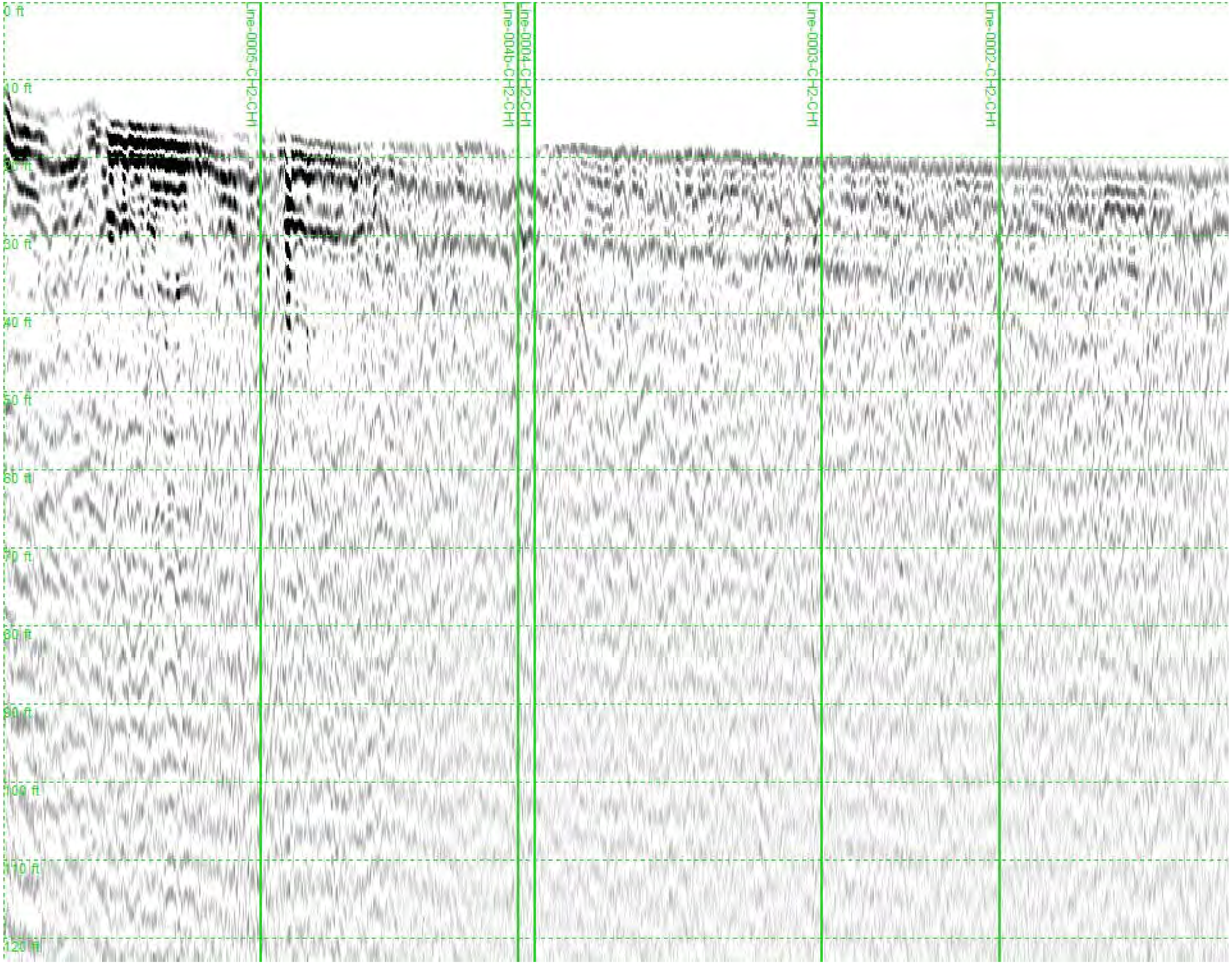

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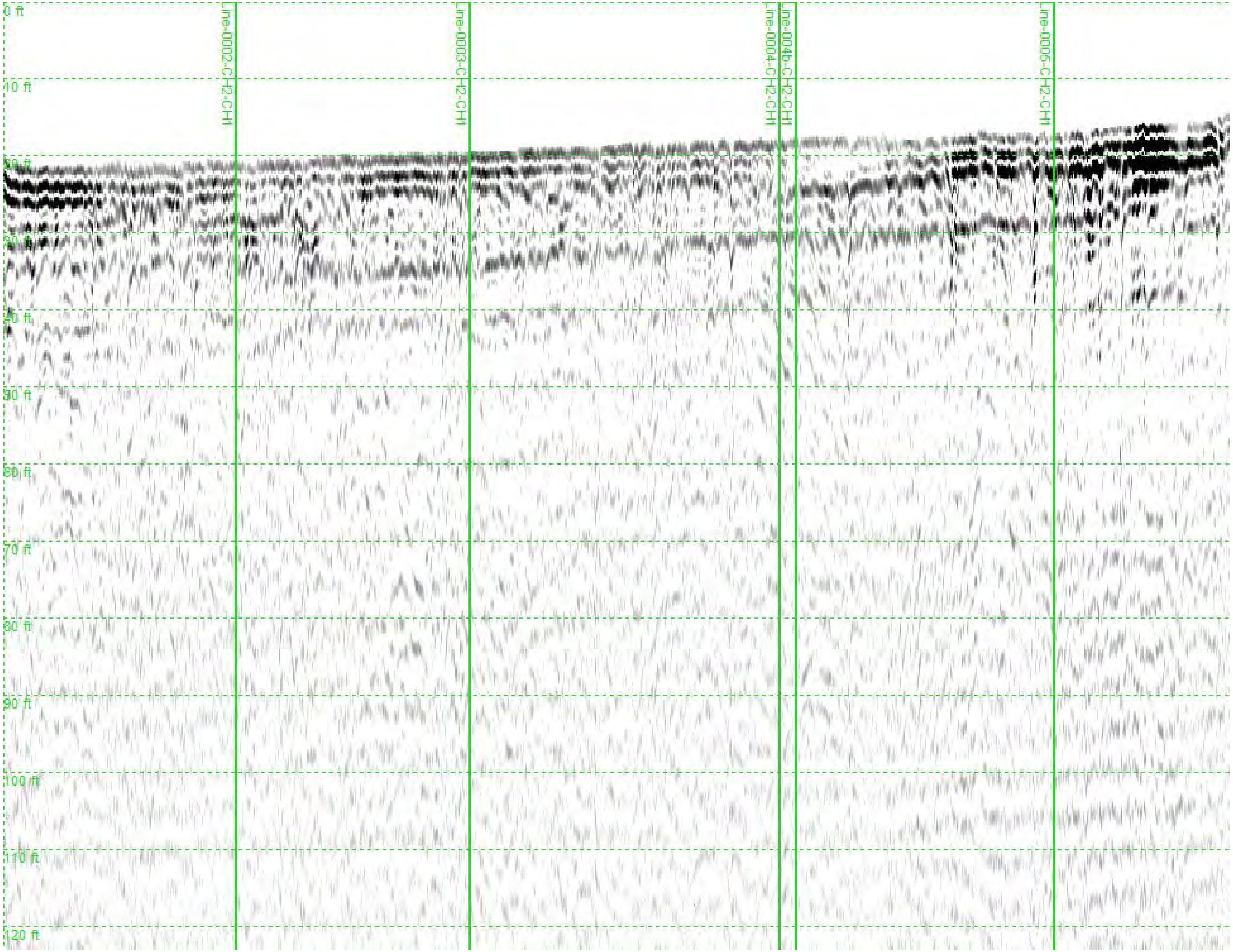

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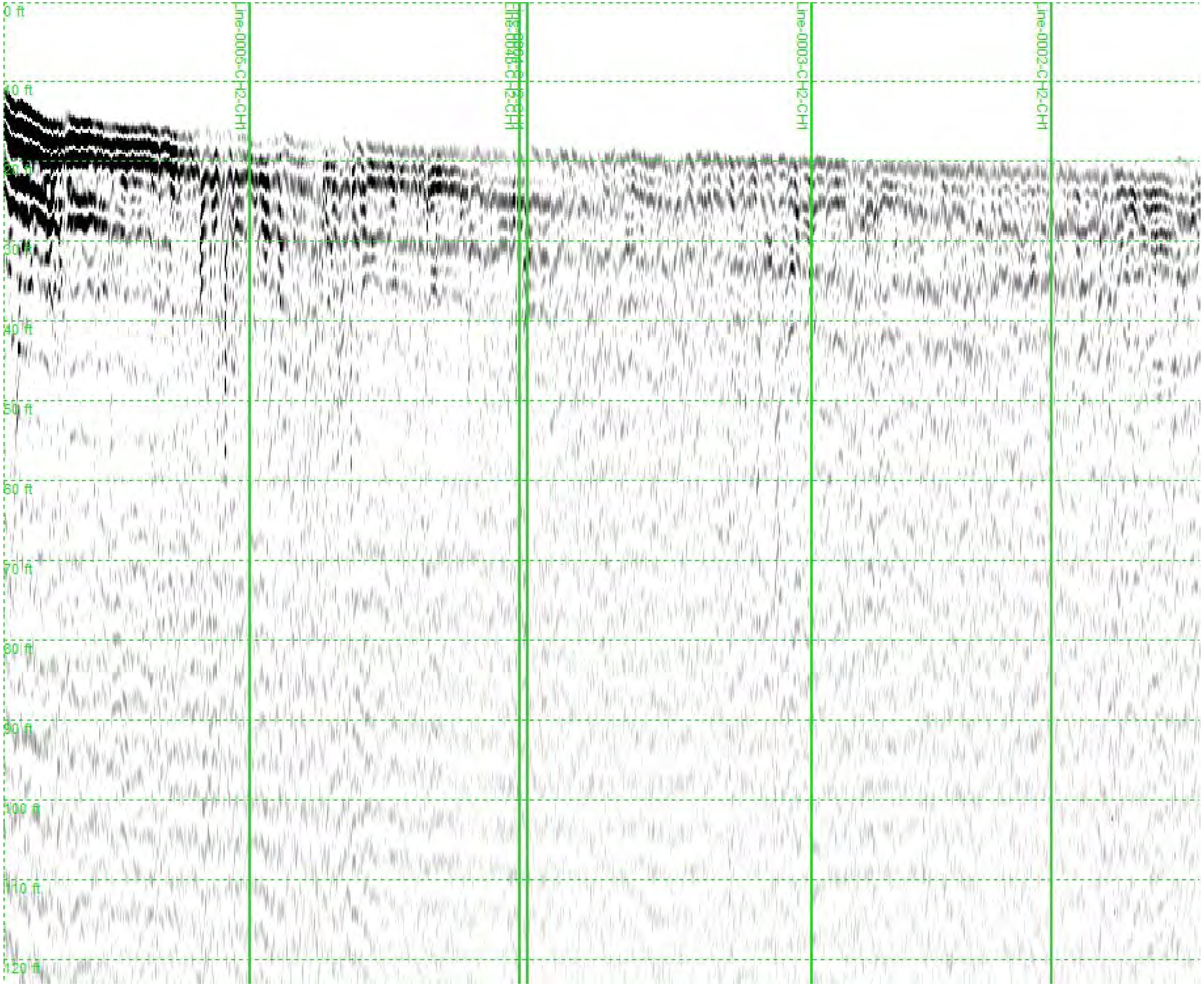

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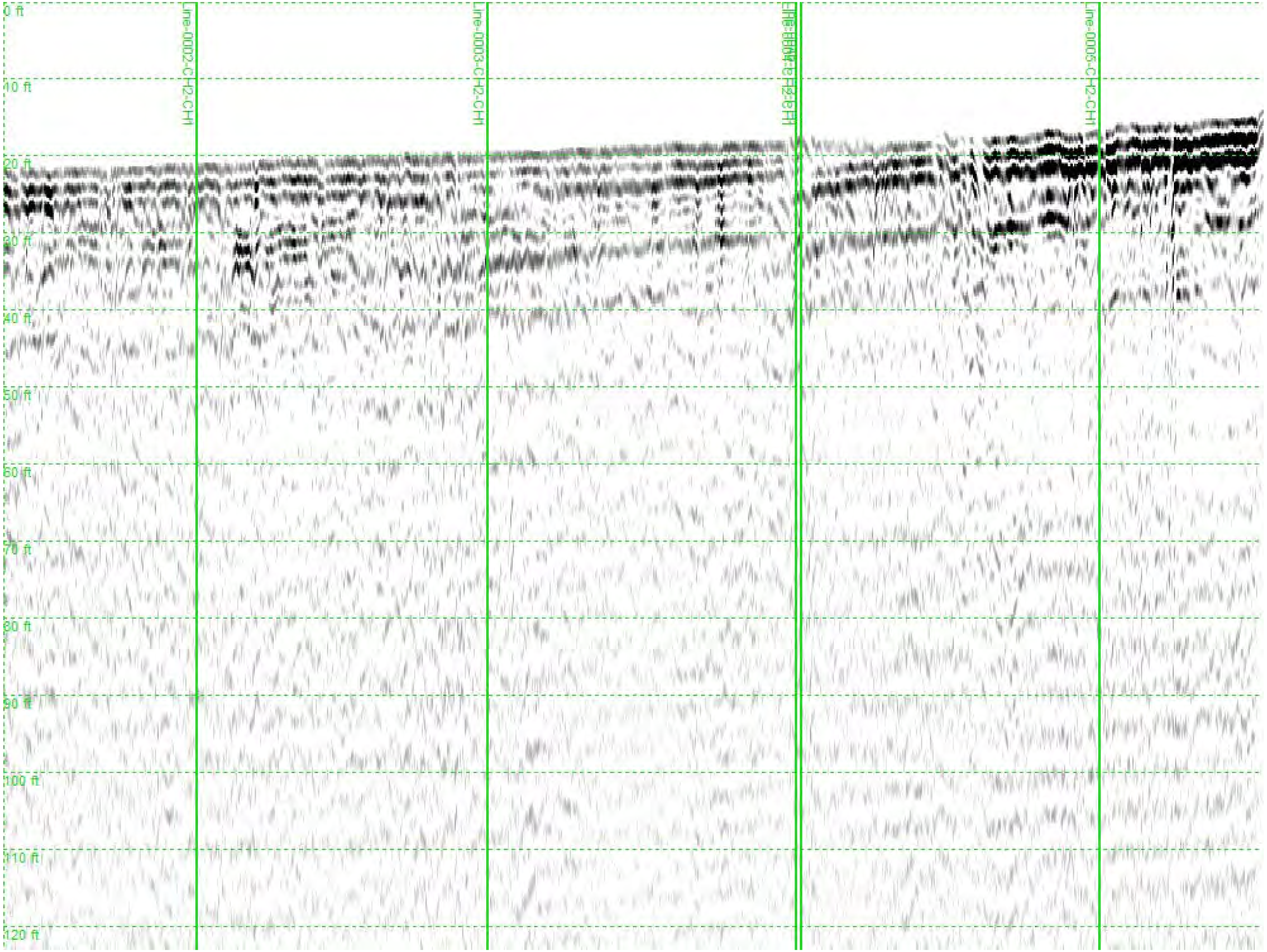

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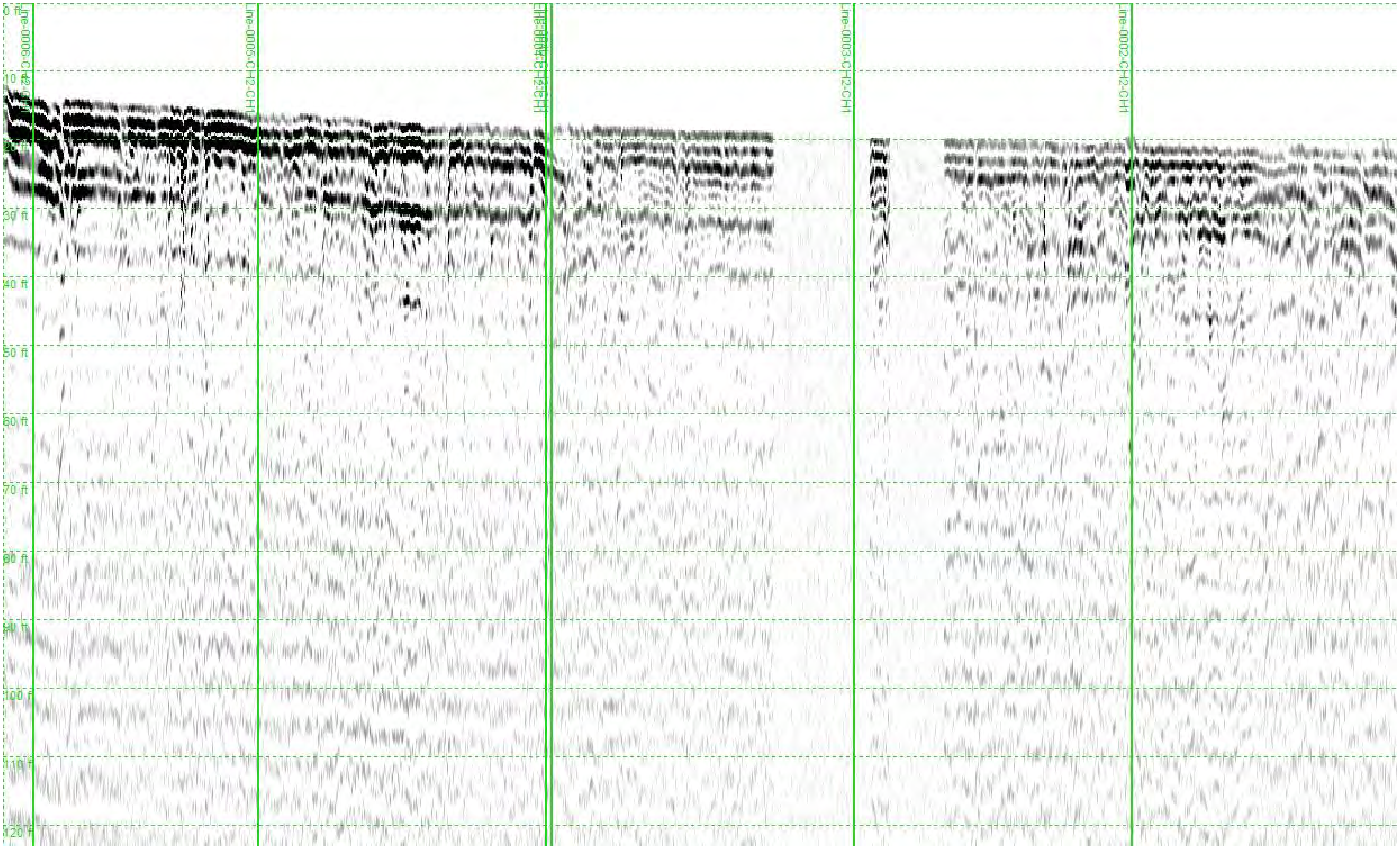

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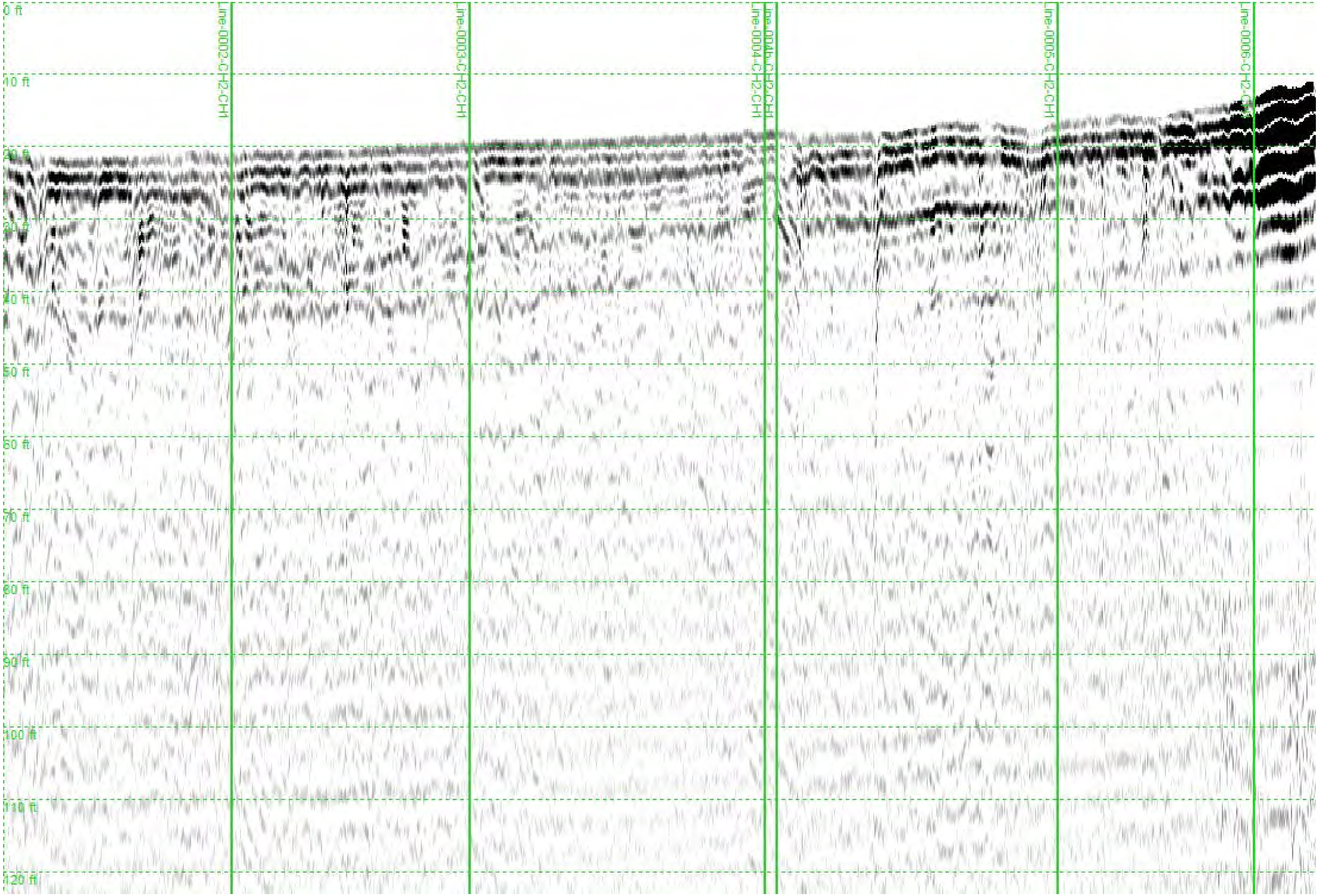

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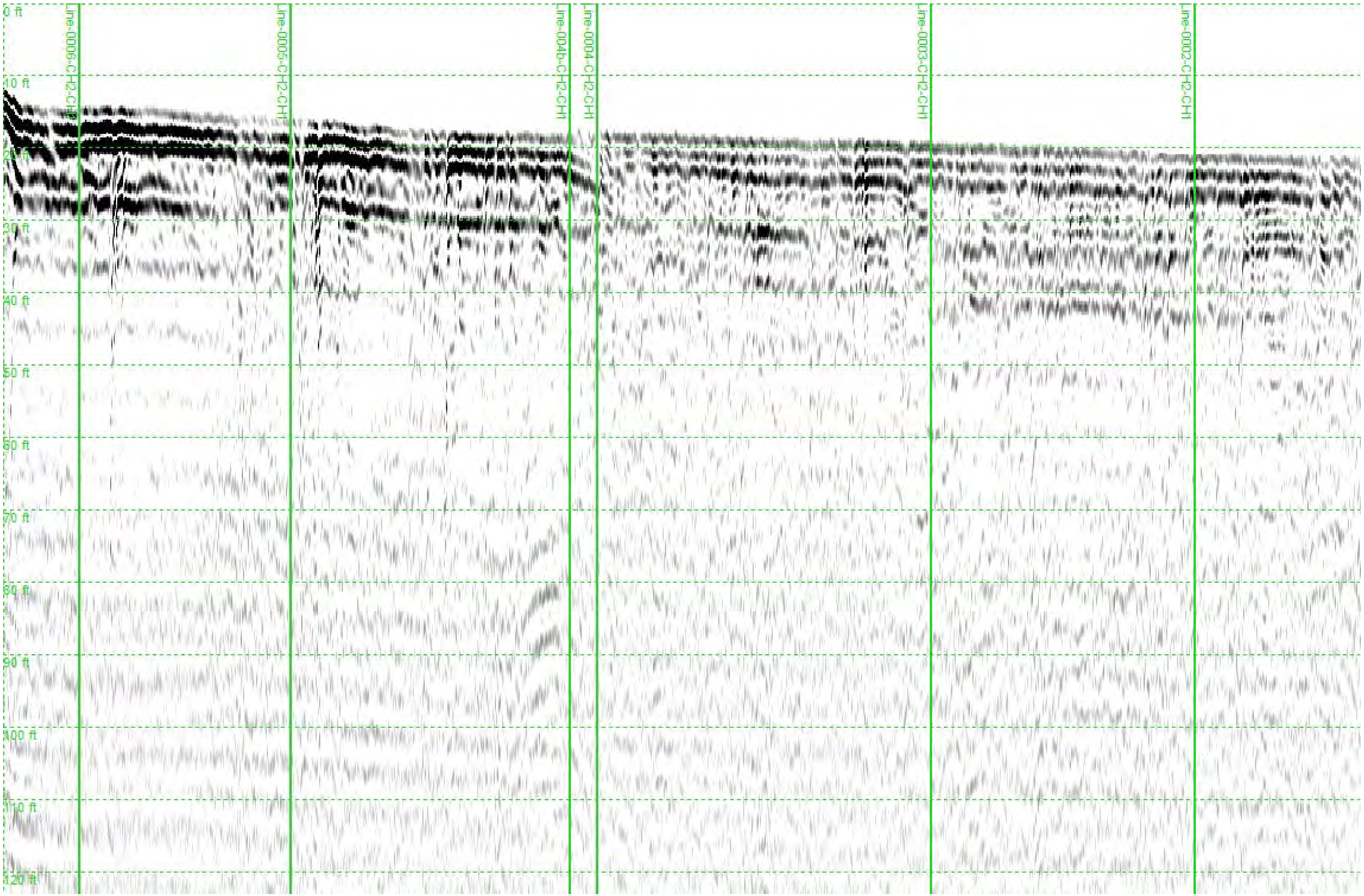

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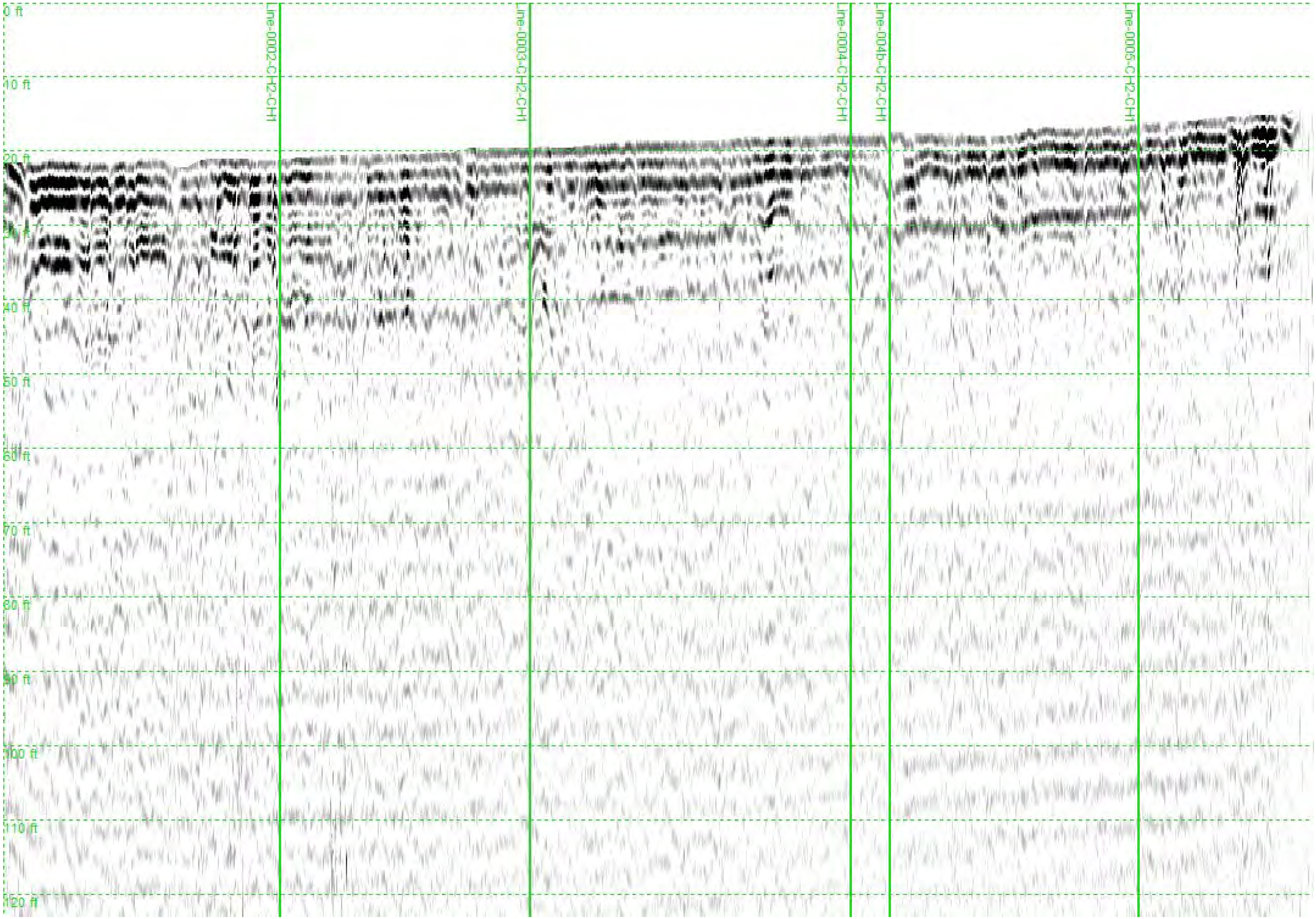
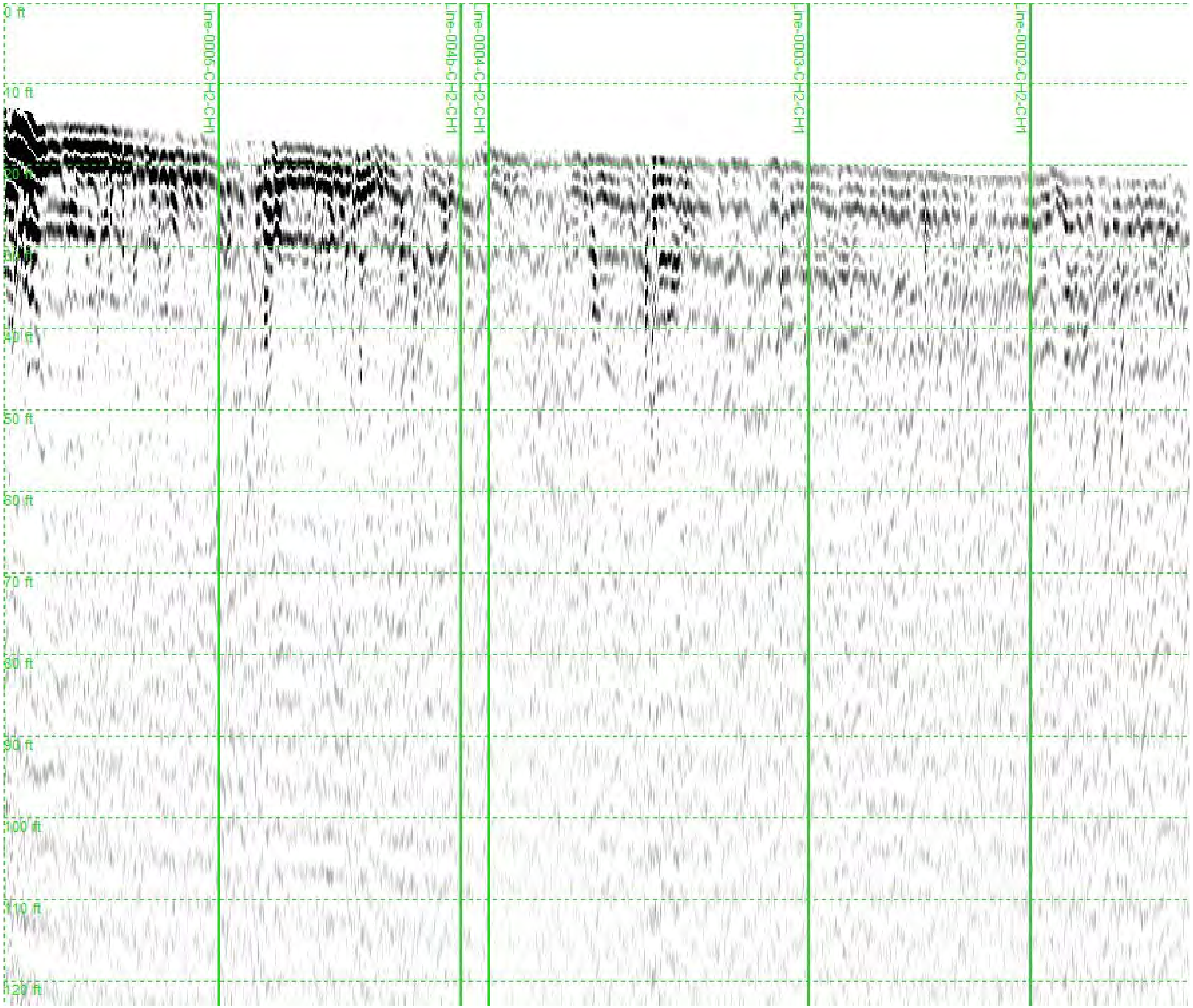
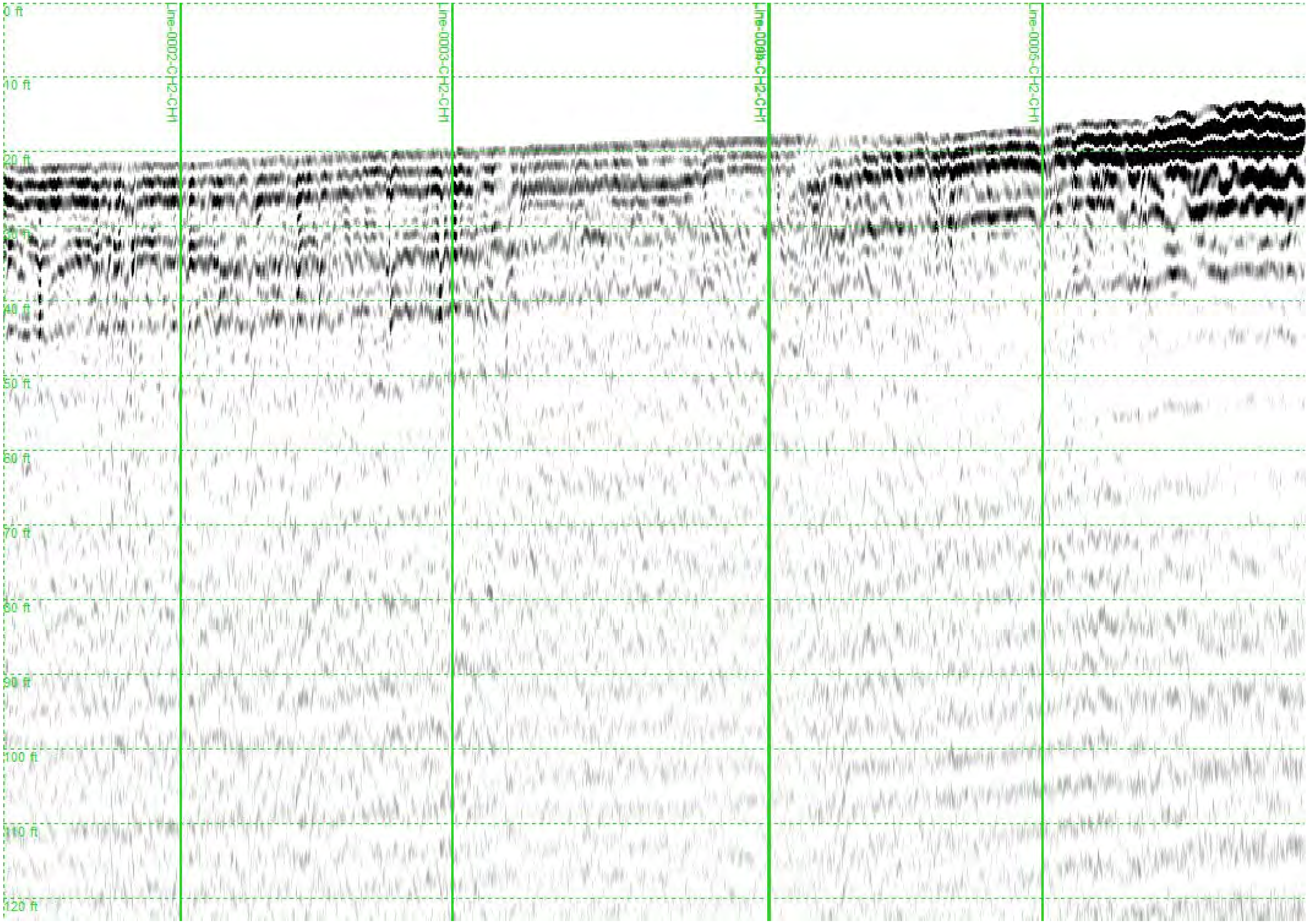


Line-0020-CH2-CH1.jpg



Line-0021-CH2-CH1.jpg



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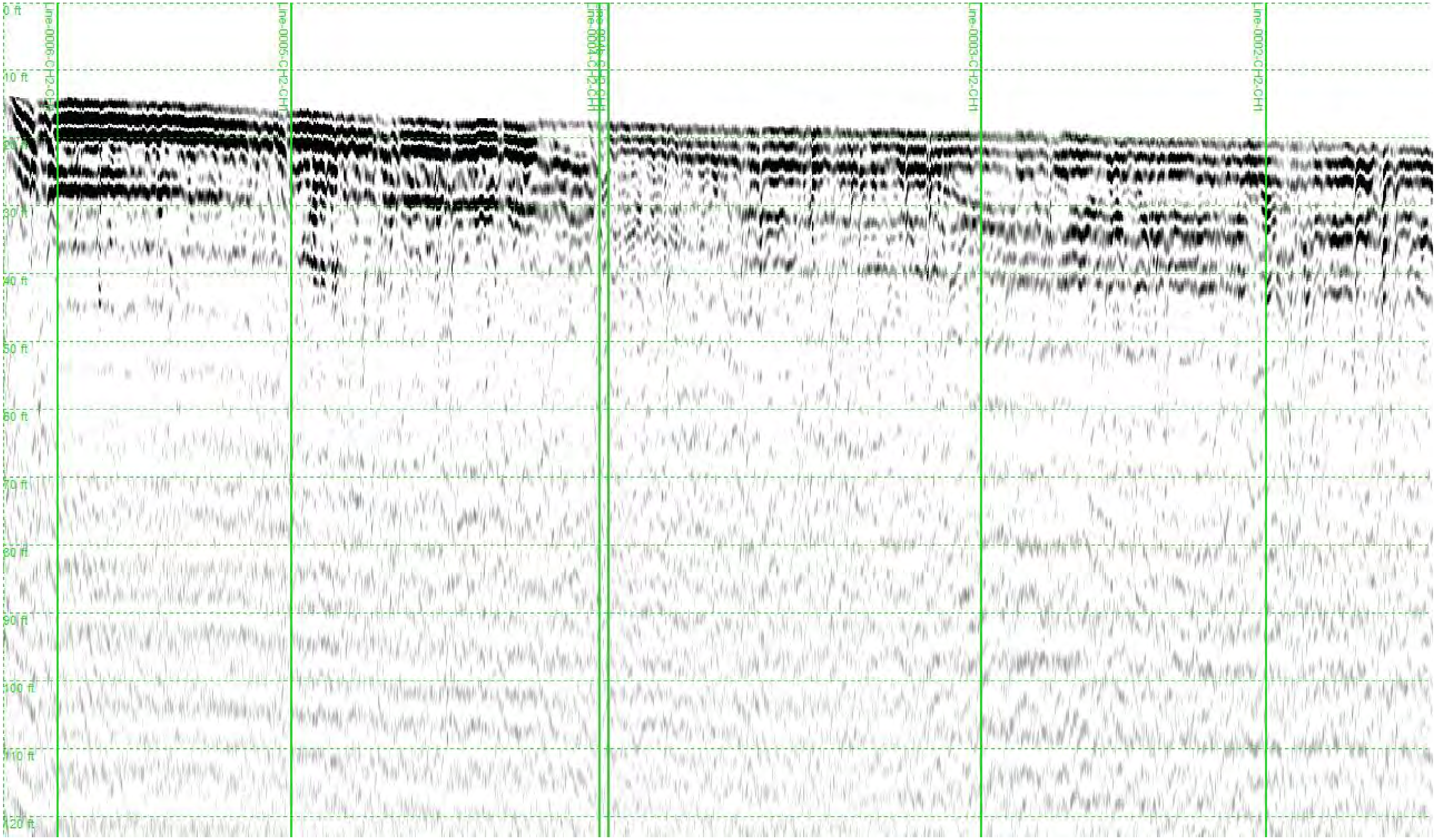

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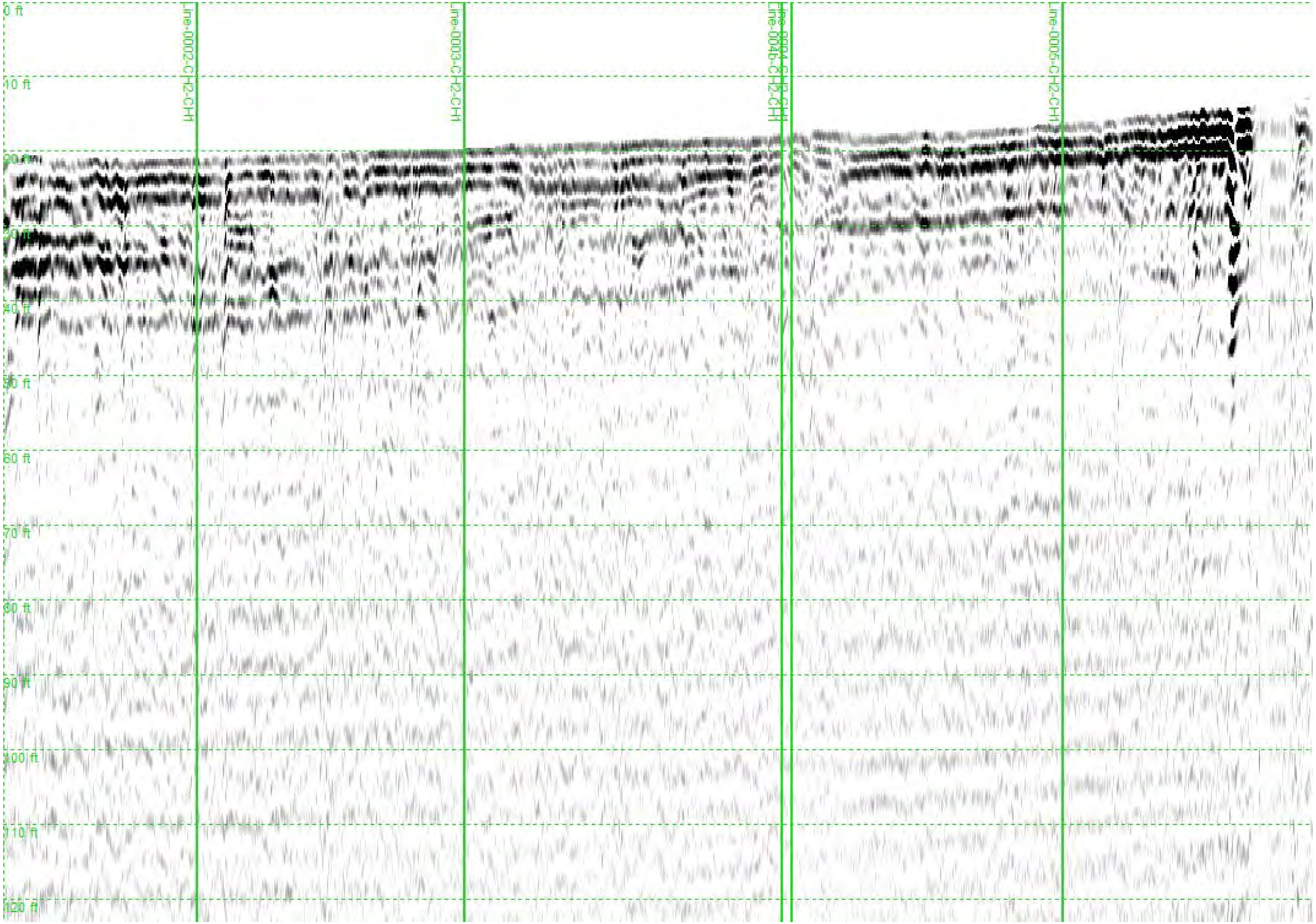

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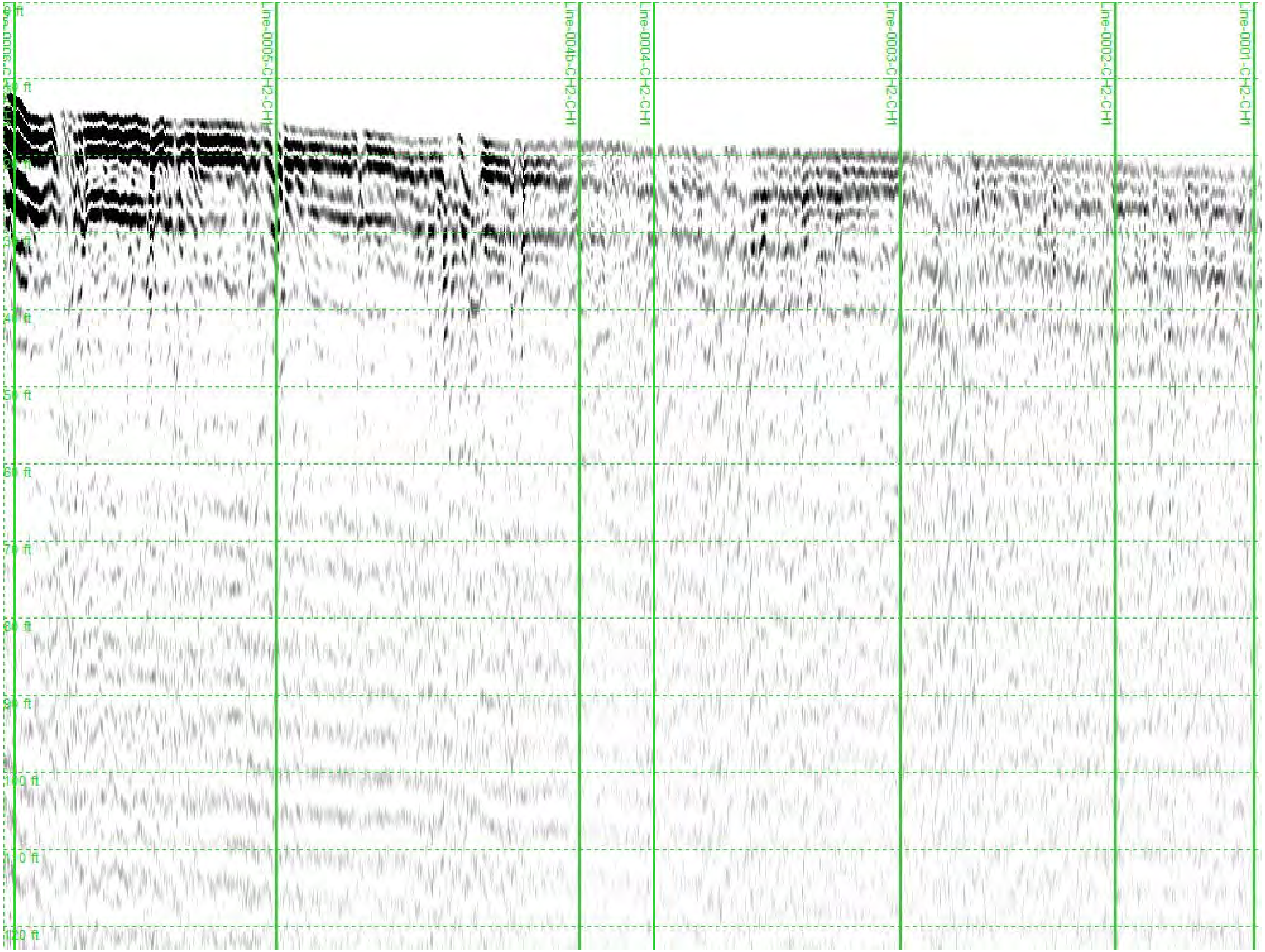

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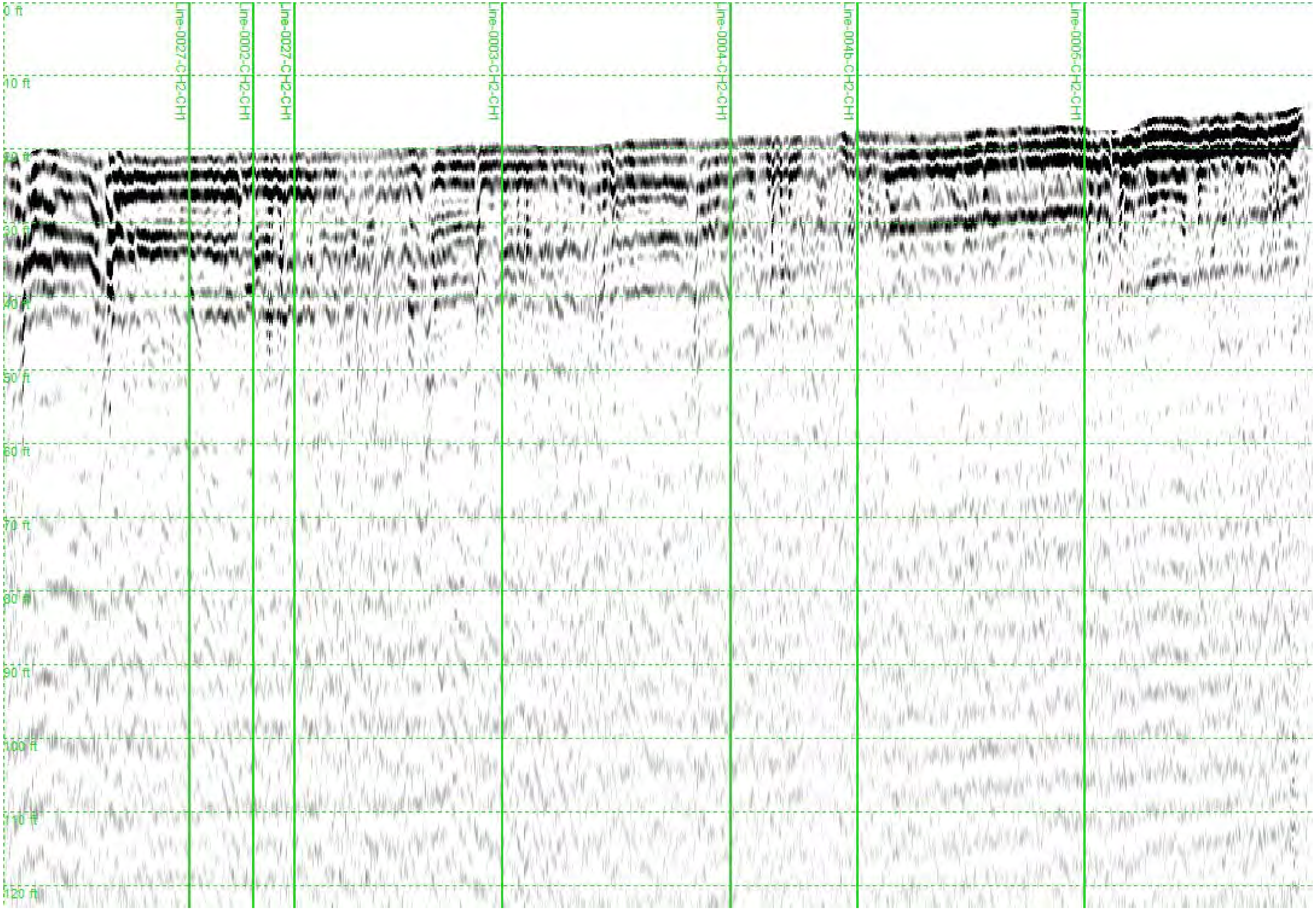

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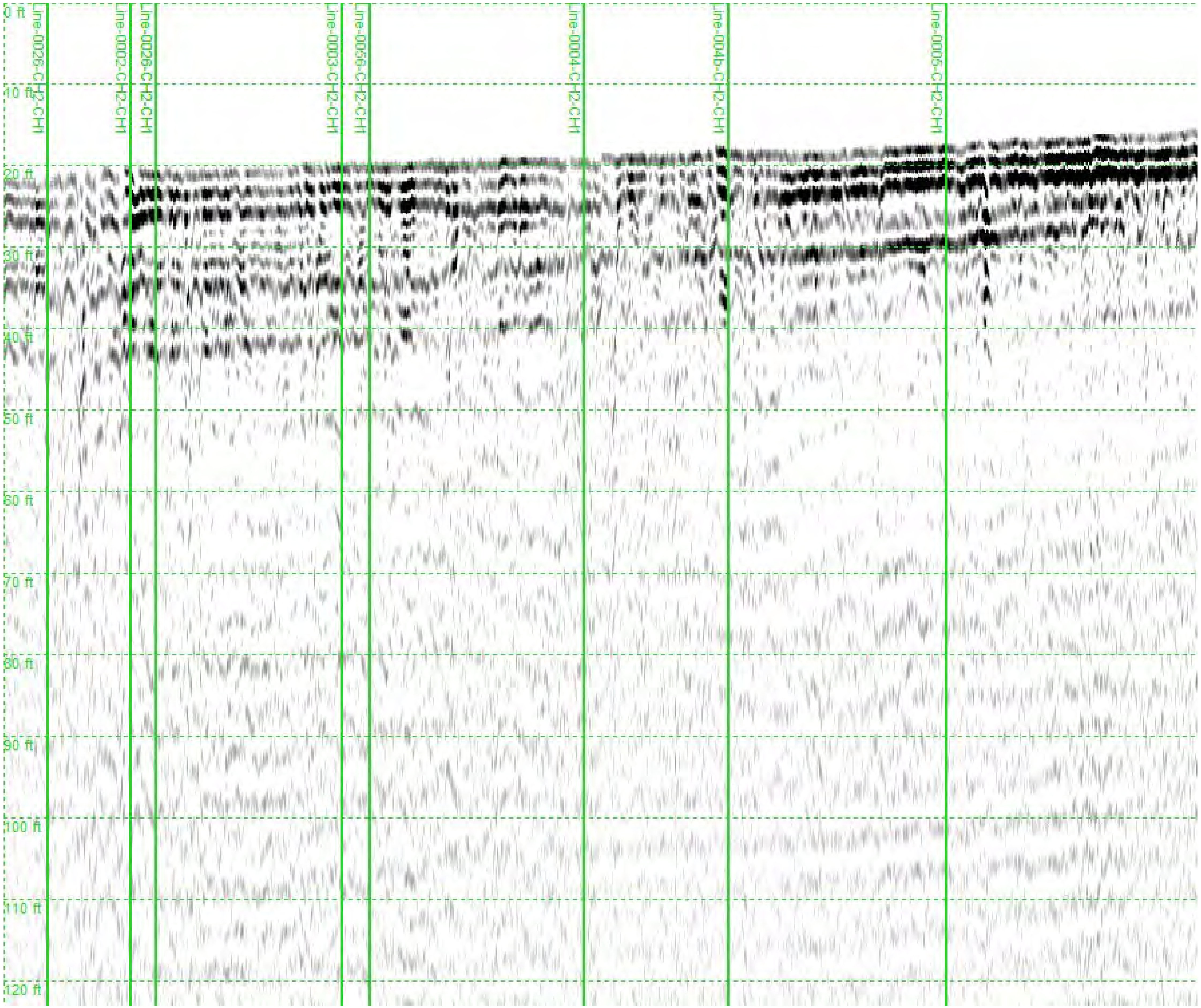

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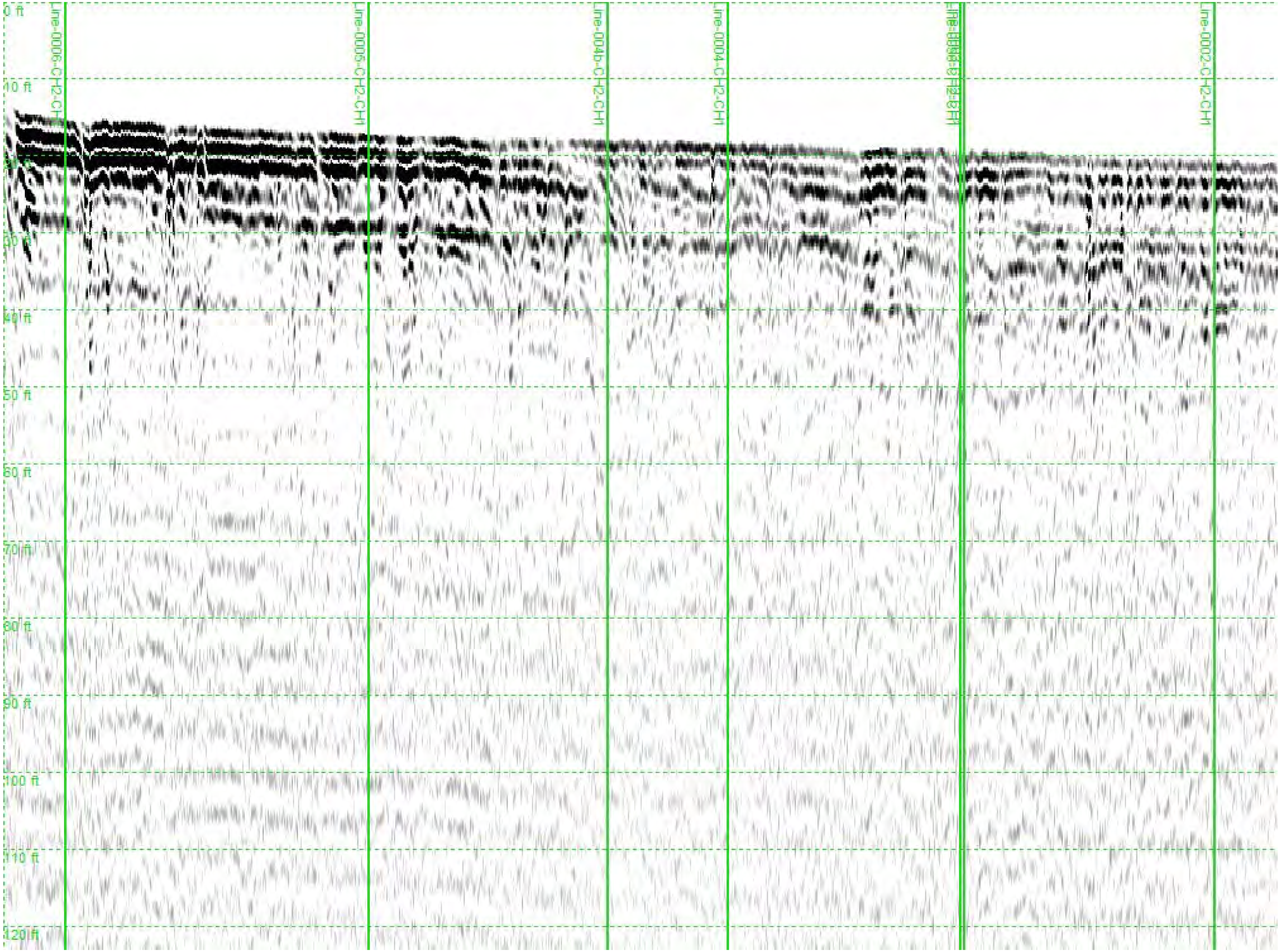

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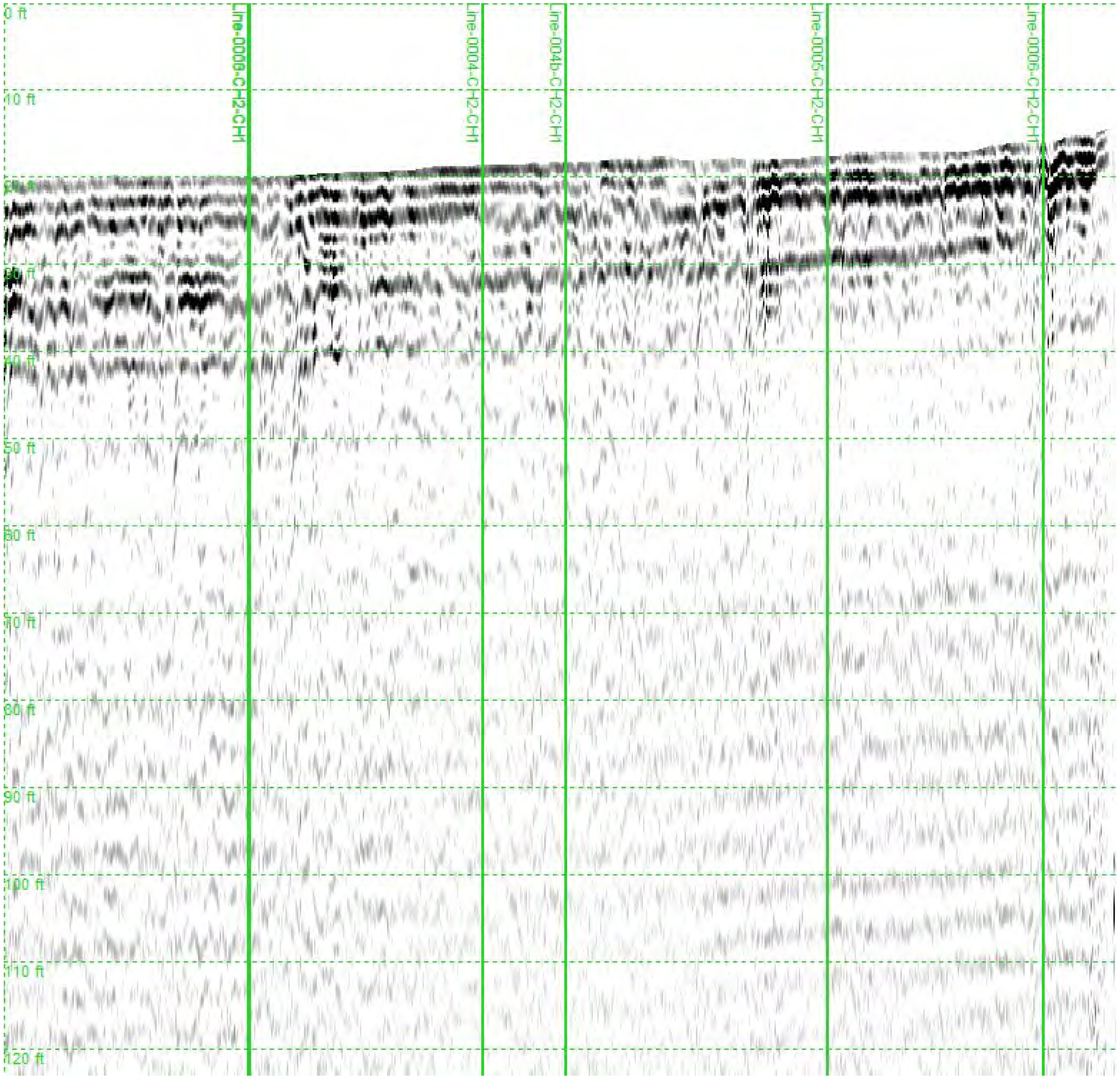

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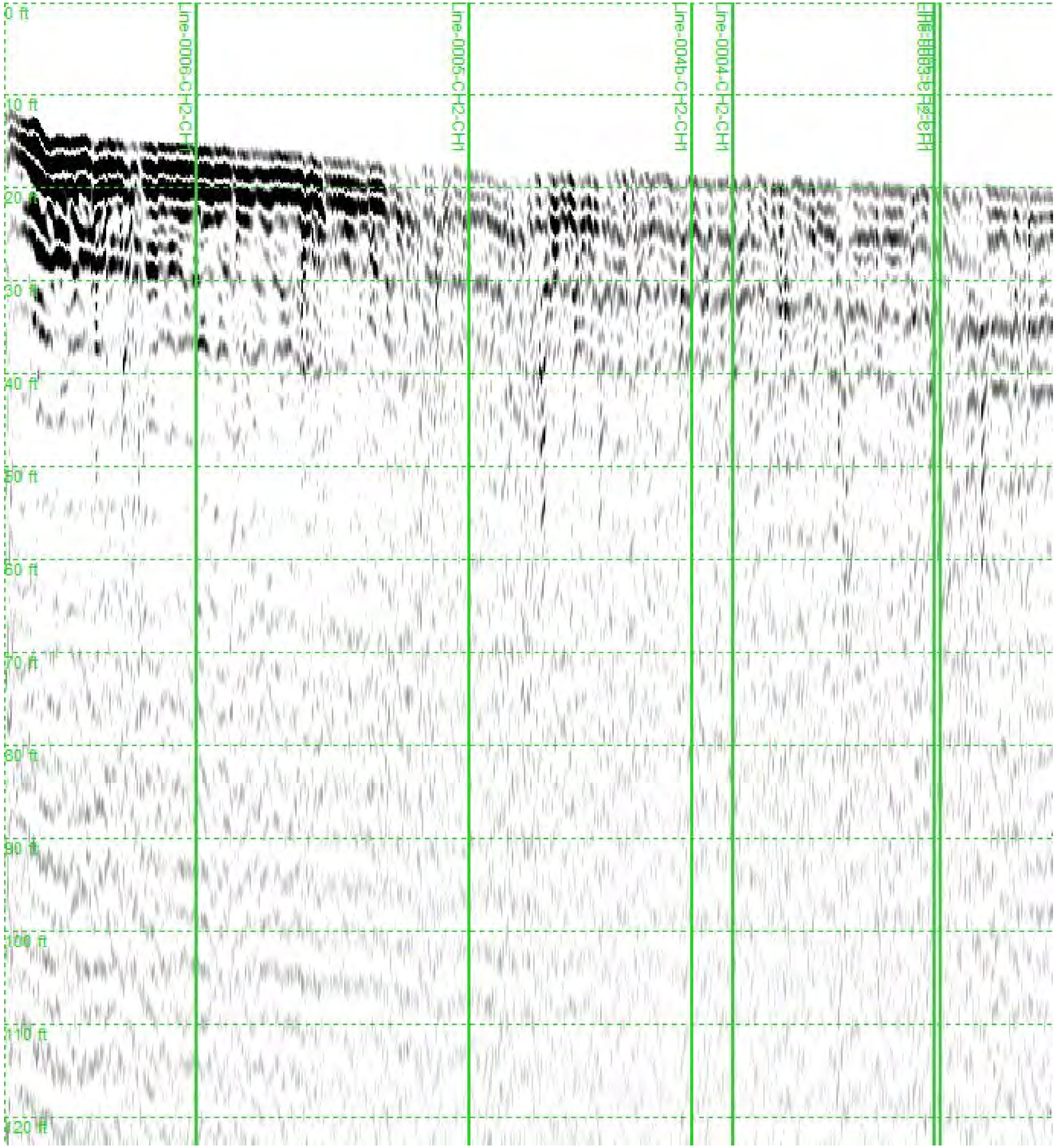

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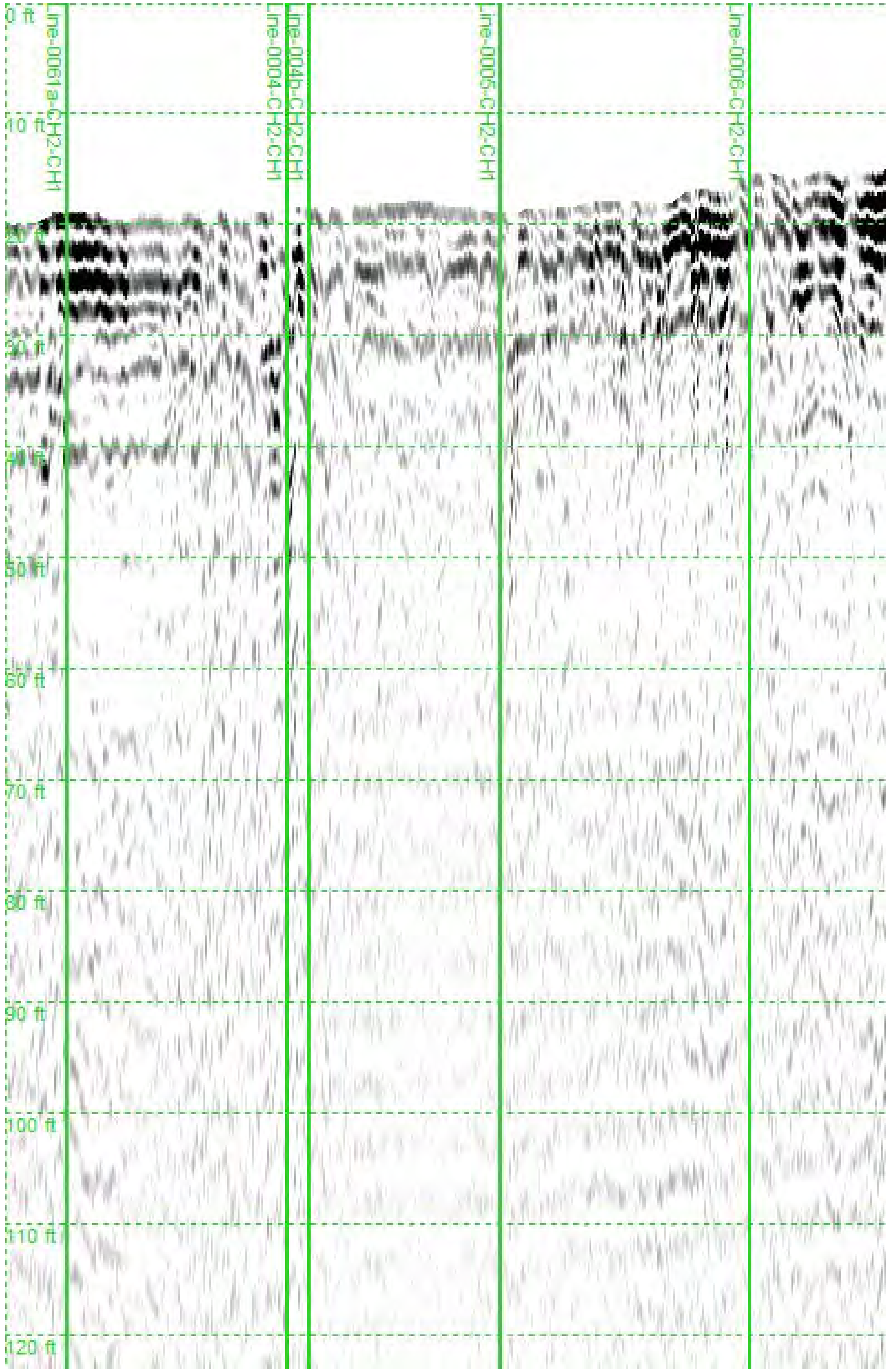

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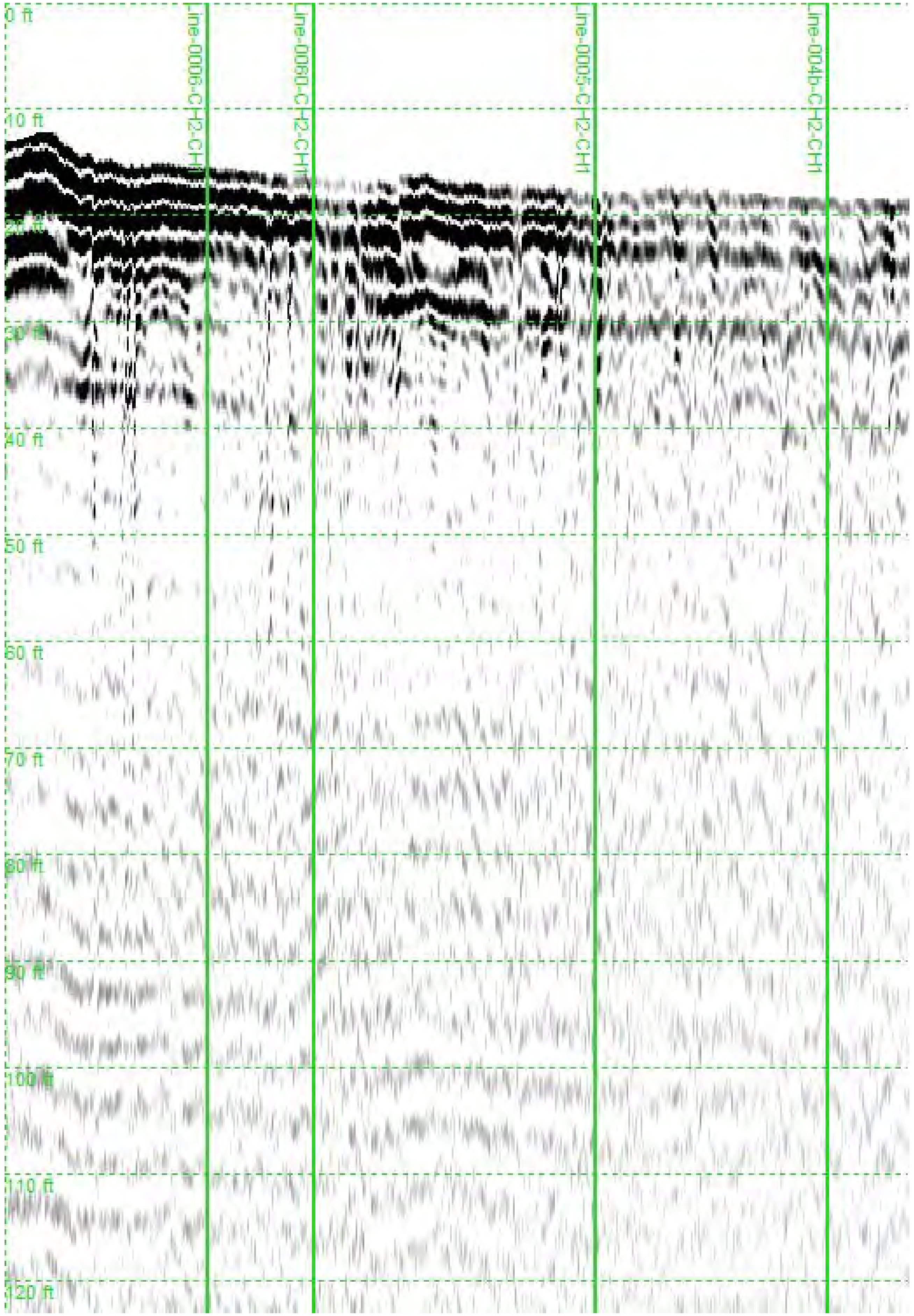

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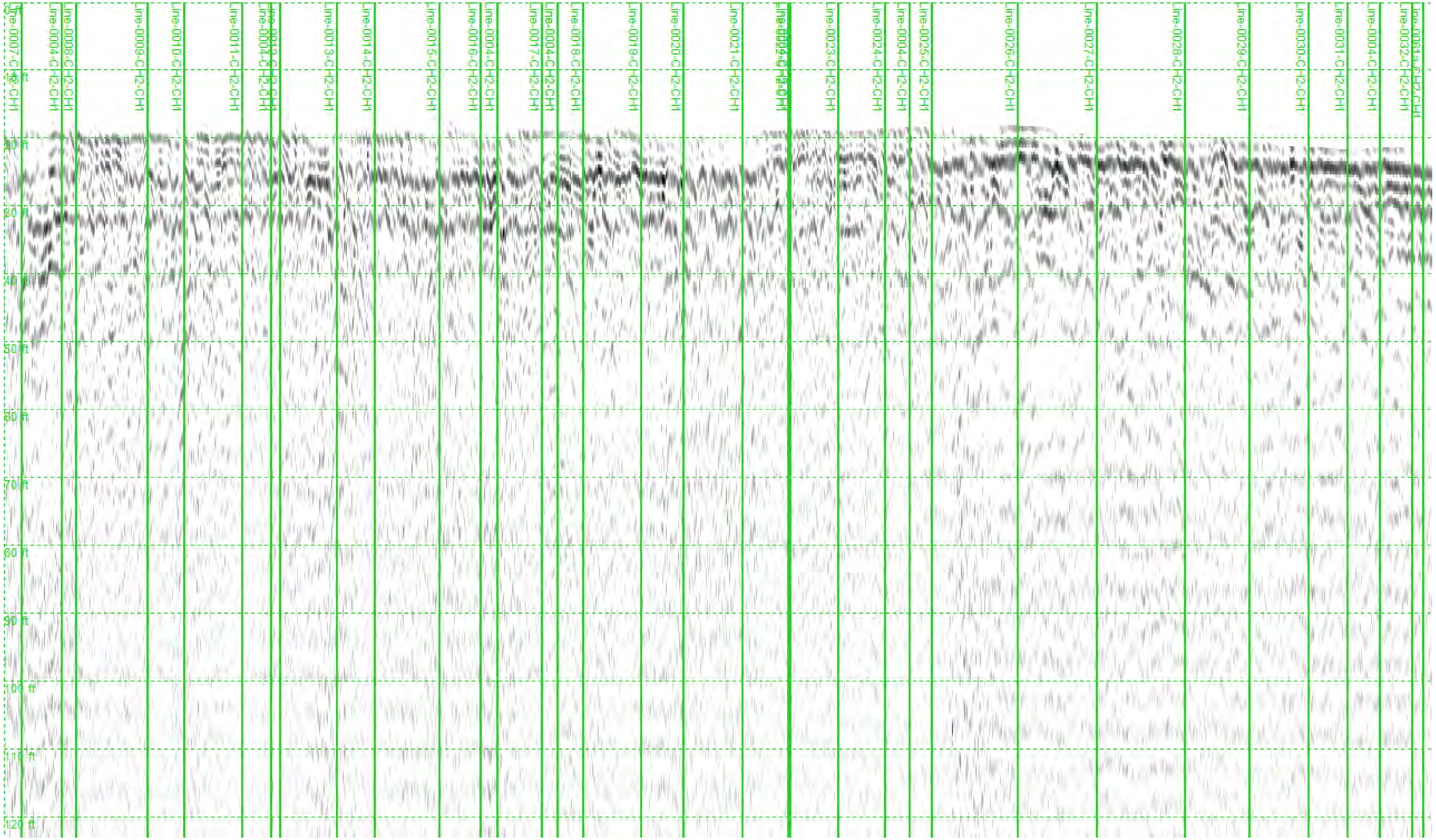

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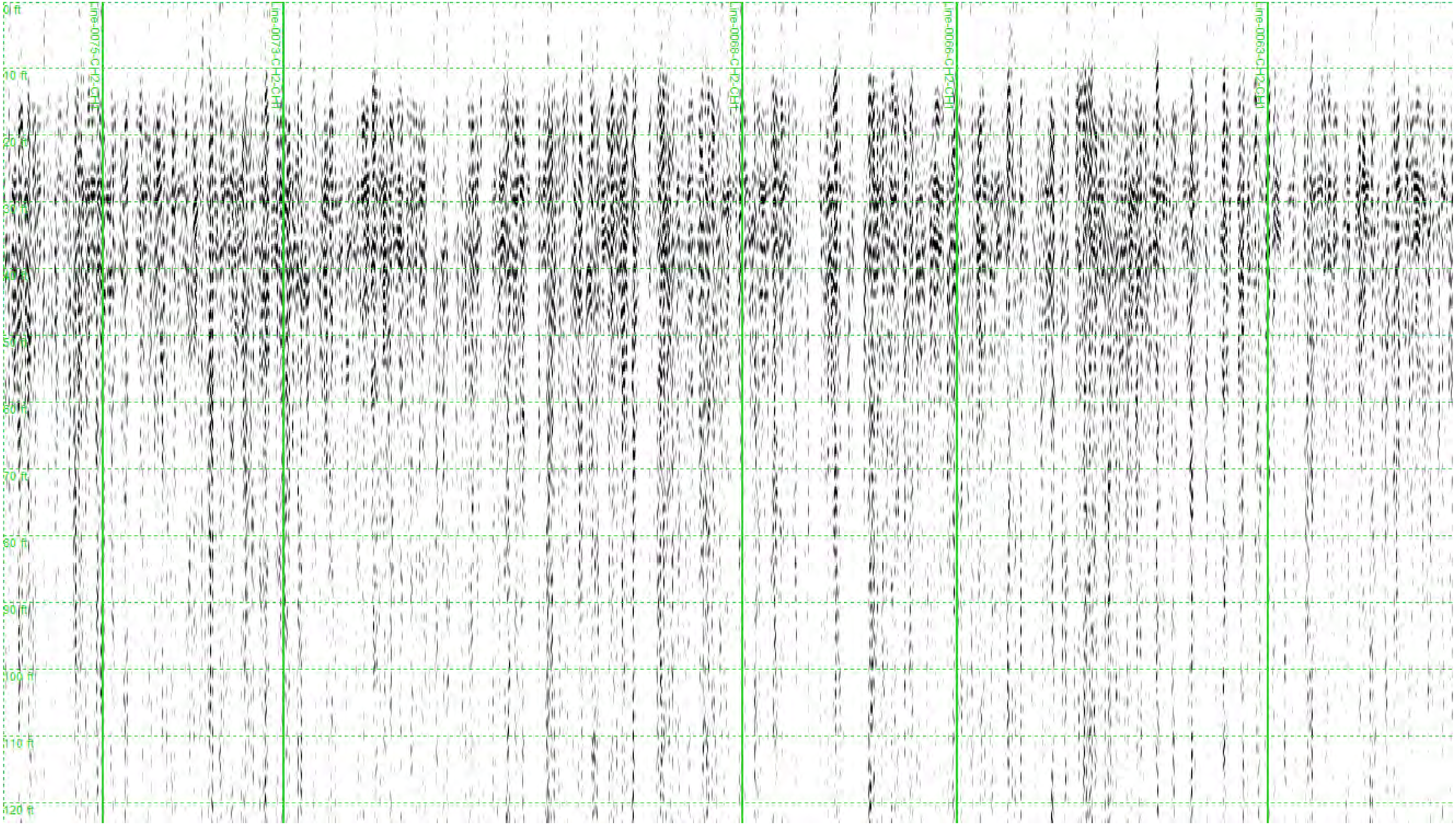

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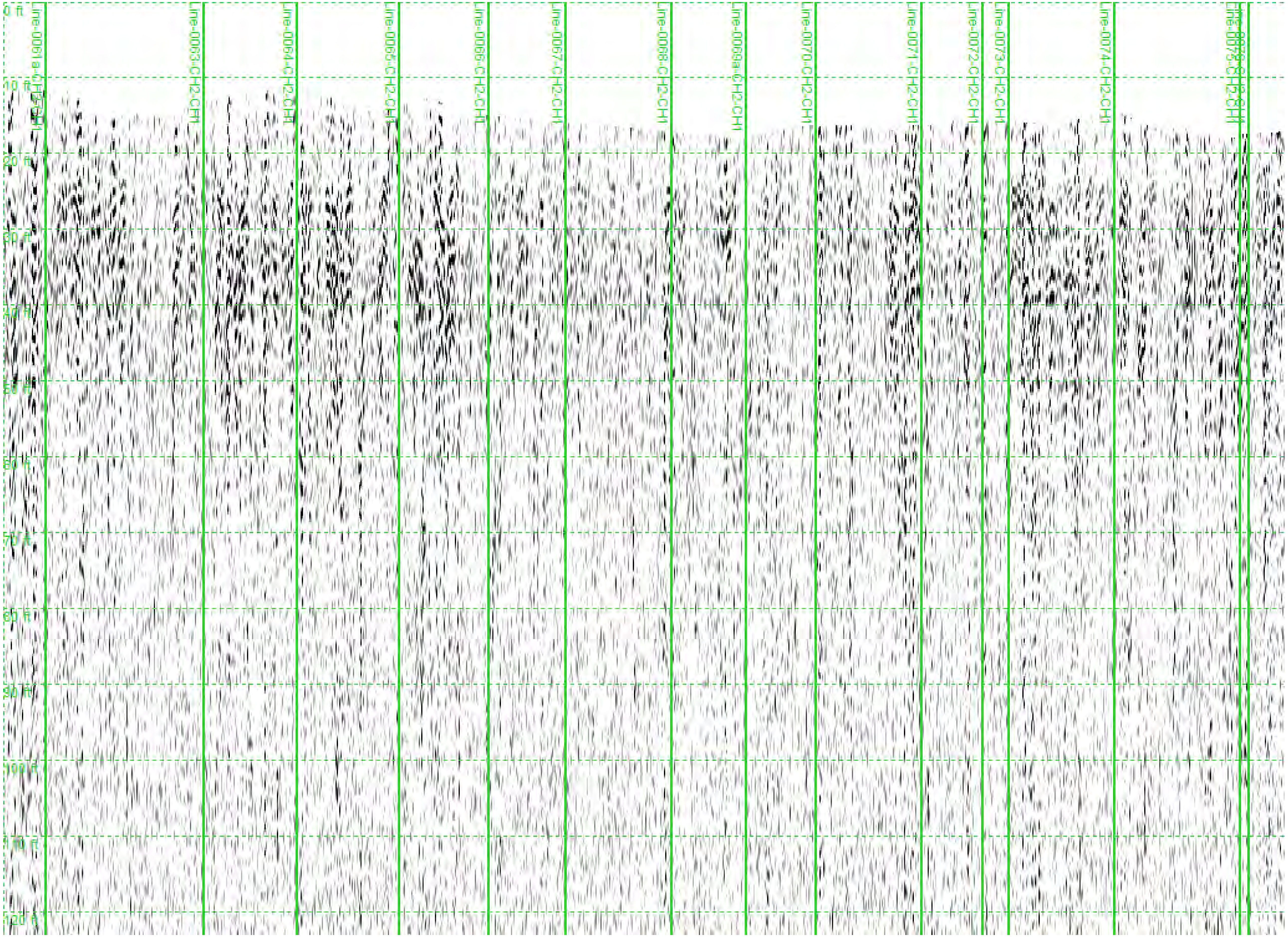

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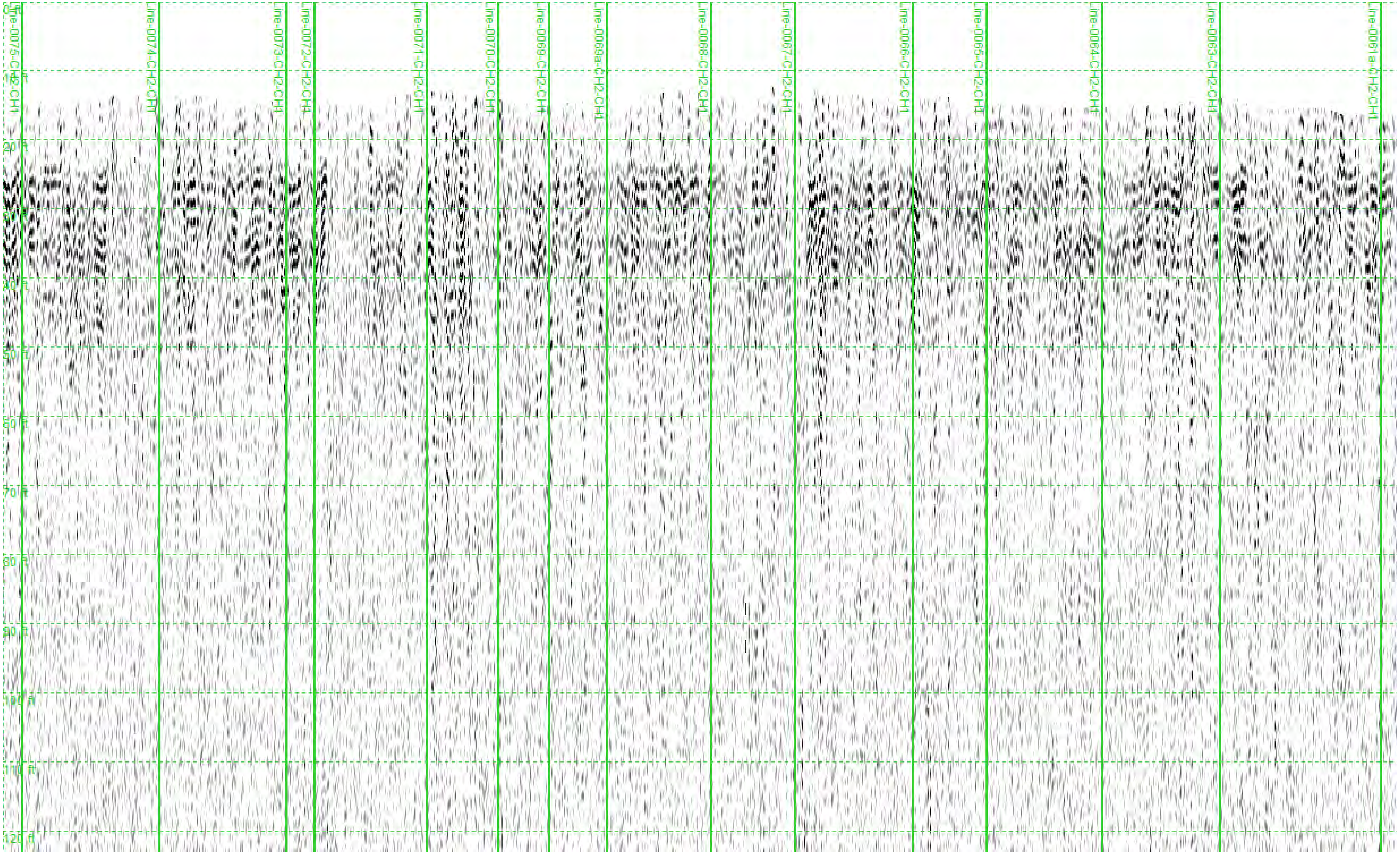

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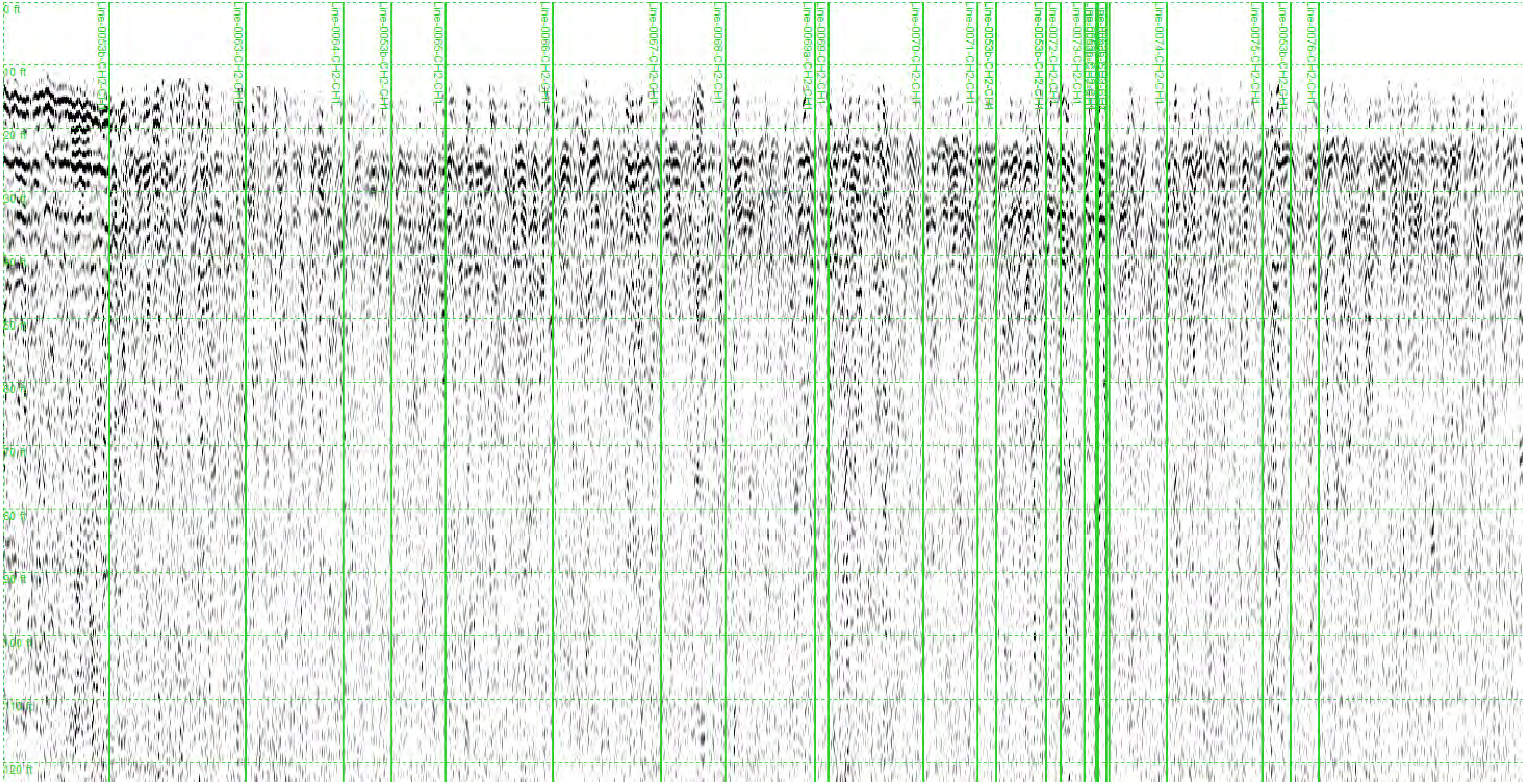

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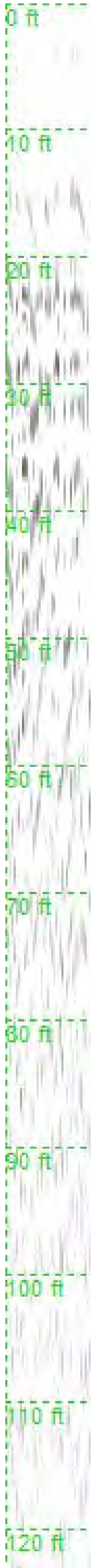

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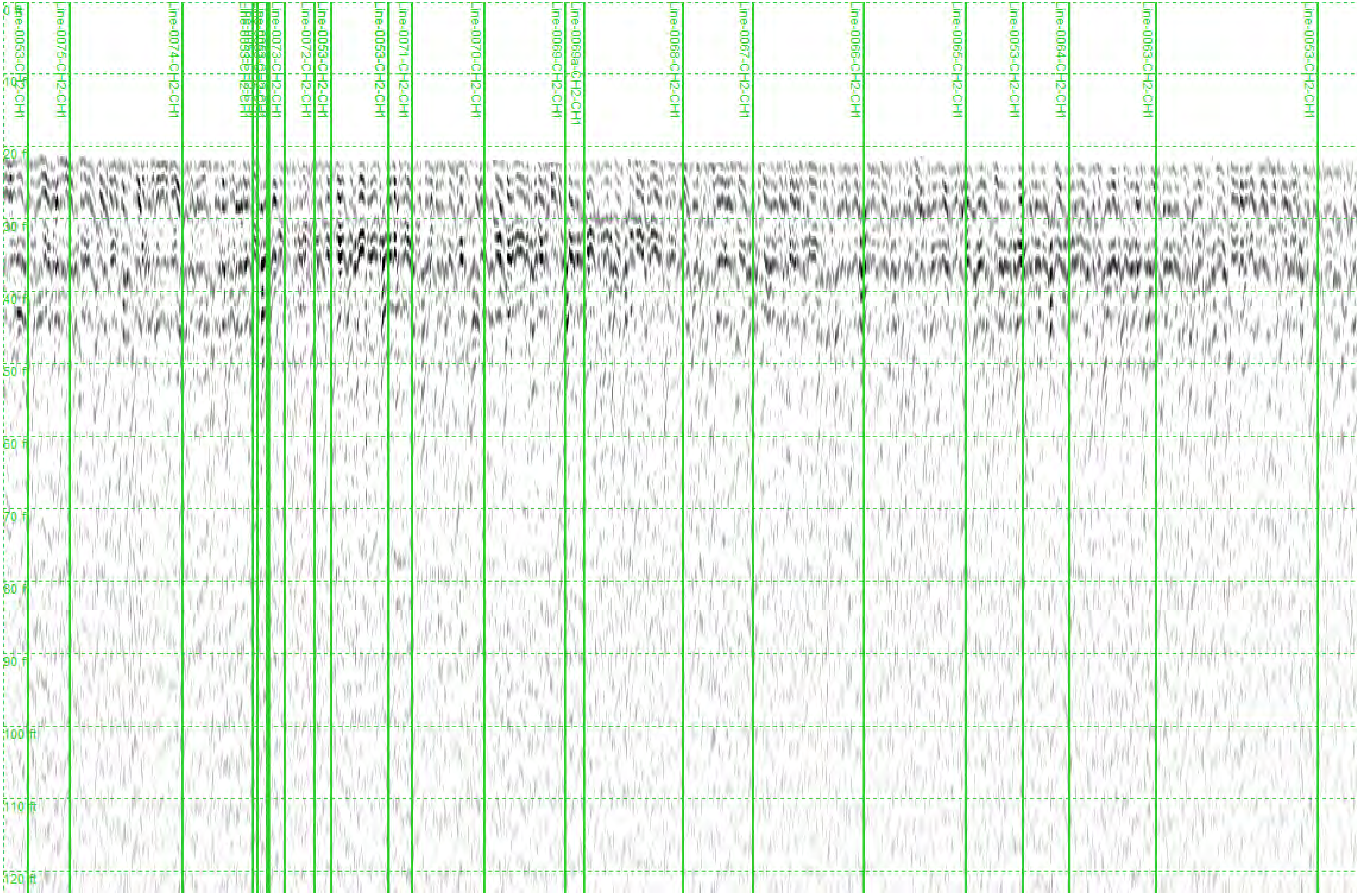

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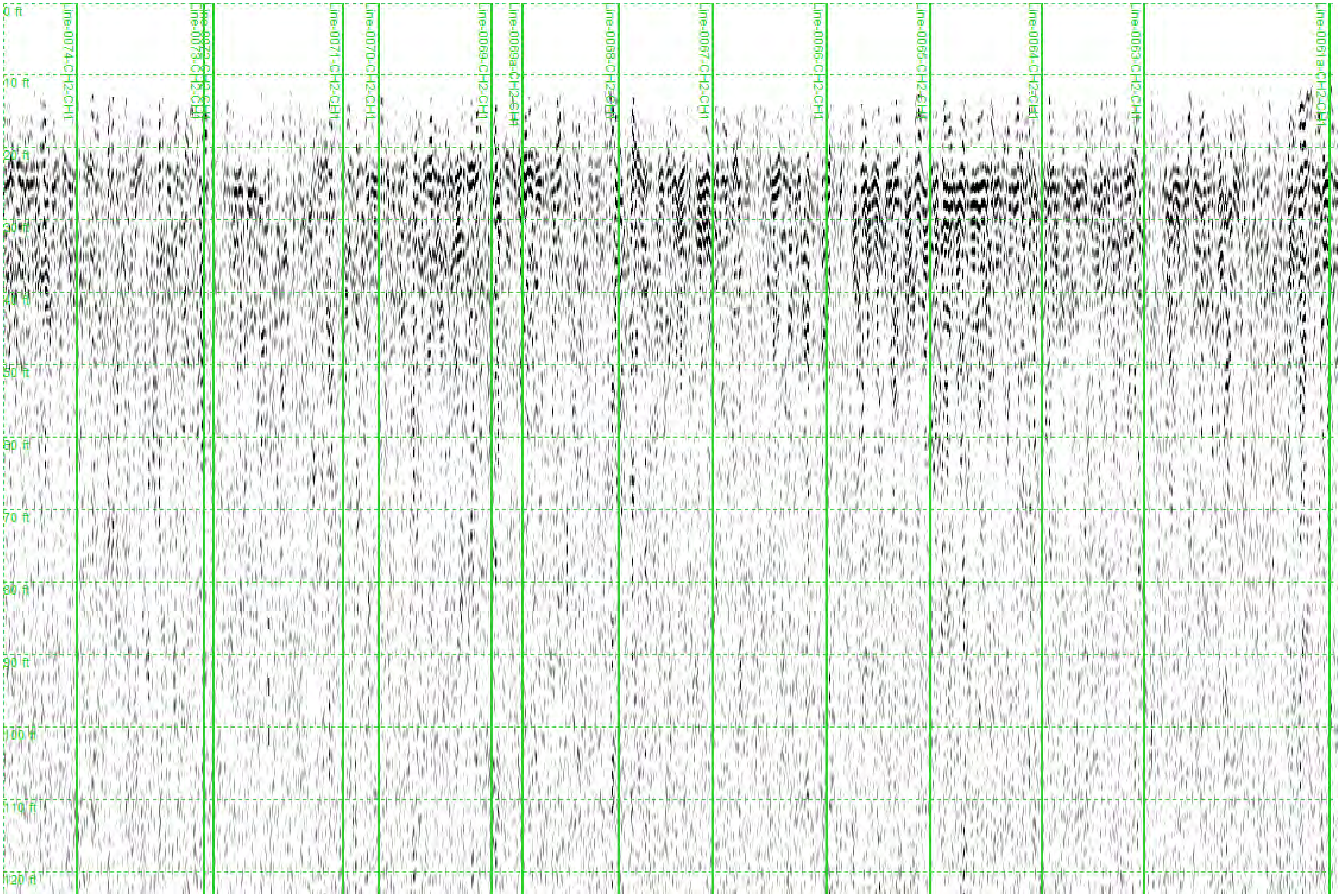

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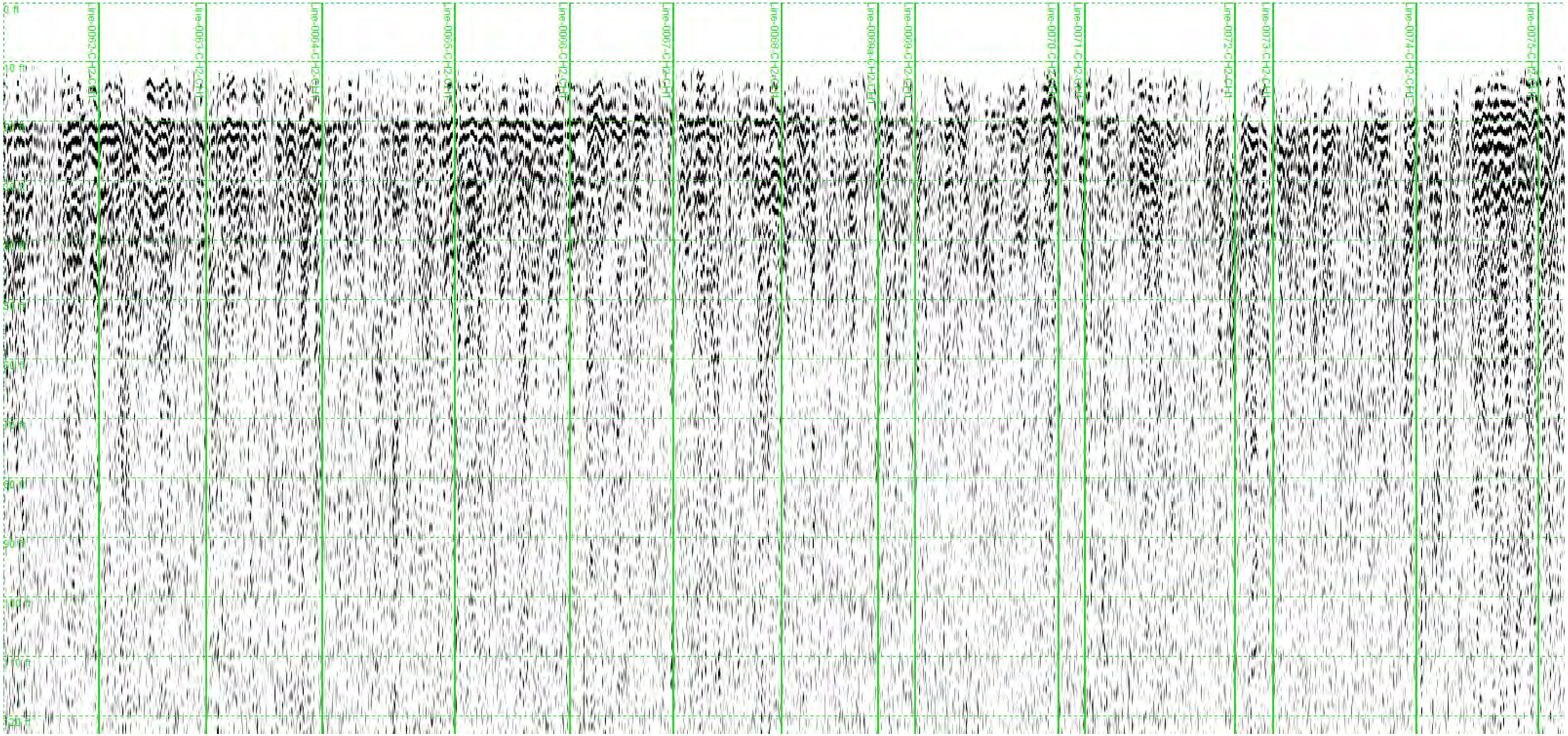
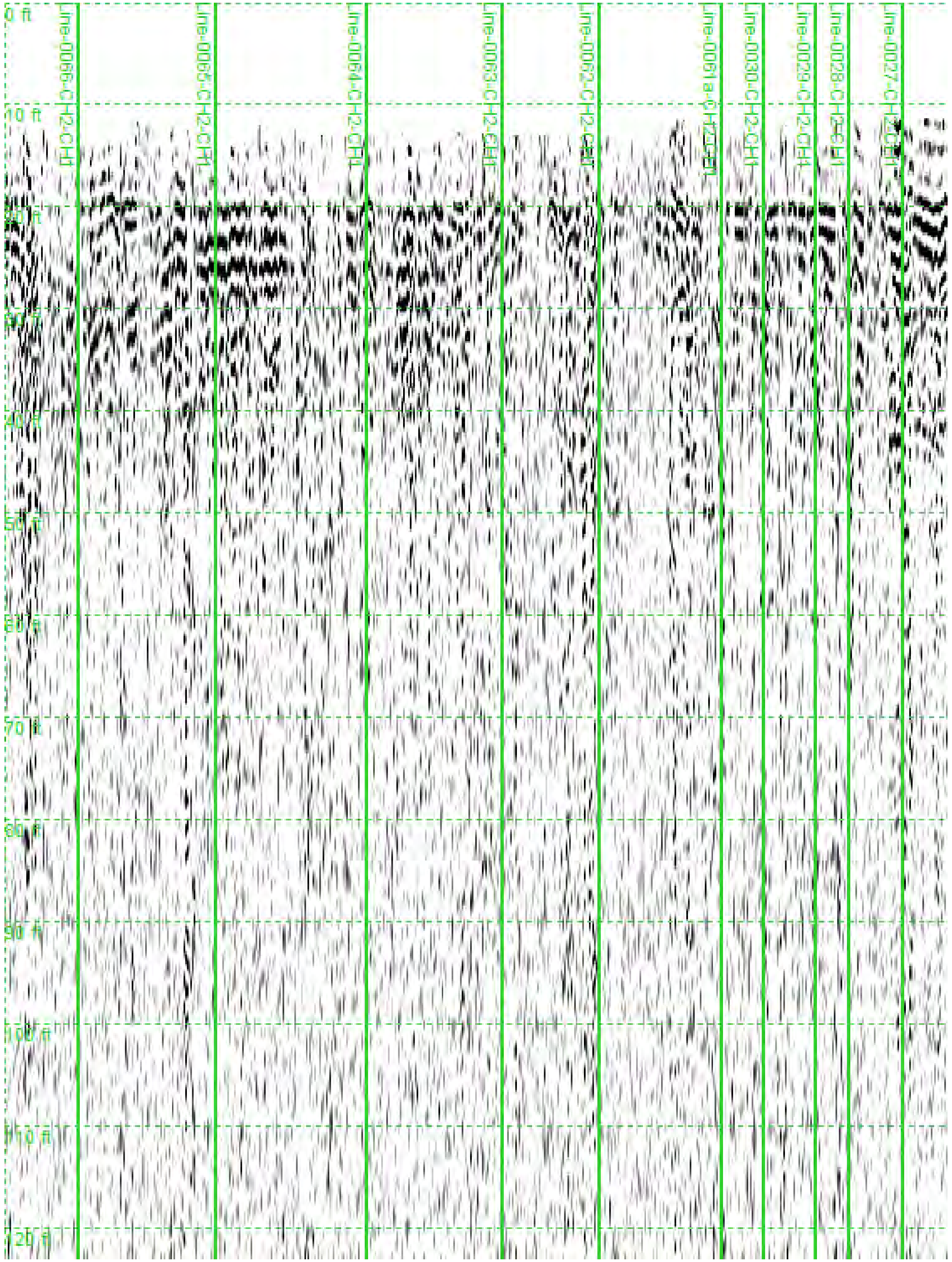


Line-0055-CH2-CH1.jpg



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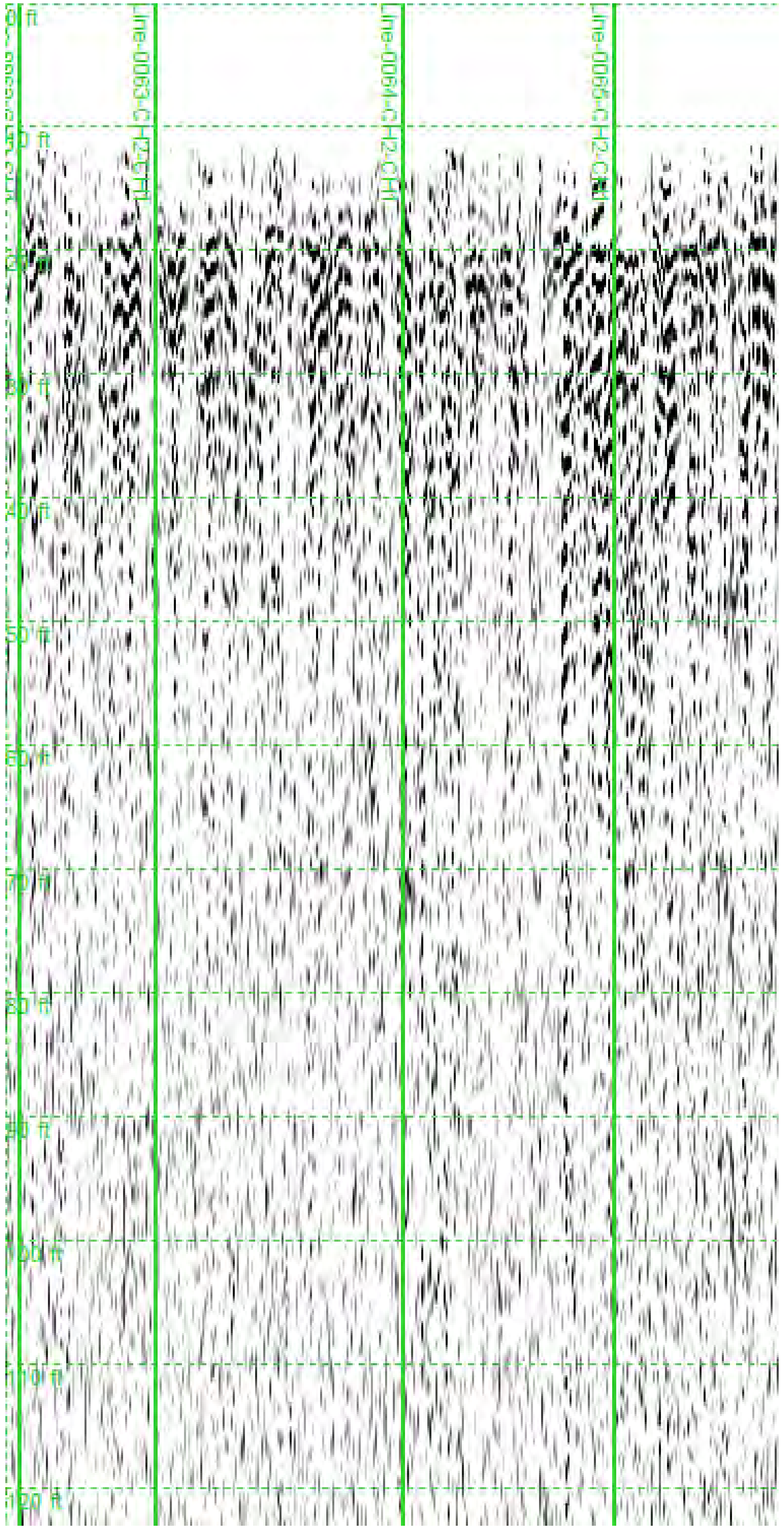

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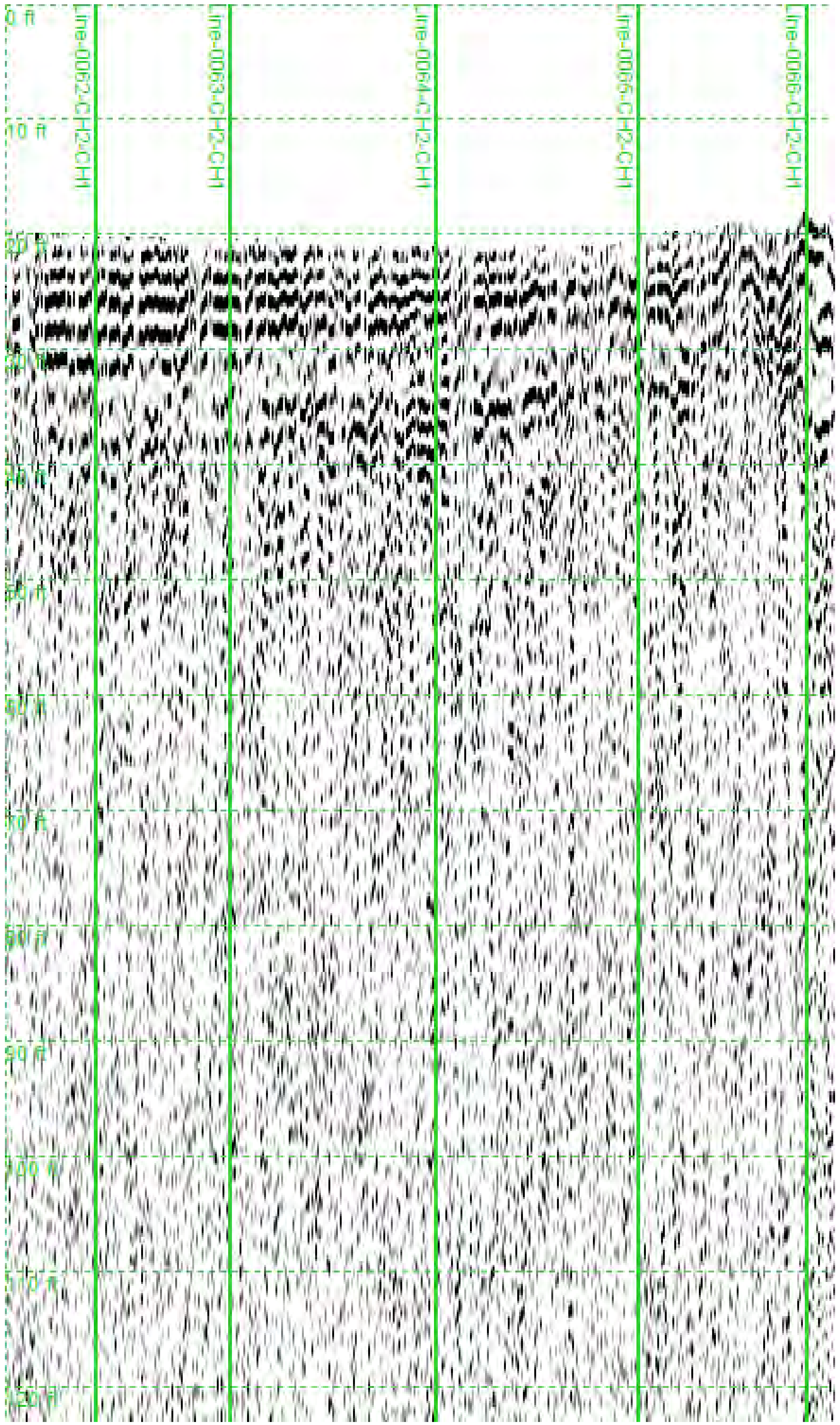

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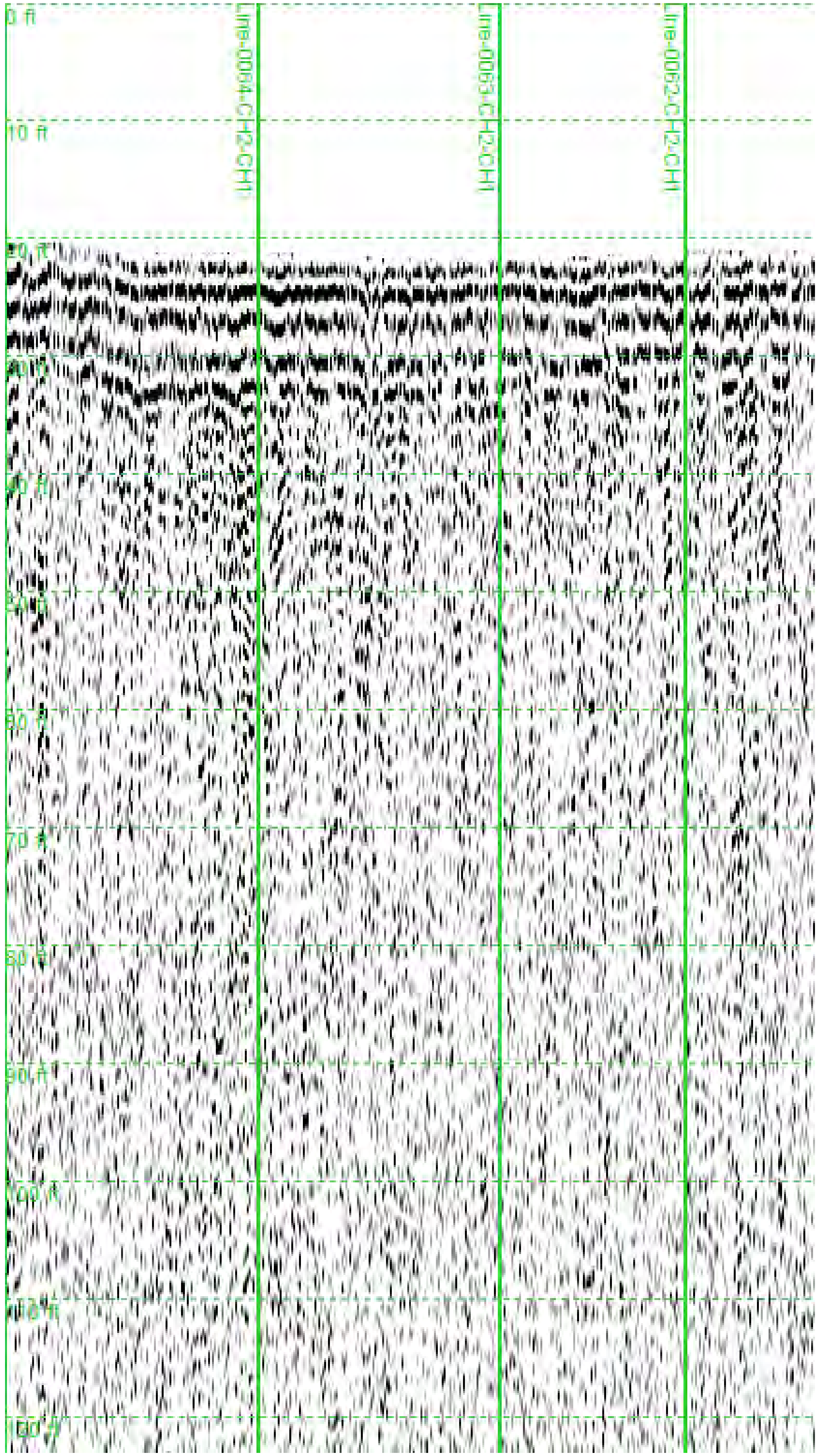

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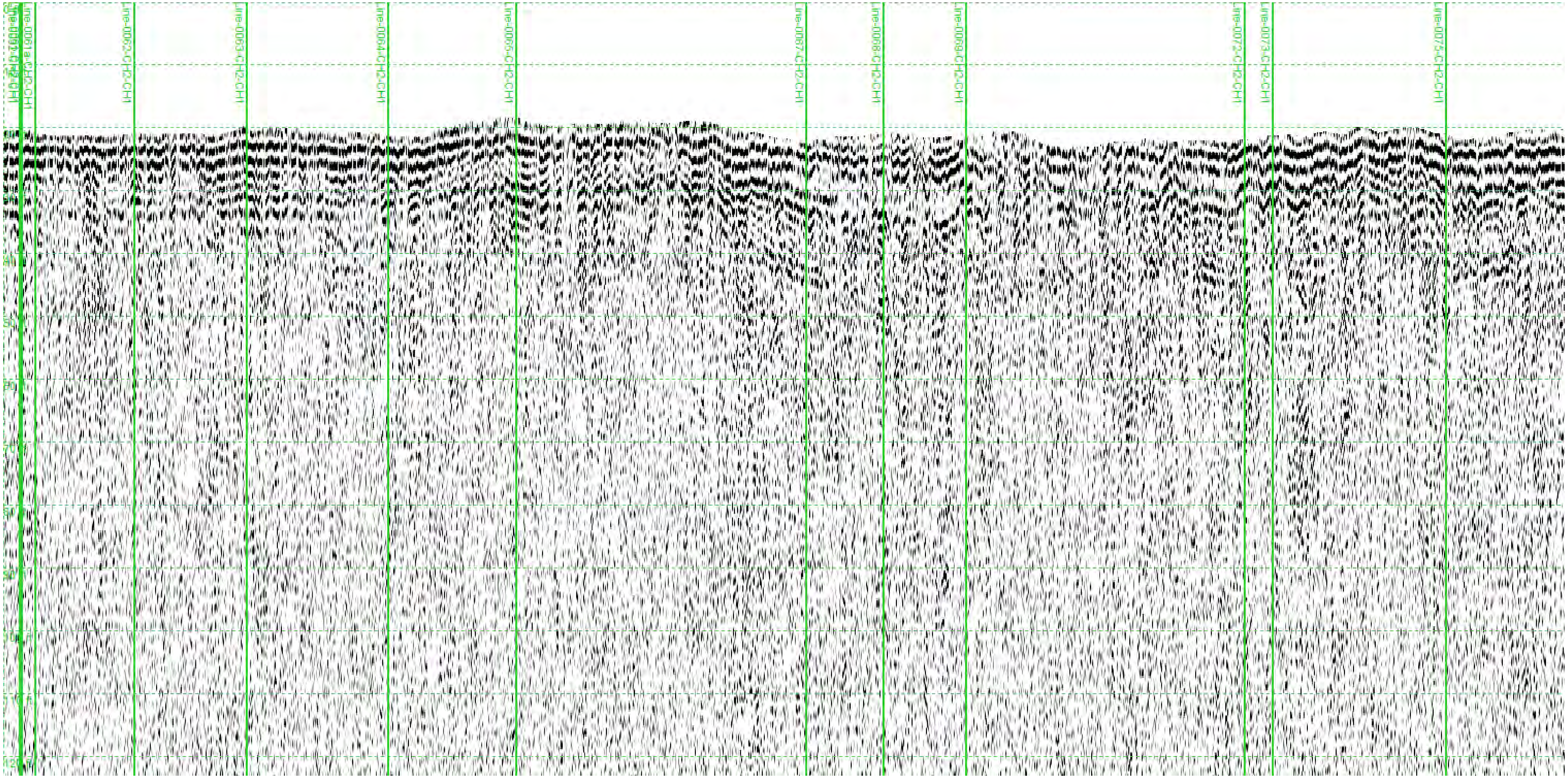

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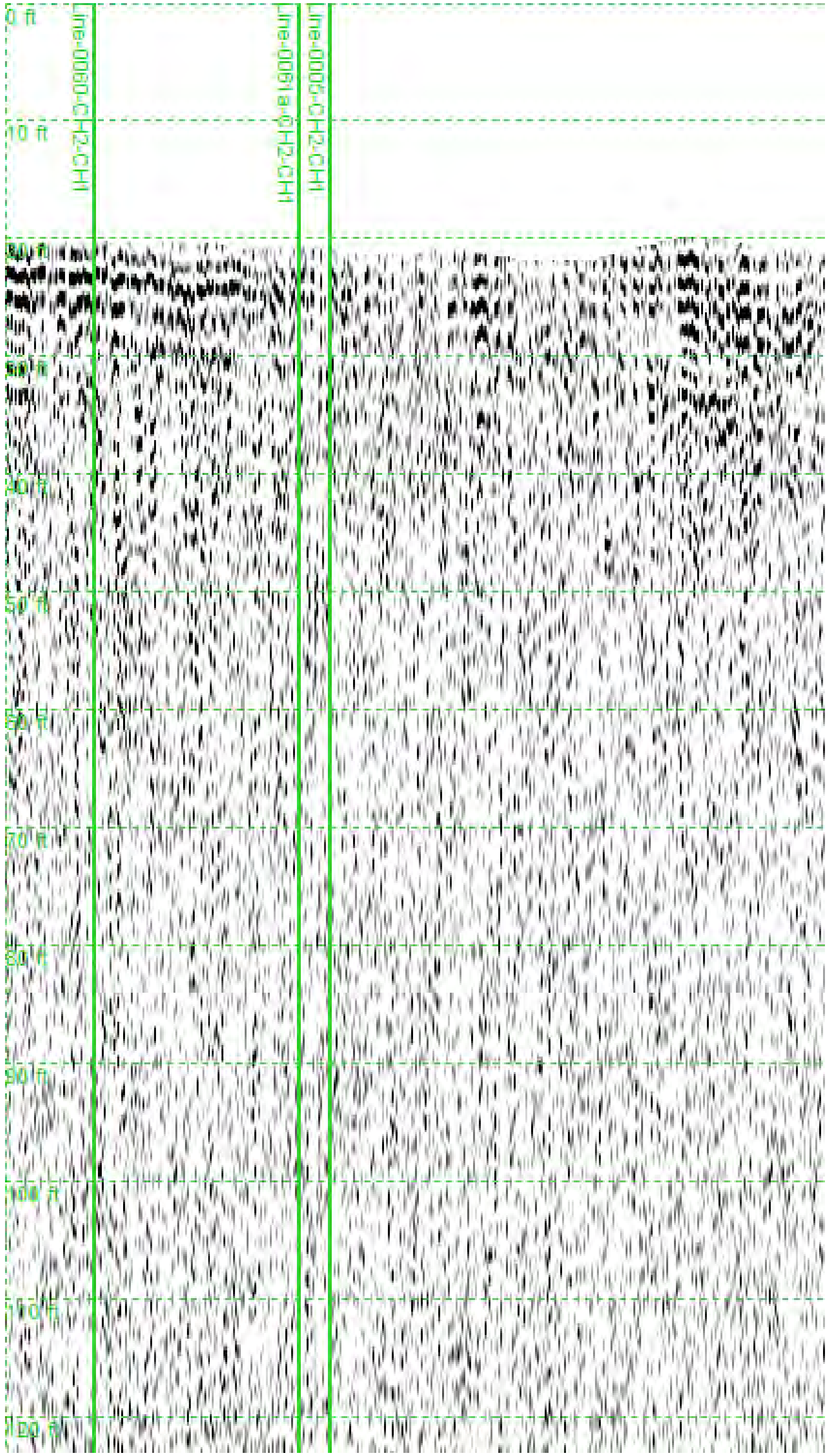

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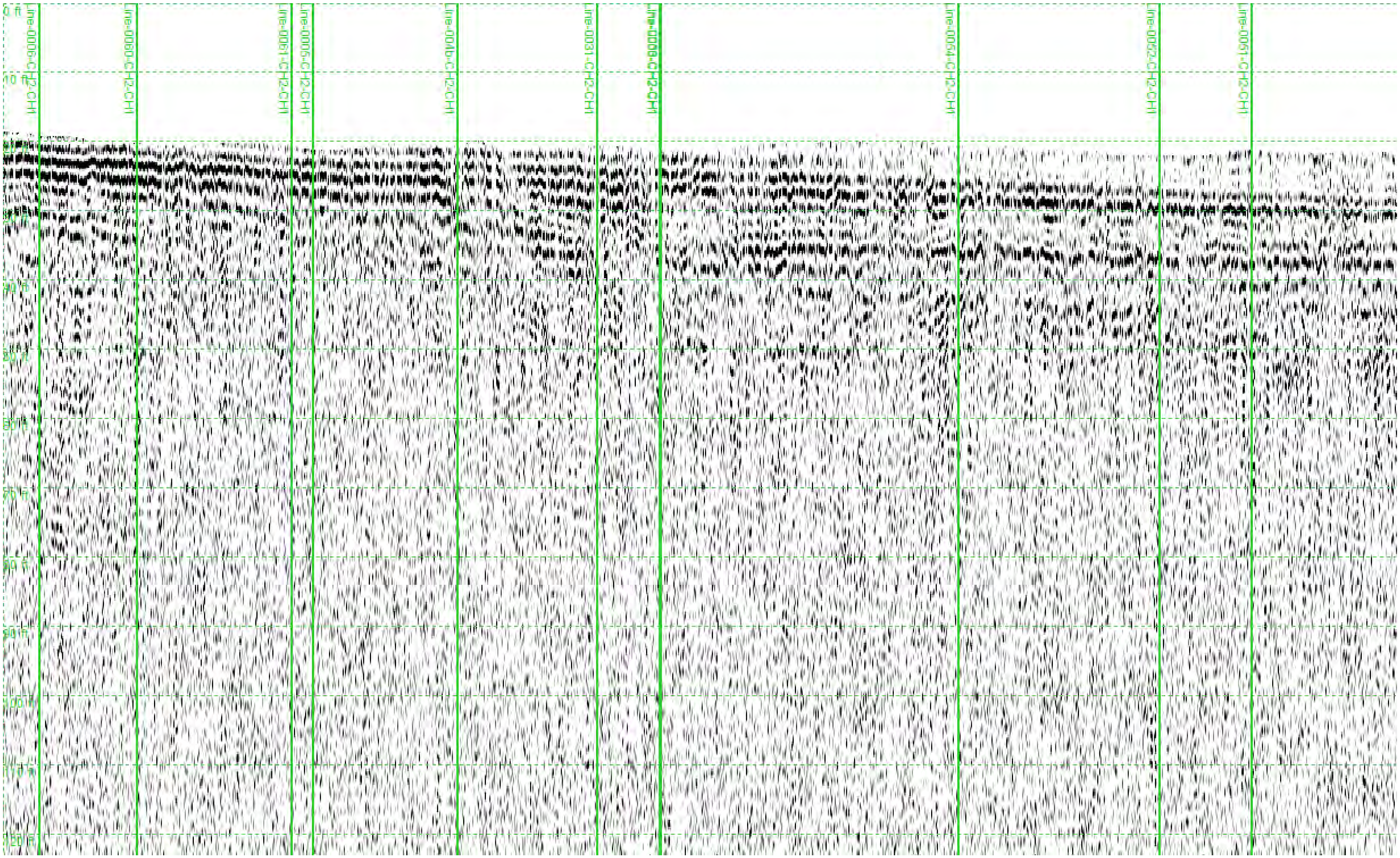

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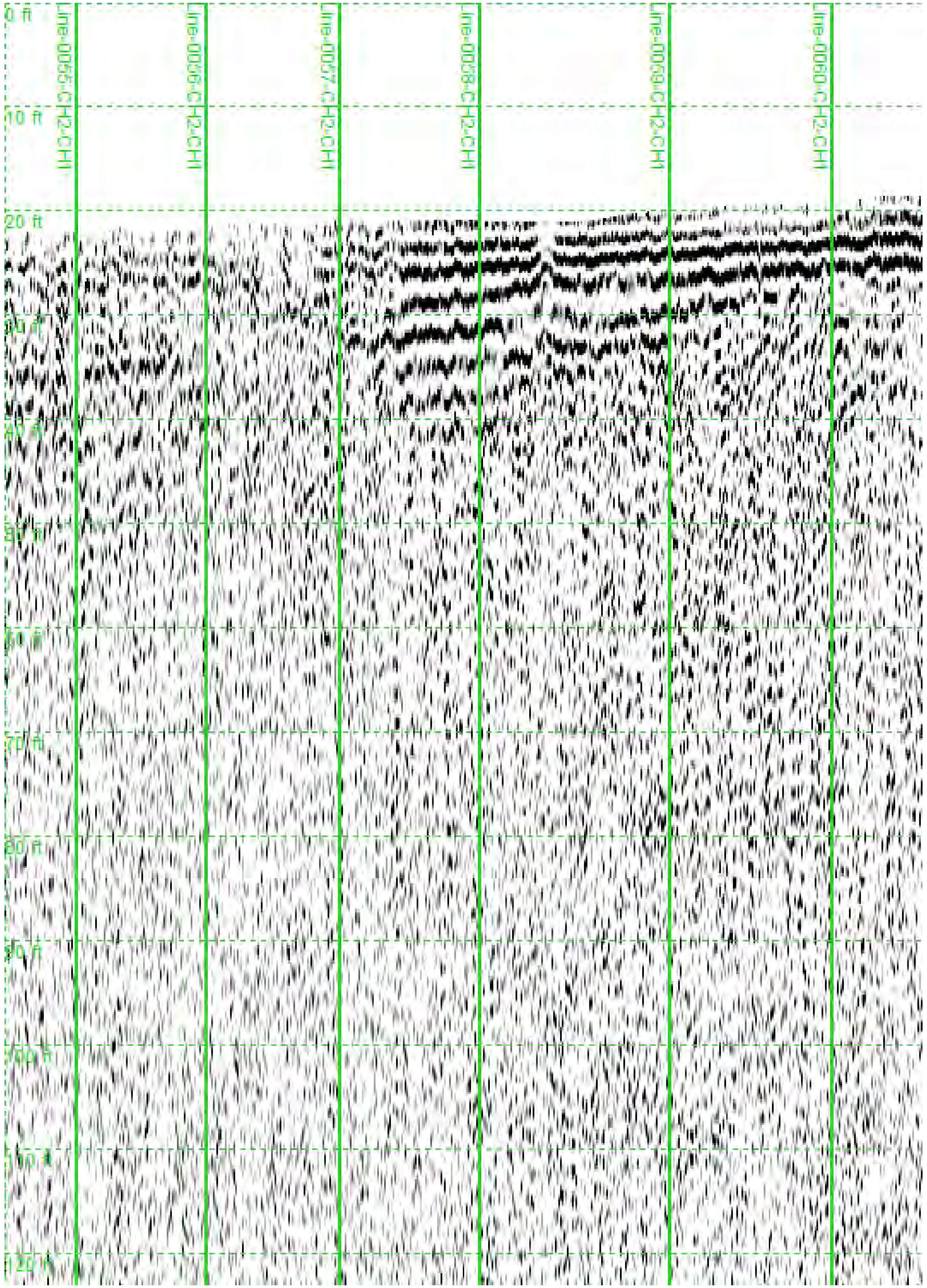

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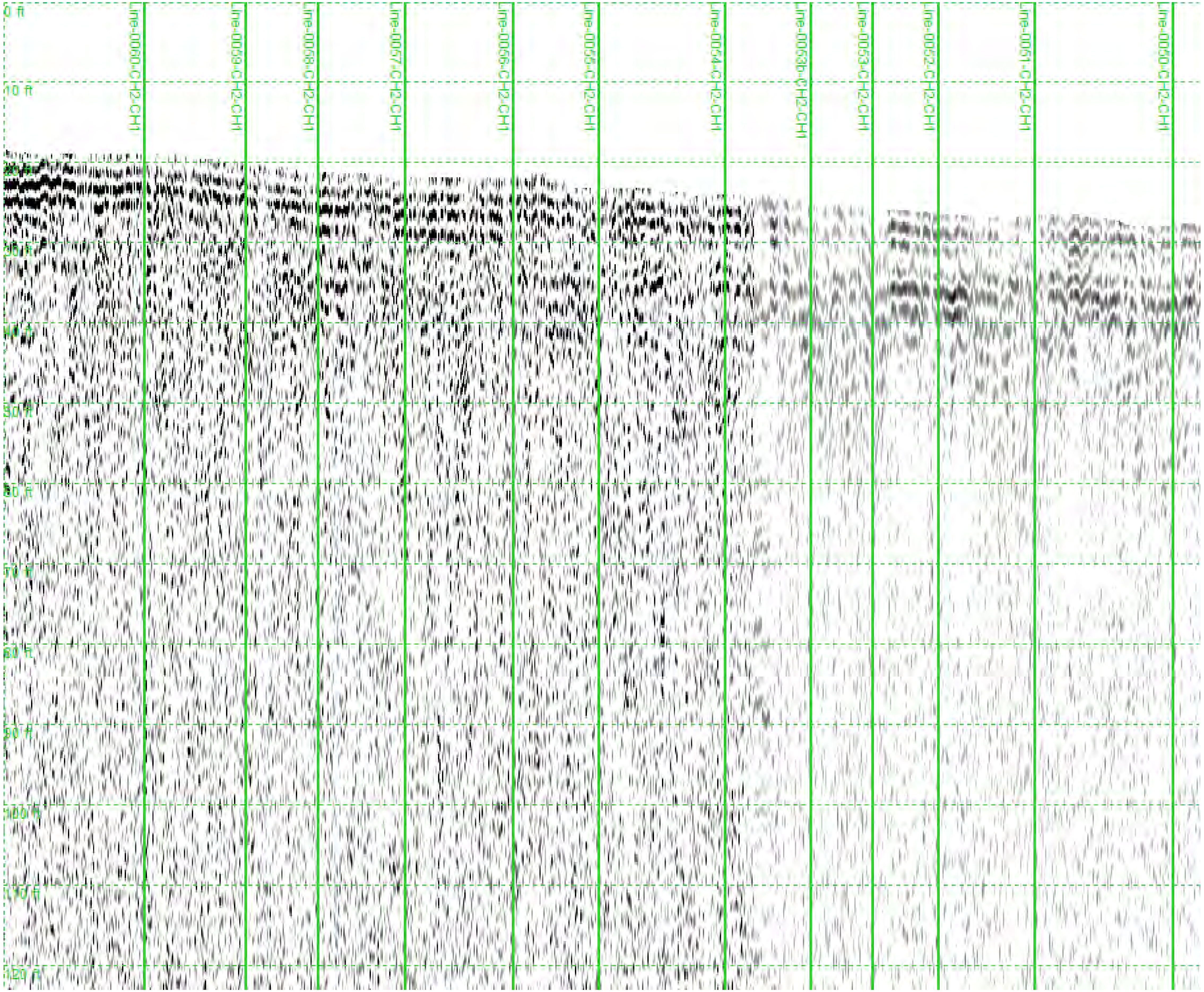

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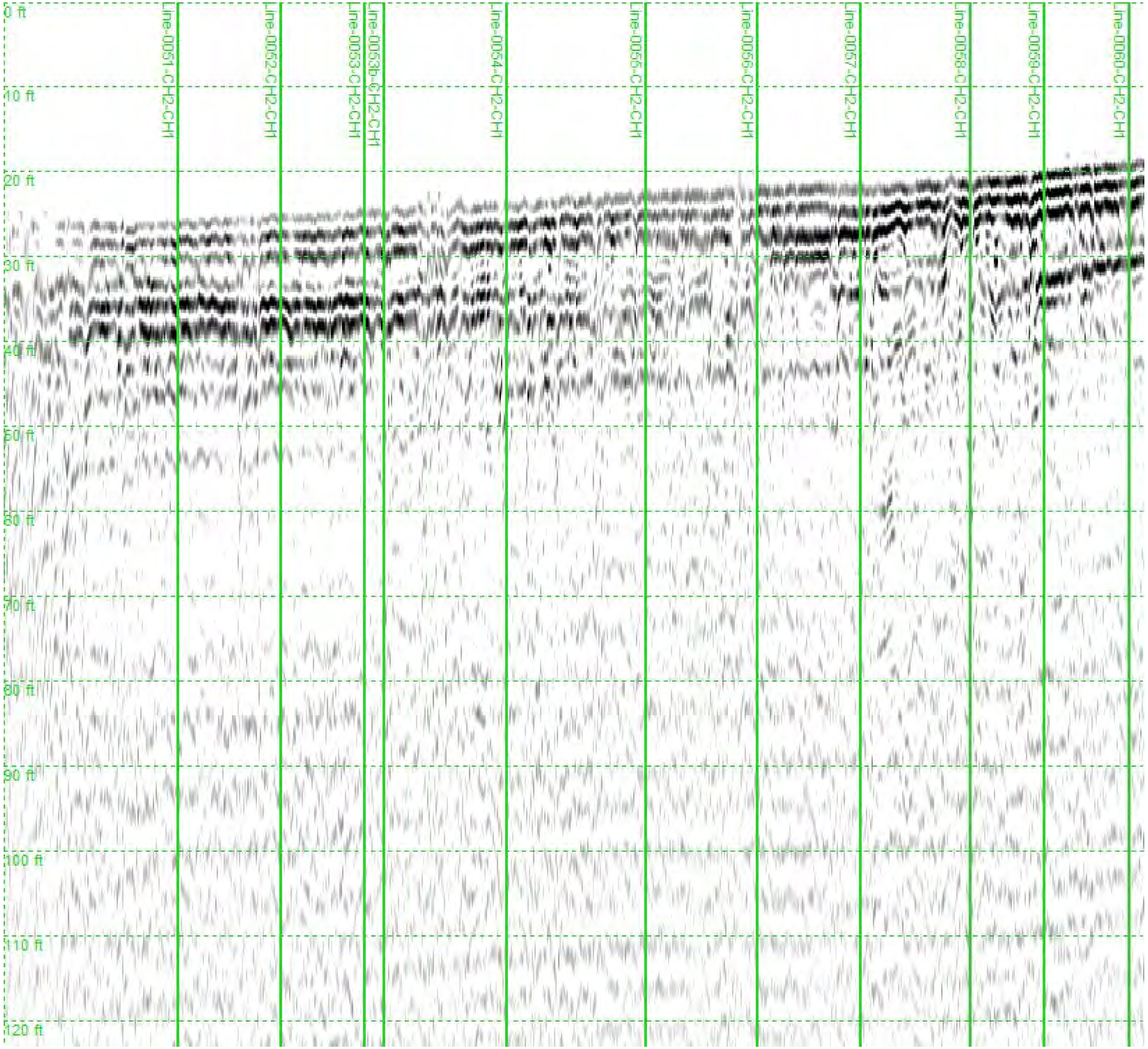

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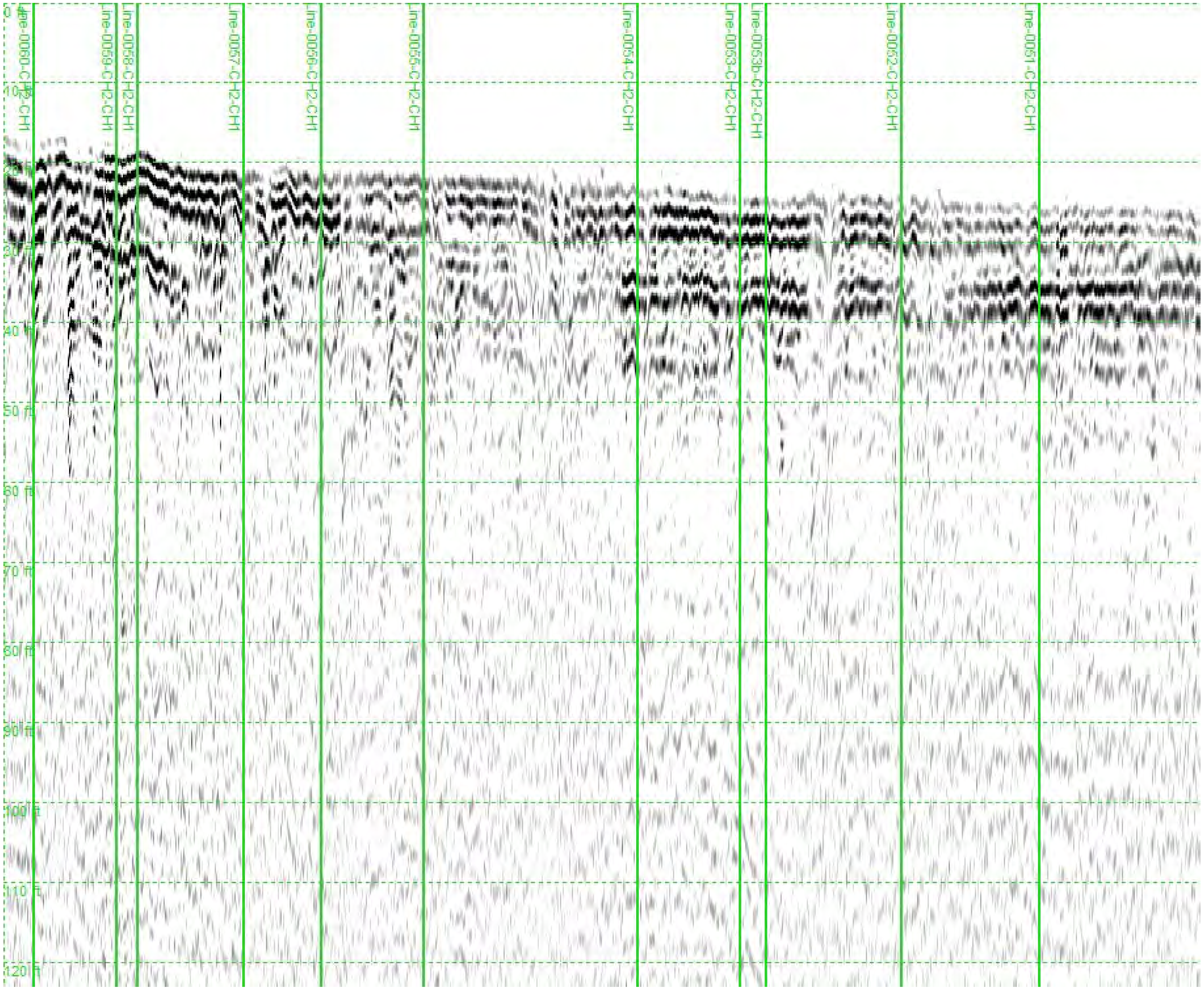

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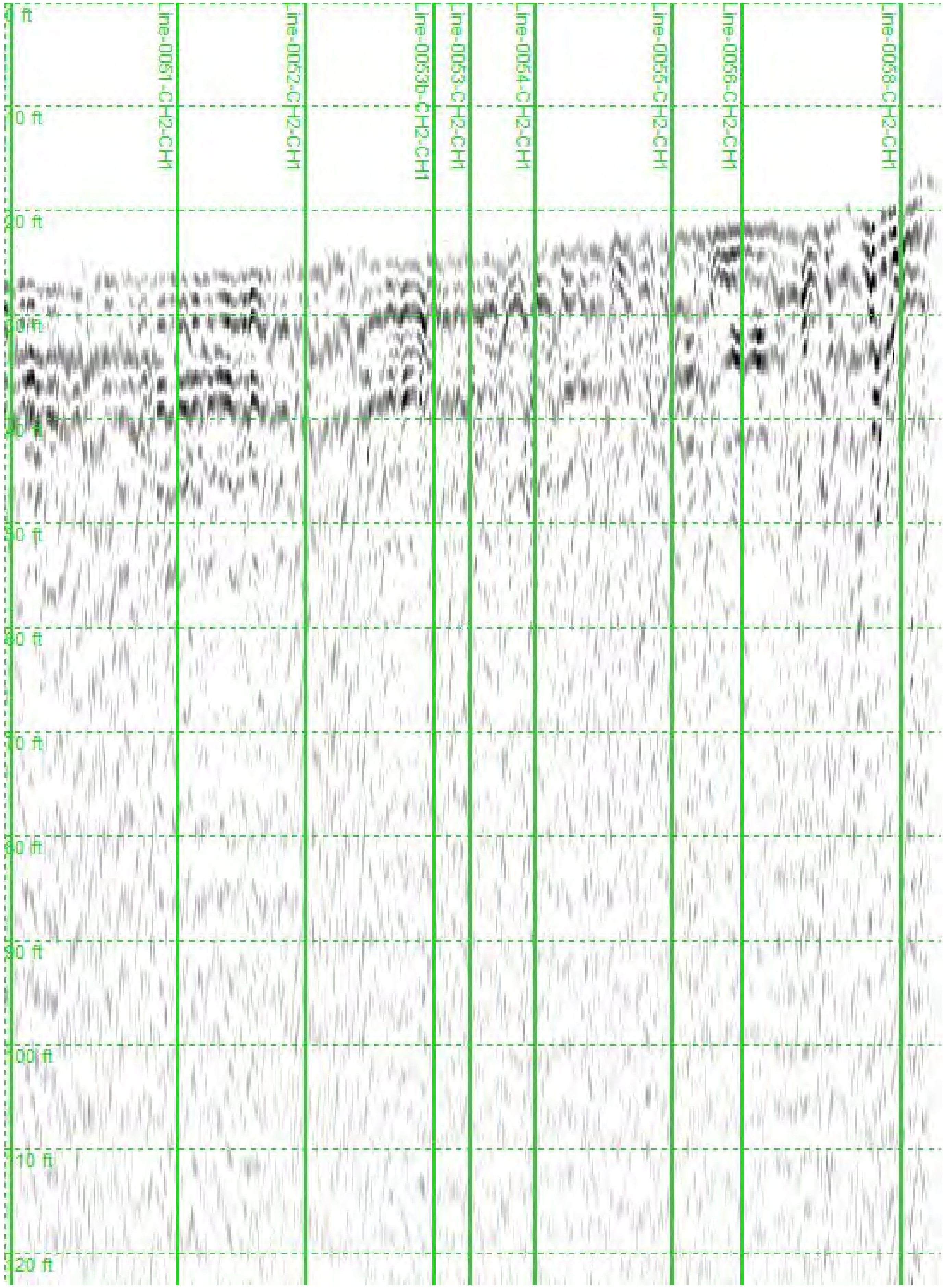

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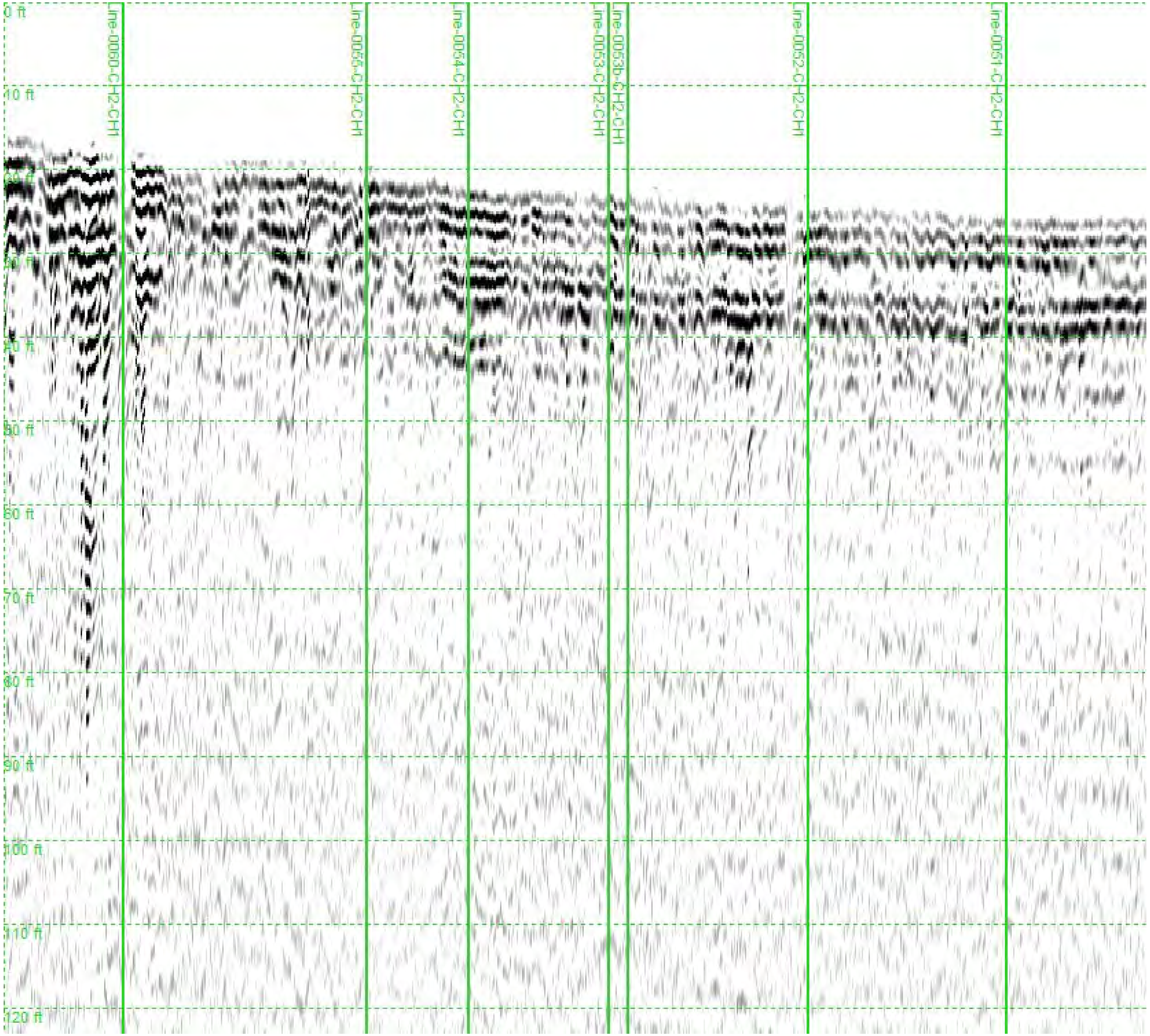

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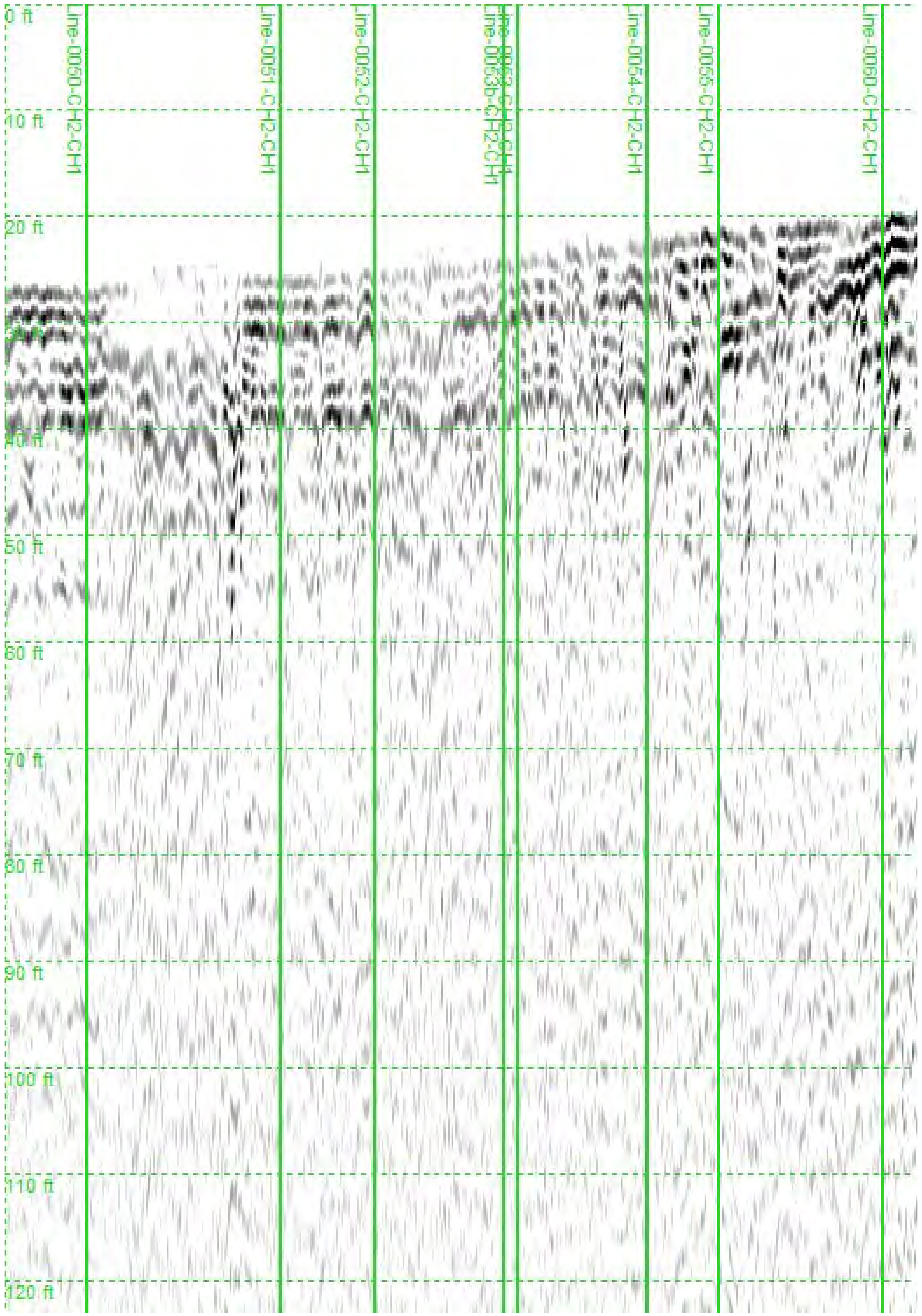

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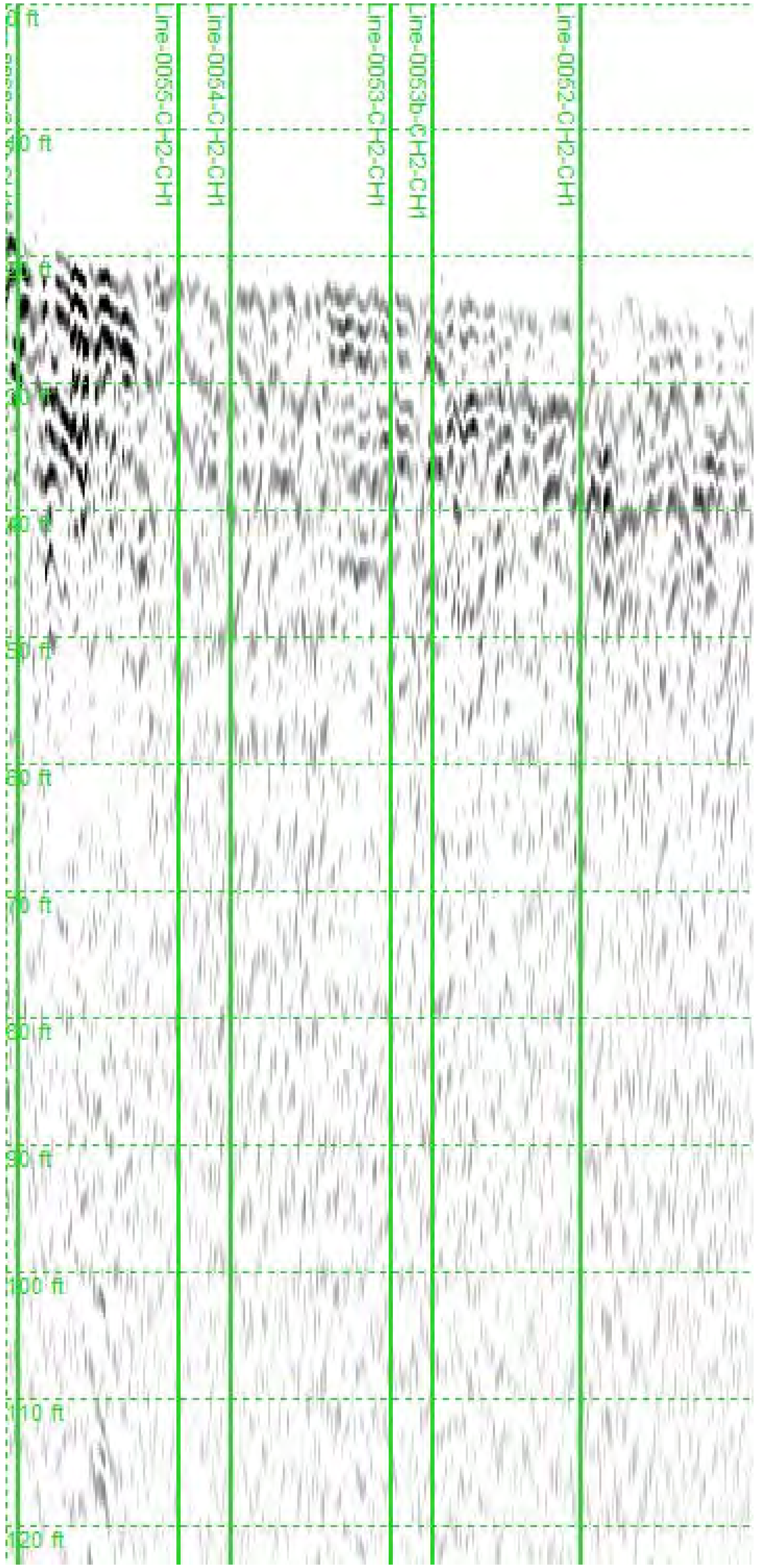

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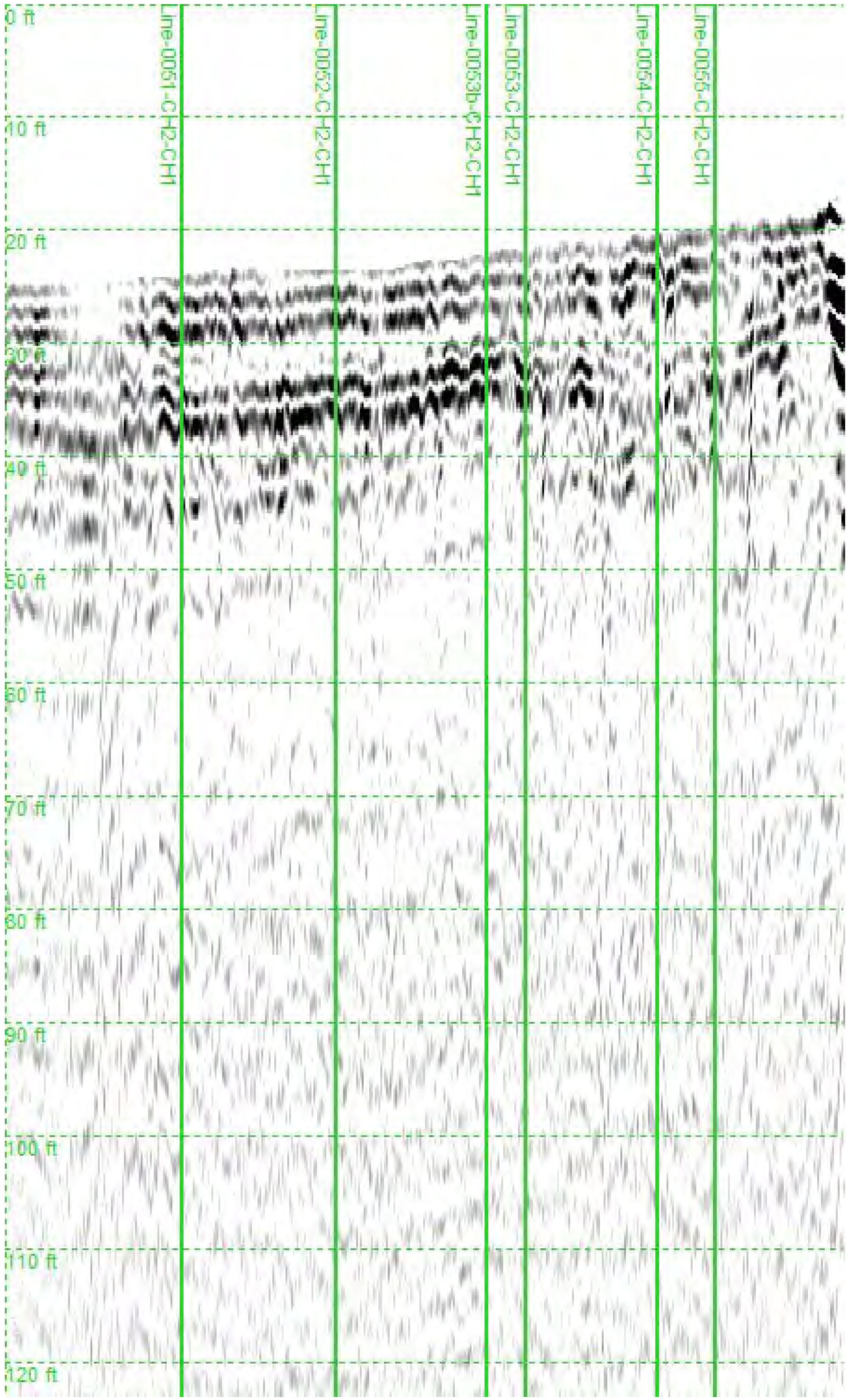

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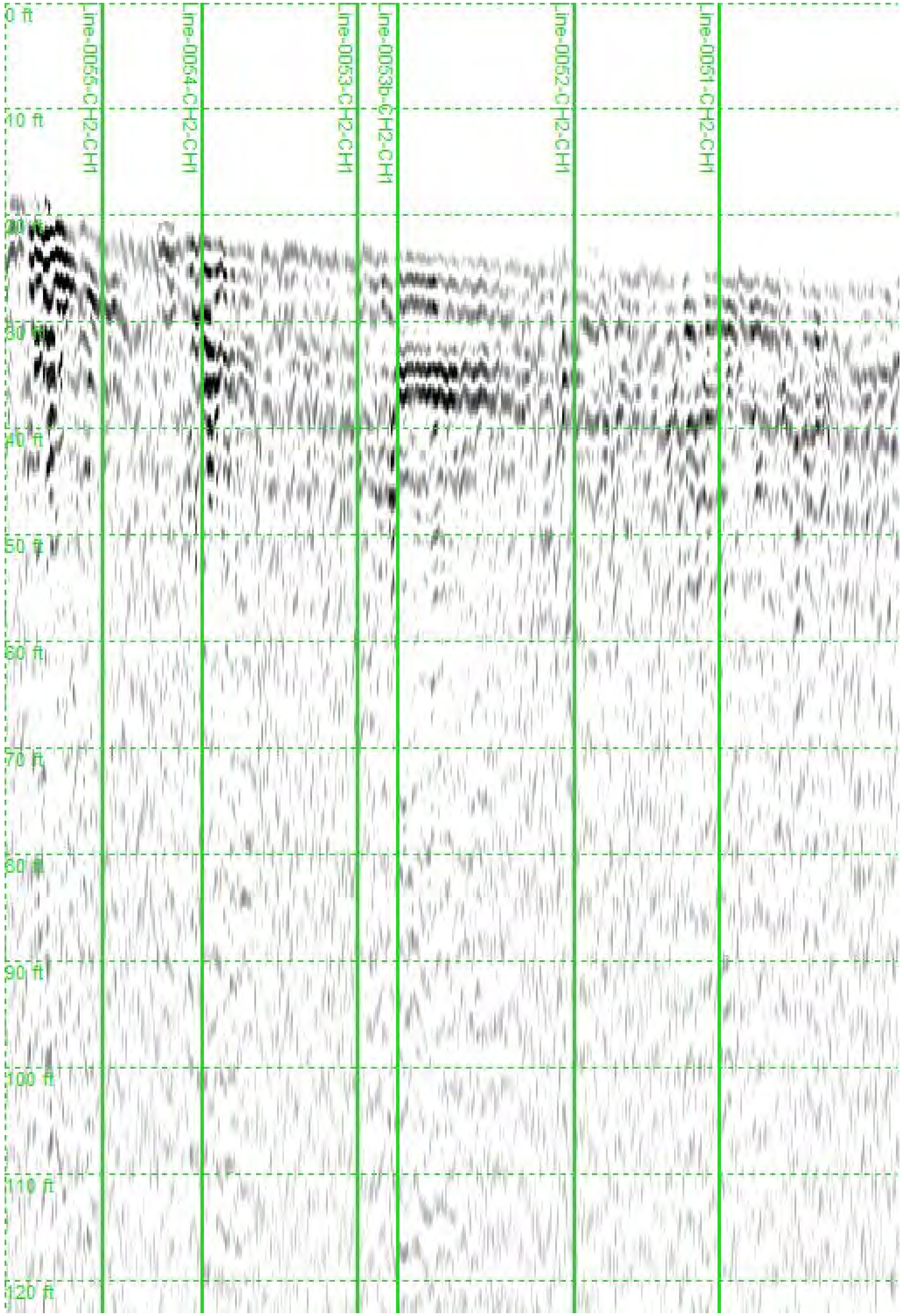
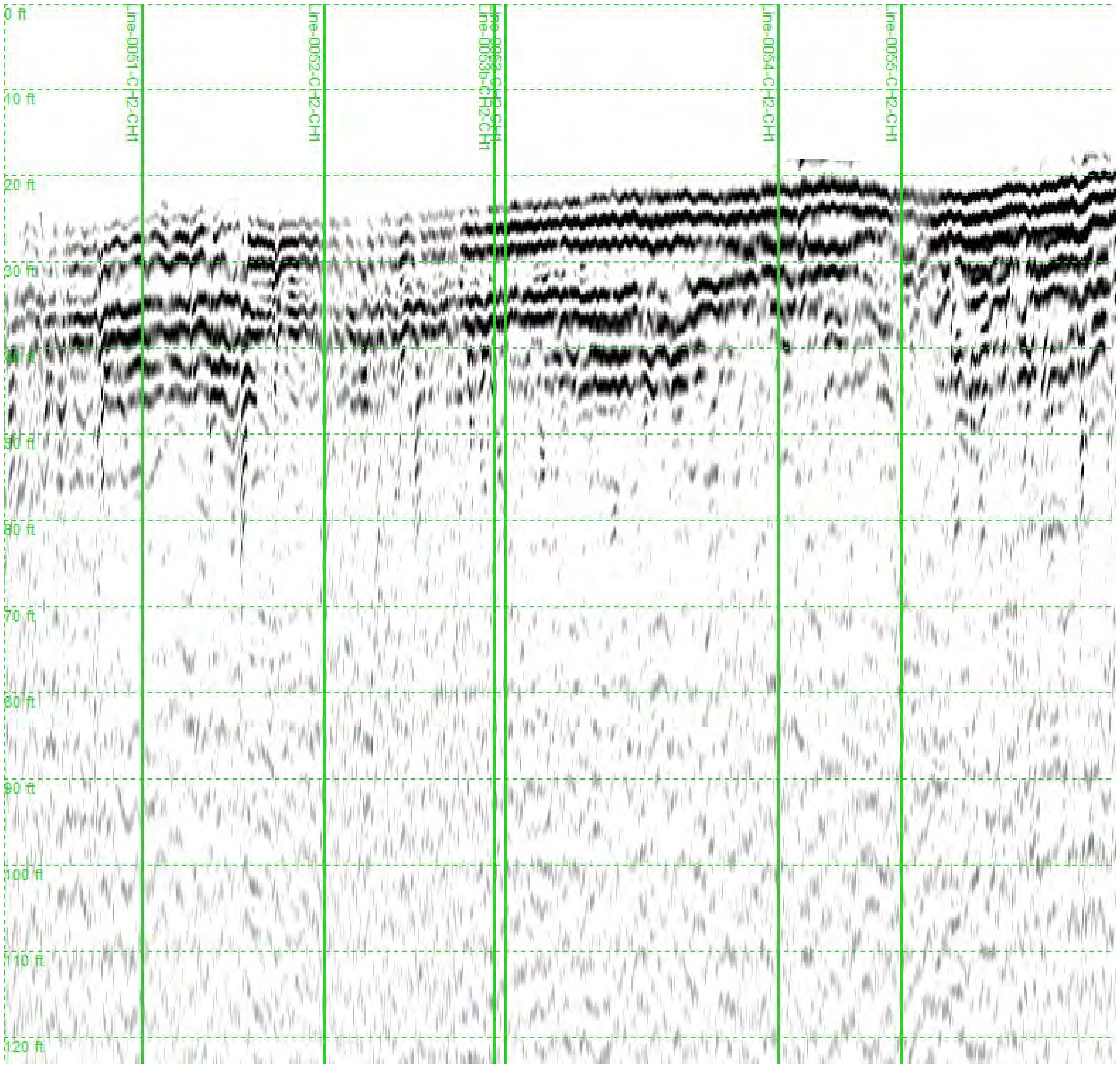
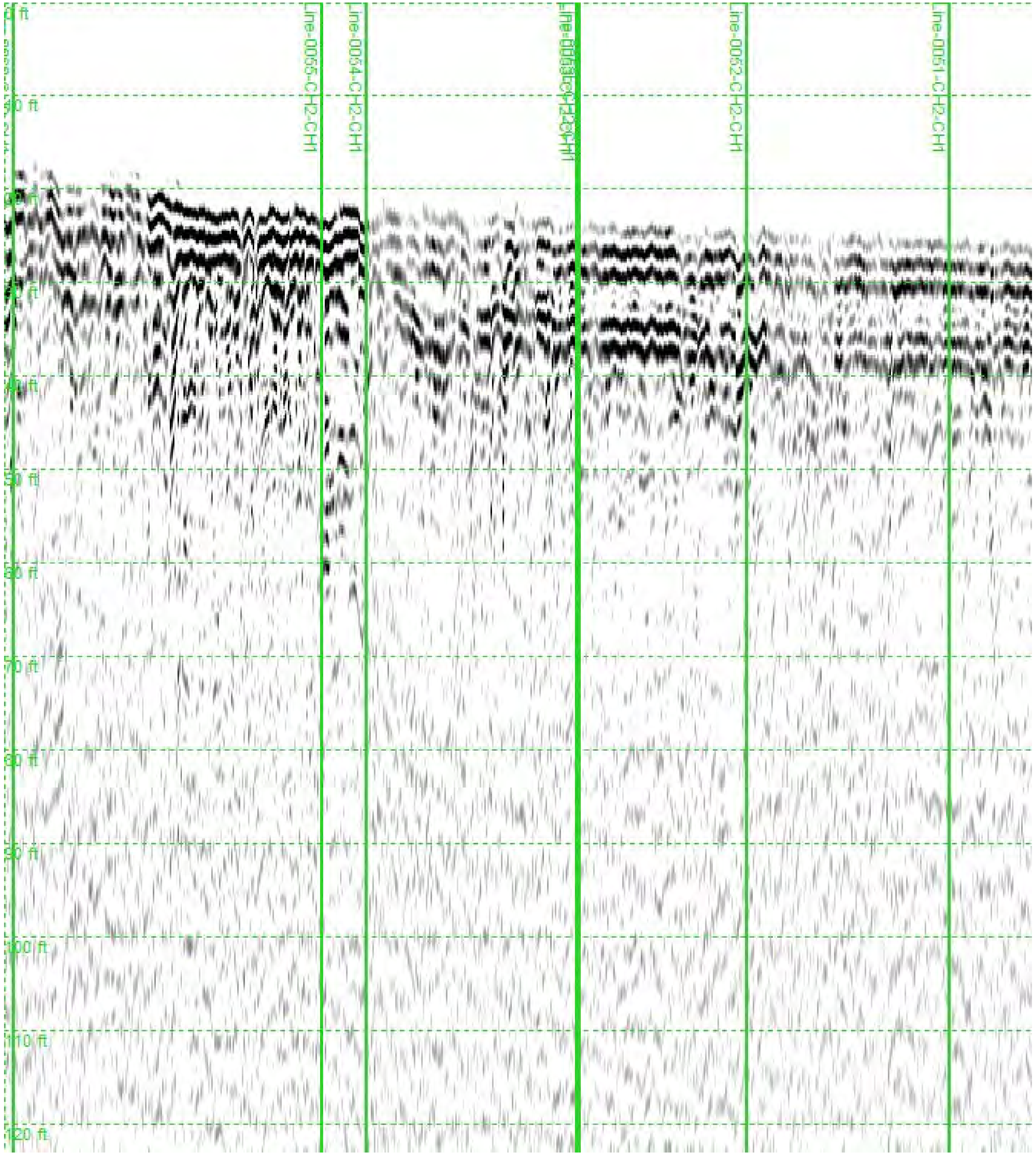


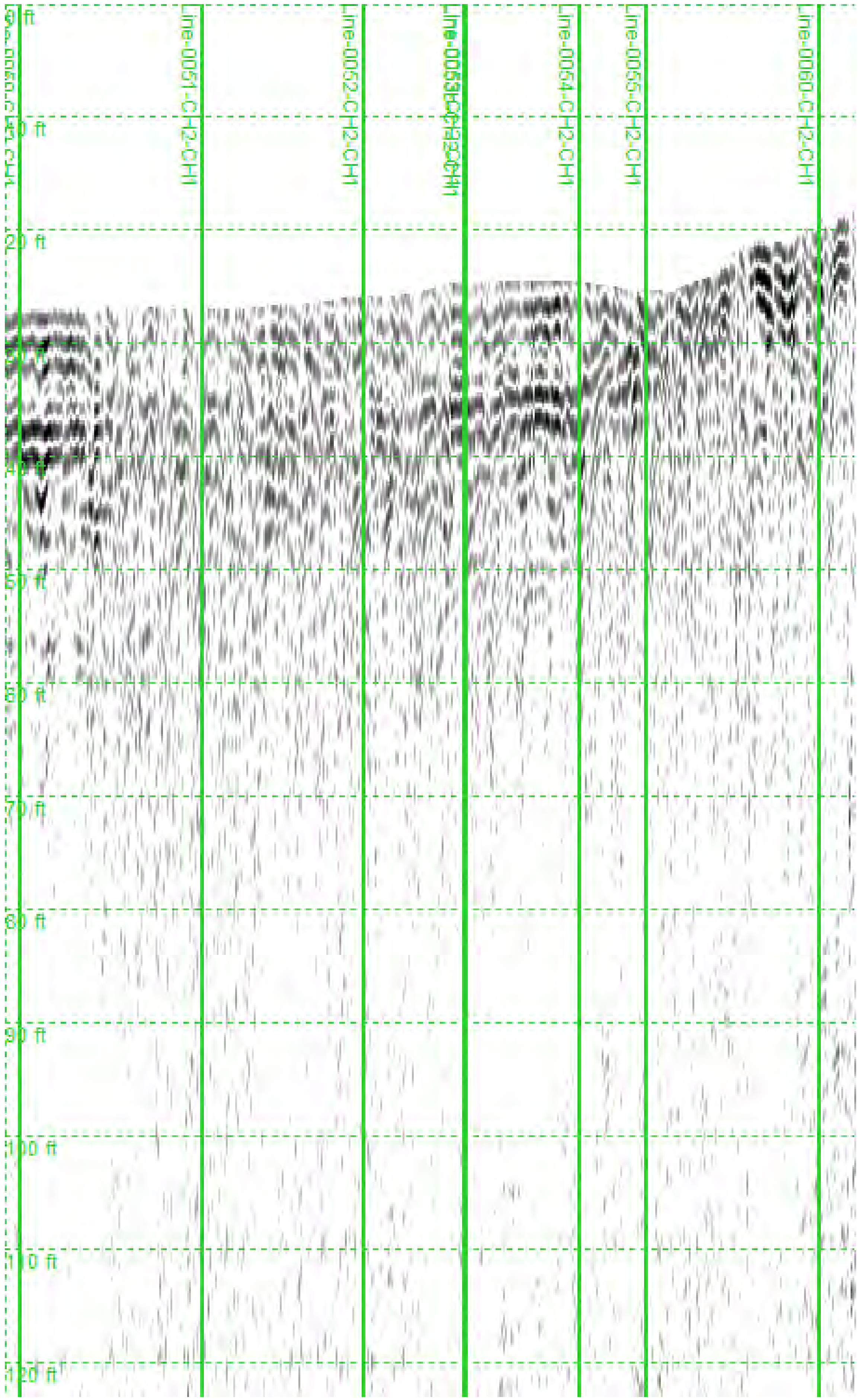
Line-0070-CH2-CH1.jpg



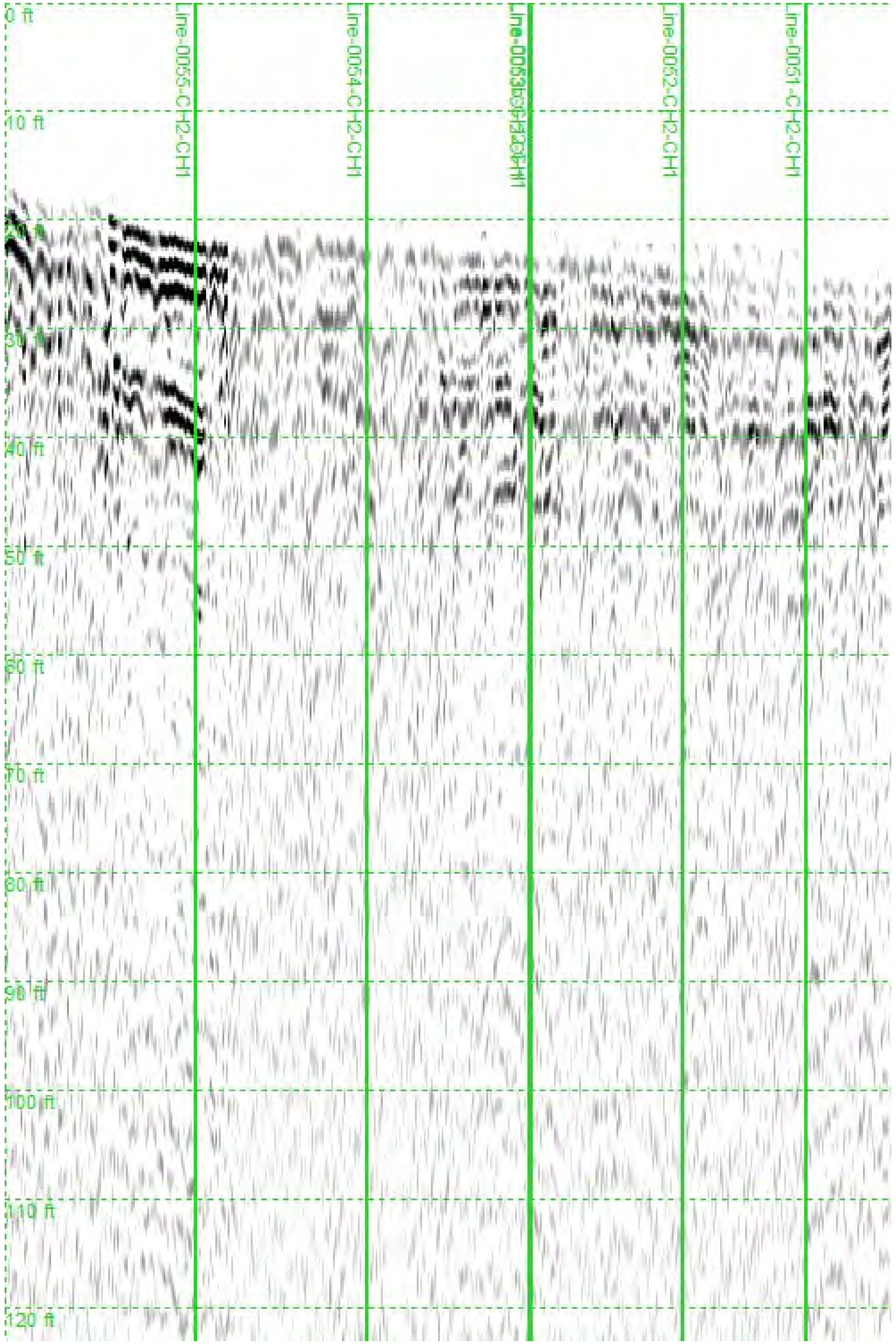
Line-0071-CH2-CH1.jpg



Line-0072-CH2-CH1.jpg



Line-0073-CH2-CH1.jpg



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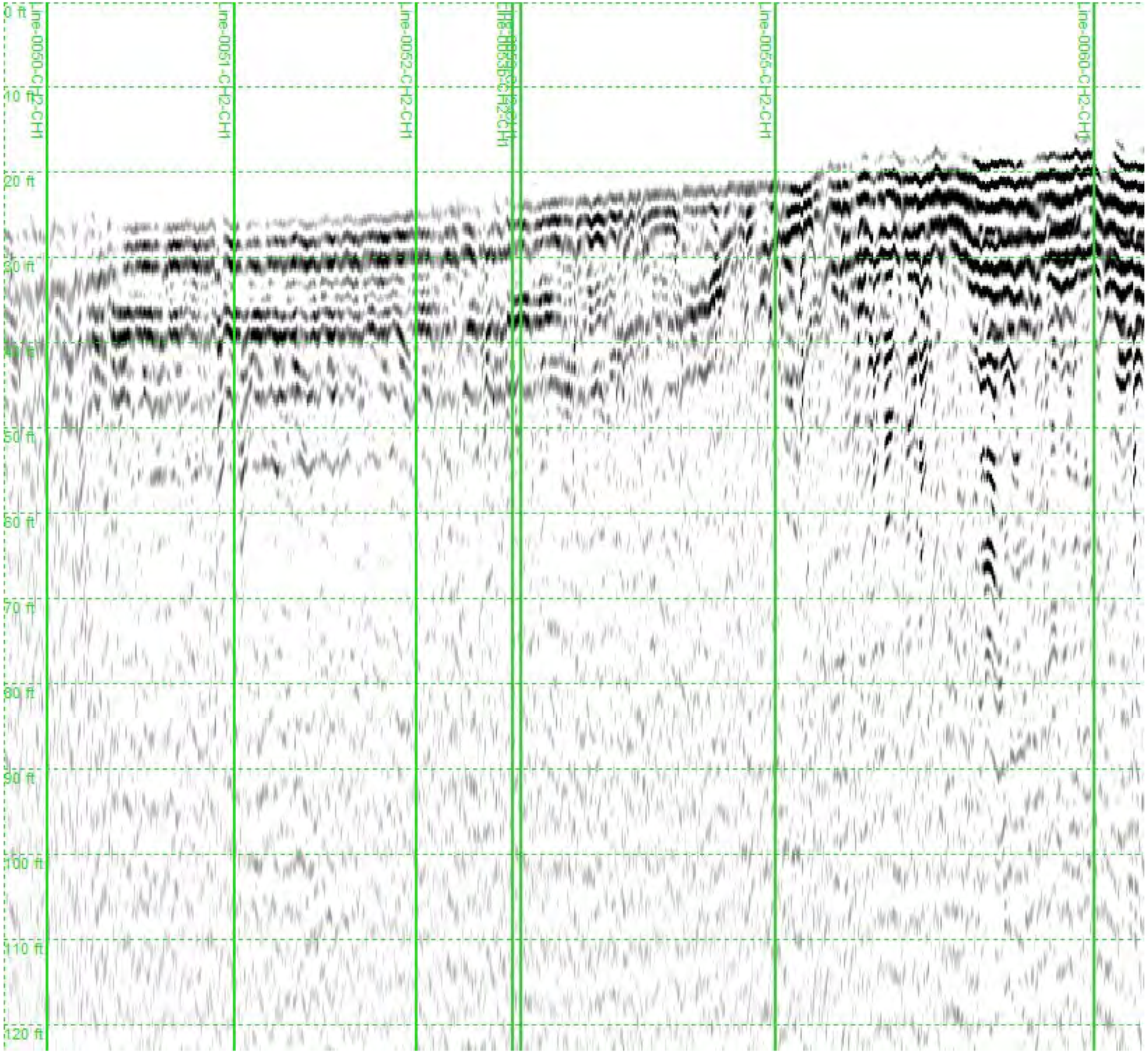
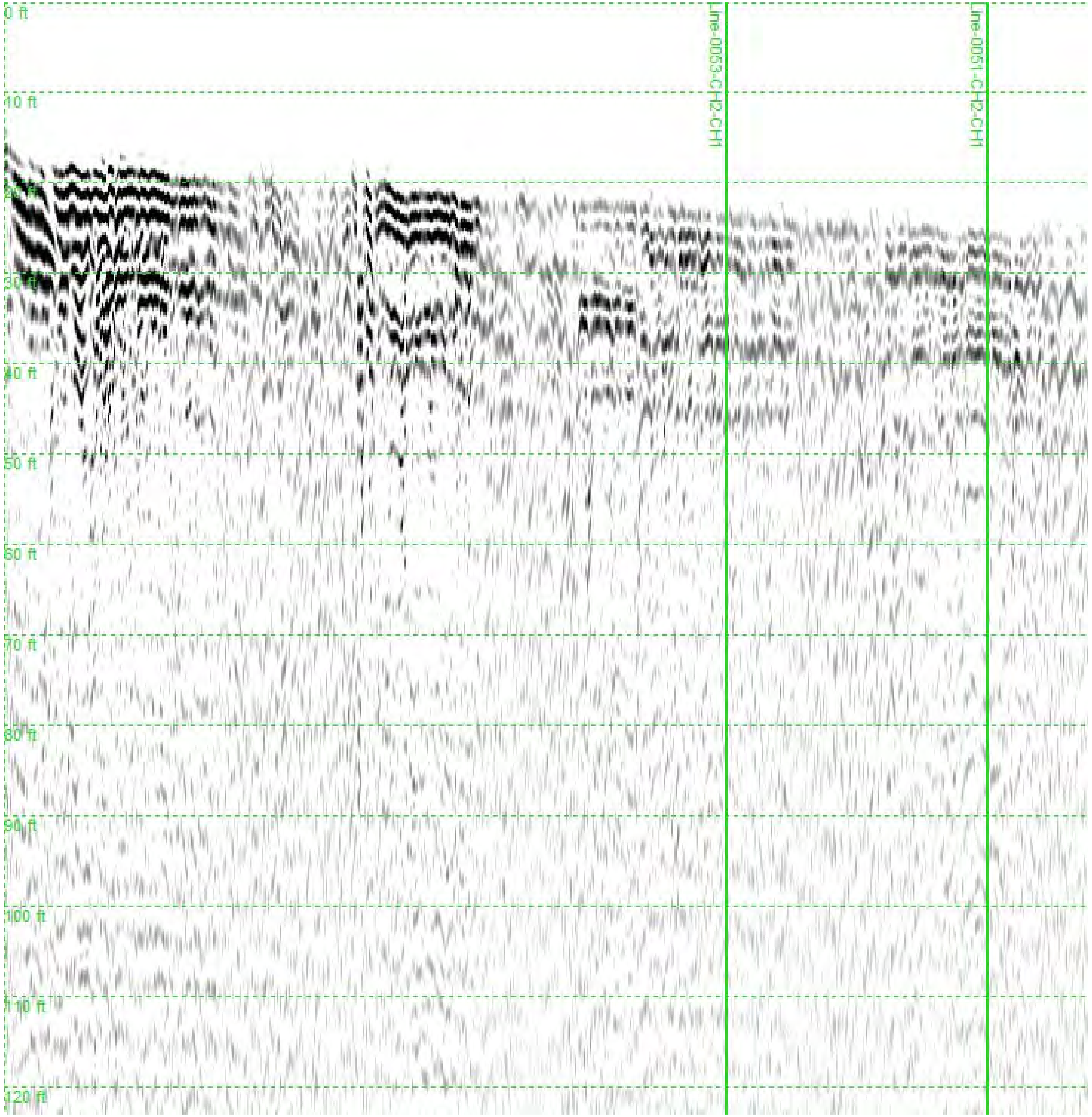


Line-0075-CH2-CH1.jpg



Line-0076-CH2-CH1.jpg

APPENDIX C

Field Notes

Elim

Mary (907) 890-3441

Eric Amaktoolik (907) 739-1311

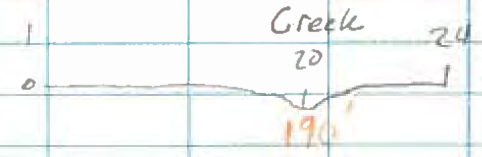
19125762

8/14/19

Seismic Refraction

Line 1 SP 1

NE end @ Bedrock near
RTK Base Station
GP1 @ NE end GP20 Disconnected
GP24 @ SW end



GP 19-24 ~ 3' lower
from rest of line.

Collected passive MASW
16 sec @ 1ms
files 1-6
Refraction 0.25 sec @ 62.5us

Shot	Ref	File
-10	0, -10	0007.dat & 0008.dat
55	6/7	9
115	12/13	10
175	18/19	11
225	F+5	12
280	F+60'	13

Rite in the Rain

19/25 762

Spread 2

Passive again files 14 - 19

Refraction

Shot	Ref	file
160	n-60	20
215	n-5	21
275	6/7	22
335	12/13	23
385	18/19	24
455	F+5	25
550	F+100	26

Spread 3

Passive again files 27-32

Refraction

Shot	Ref	file
350	n-100	33
445	n-5	35
505	6/7	36
575	13/14	37
625	18/19	38
685	F+5	39
780	F+100	40

* Need to reverse spread

19125762

Spread 4

Passive again files 43-48

Refraction

Shot	Ref	file
560	n-100	49
675	n-5	50
735	6/7	51
795	12/13	52
855	18/19	53
915	F+5	54
1010.	F+100	55

Spread 5

Passive files 56 to 61

Refraction

Shot	Ref	file
830	n-80	62
905	n-5	63
965	6/7	64
1025	12/13	65
1085	19/20	66
1145	F+5'	67
1200	F+60	68

8/14/19 19125762

Set up RTK Base Station

Base Station point ELI TIDAL GPS

LAT 64° 36' 59.46073"
LON -162° 15' 7.57109"
ELL HT 12.132 m

Set up RTK.

- Start GPR on beach

Line

File #9 Start @ Rock by water w/ base Station, end at creek

File 11 Start @ 0 on Surface line to creek & to Rock pile

File 13 from Rock pile to end of beach

A.A.

8/14/19 19125762

File 14 from end of beach toward NE, just above surf line

File 15 Cont. line 14 to end by RTK base station.

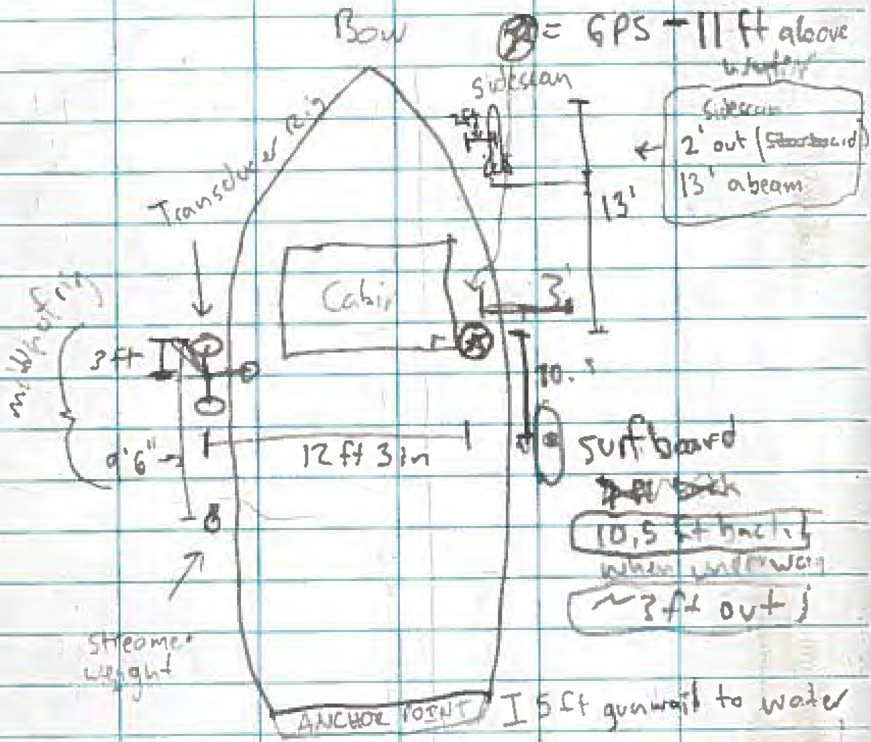
Packed up Base Station

end of day

19125762

Instrument locations on M/V Anchor Point

→ distances refer to center of Trimble R8



Notes; 8-15 → seas (lumpy) rougher than ideal 3.5 ft seas (6 max)

8-16 → Seas calm, mostly clear skies; offshore winds

Survey Line Notes (CHT) 19125762

Thurs, Aug 15, 2019

Line Name	Direction	Start Time	Line	Direction	Start time
1	W	2:26 pm	65	S	1:04
2	E	2:37	66	N	1:10
3	W	2:47	67 ✓	S	1:13
4	E	2:57	68	N	1:19
5	W	3:09	69	S	1:23
→ Airport line set ↓			69A (redo)	N	1:26 ish
50	E	3:26	70	S	1:31
51	W	3:36	71	N	1:36
52	E	3:46	72	S	1:41
53	W	3:56	73	N	1:47
54	E	4:06	74	S	1:50
55	W	4:18	75	N	1:55
56	E	4:31	76	S	2:00
57	W	4:36 pm	53A (redo)	W	2:09
End of Day Fri. 8-16-19	–	–	53B (redo2)	W	2:15
58	W	11:45 AM	27	N	2:26
59	E	11:48	28	S	2:32
60	W	11:53	29	N	2:43
06	E	12:09 PM	30	S	~~[illegible]~~ ?
61	S	12:30	31	N	2:54
61a (re-do)	S	12:36	32	S	2:58
62	N	12:46	26	N	3:05
63	S	12:51	25	S	3:12
64	N	12:58	24	N	3:19

OVER →

19125 762

Survey Line Notes, Cont. - Elim AK

Line	Direction	Start Time
23	S	3:26
22	N	335
21	S	3:42
20	N	3:50
19	S	3:57
18	N	4:04
17	S	—?
16	N	4:23
15	S	4:29
14	N	4:35
13	S	4:42
12	N	4:48
11	S	4:55
10	N	5:02
9	S	5:07
8	N	5:13
7	S	5:19
4B	W	5:33

Sidescan - 8-16-19

Line	Dir	Start time
105	W	8:38 pM
105B (redo)	E	8:4 something
105c Halfway b/w 105 + 106	W	8:59
103	E	9:07
102	W	9:16
161	N	9:38
162	S	9:42
163	N	9:47
164	S	9:50
166	N	
~~167~~	~~S~~	
157		
170		
155	W	
154	E	
153	W	10:21
152	E	10:28
151	W	10:33
150	E	10:39

8/17/19 19125762

Spread 2 Reflection on Line 2, on High tide berm on beach

Passive MASW
65 sec @ 1,00 ms
Files 200 - 205

Spread 2, Shooting on BR

Shot	Rec	File
-30	n-30	206
-5	n-5	207
55	6/7	208
115	12/13	209
175	18/19	210
235	F+5	211
320	F+90	212

Spread 2 centered on GP 6 & 7

230 ——— 460

Passive MASW Files 213 - 218

D.H.

8/17/19 19125762

Shot	Ref	File	L2 Spread 2 cont.
160	n-70	219	
225	n-5	220	
275	5/6	221	(not 6/7 in creek)
345	12/13	222	
405	18/19	223	
465	F+5	224	
560	F+100	225	

L2 Spread 3

460 – 690 on beach

Passive data, files 226 to 231

Shot	Ref	File	
360	n-100	232	
455	n-5	233	
515	6/7	234	
575	12/13	235	checked GP#10
635	18/19	236	
695	F+5	237	
790	F+100	238 & 239	

D.H.

8/17/19 19125762

Spread 4

790 to 920

Passive data files 240 to 245

Shot	Ref	File	
590	n-100	246	- noisy.
685	n-5	247	
745	6/7	248	
805	12/13	249	
865	18/19	250	
925	F+5	251	
1000	F+80	252	

Spread 5

920 to 1150 ending near bedrock

Passive files 253 to 258

Shot	Ref.	File
840	n-80	259
915	n-5	260
975	6/7	261
1035	12/13	262
1095	18/19	263
1155	F+5'	264
1190	F+40'	265

D.H.

GOLDER

golder.com

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