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MBTA GREEN LINE TESTS  
RIVERSIDE LINE  
DECEMBER 1972

Volume II  
Track Geometry Data Plots

George W. Neat, Editor



OCTOBER 1973  
FINAL REPORT

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16. Abstract <p>The UMTA sponsored Urban Rail Supporting Technology Program emphasizes three major task areas; facilities development, technology development, and test program development. The test program development is composed of three sub-areas; vehicle testing, ways and structures testing, and track geometry measurement. This report, in five volumes, presents the technical methodology, data samples, and results of tests conducted on the Massachusetts Bay Transit Authority (MBTA) Green Line in December, 1972 prior to initiation of the Green Line refurbishment effort.</p> <p>An instrumented revenue type car was used for the measurement of track geometry, ride roughness, and interior noise. Actual car speed was approximately the same as normal revenue speed. The objectives of the tests were to identify critical track sections for improvement to quantify the benefits produced by the track rehabilitation program, and to provide data for TSC's development of an advanced track geometry measurement system.</p> <p>Volume II presents track geometry analog data plots for the complete length of track.</p>				13. Type of Report and Period Covered Final Report	
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## VOLUME II TRACK GEOMETRY DATA PLOTS

This Volume contains the complete group of MBTA Green Line (Riverside Line) track geometry plots taken in December 1972. Examples of this data were presented in Volume I, Appendices B and C, of this report. Each chart contains the right and left profile plots as well as the gage plot.

A map of the Green Line is shown in Figure 1, and the station distances are given in Figure 2.

The Summary Sheets, Test and Data Sections from Volume I, Appendices B and C are also reprinted here as an aid to the reader.

Computer printouts of profile and gage data are contained in Volumes III, IV and V of this report.

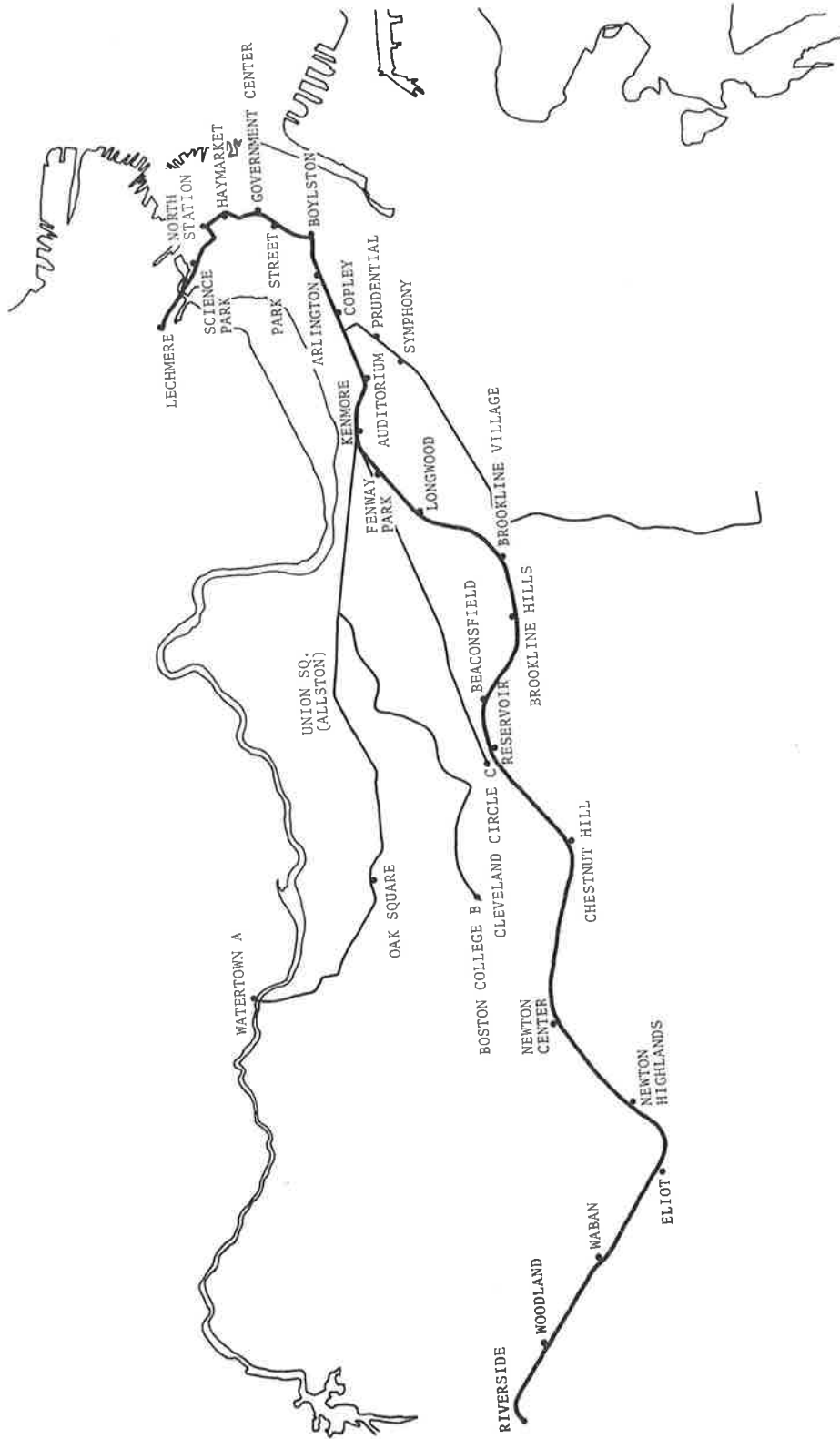


Figure 1 Map of MBTA Green Line

<u>Station</u>	<u>Distance From Last Station</u>	<u>Cumulative Distance</u>
Riverside	0	0
Woodland	2700	2700
Waban	4400	7100
Eliot	4600	11,700
Newton Highlands	4000	15,700
Newton Center	4300	20,000
Chestnut Hill	7700	27,700
Reservoir	5500	33,200
Beaconsfield	2300	35,500
Brookline Hills	4100	39,600
Brookline Village	2800	42,400
Longwood	3900	46,300
Fenway Park	2100	48,400
Kenmore	2900	51,300
Auditorium	2200	53,500
Copley	2600	56,100
Arlington	2000	58,100
Boylston	2100	60,200
Park Street	1200	61,400
Government Center	1500	62,900
Haymarket	1100	64,000
North Station	1800	65,800
Science Park	2100	67,900
Lechmere	3100	71,000

Figure 2 Station Distances





MBTA Green Line Tests, Riverside Branch

December, 1972

SEQUENCE NO. 12-72-601

PROCEDURE NO. PCC-TGC-6007-MBTA

OBJECTIVE:

To measure midchord track profile on the Riverside Branch of the Green Line, prior to initiation of track rehabilitation. These data will help establish which sections of track most severely require rework. These data will also be used for comparison with data recorded after the track has been upgraded.

STATUS:

Midchord profile data (10 foot chord) has been collected and processed for the twenty six-plus miles of the Riverside Branch track. The data is presented in 46 sets with each set representing a one-way section of track between two adjacent stations.

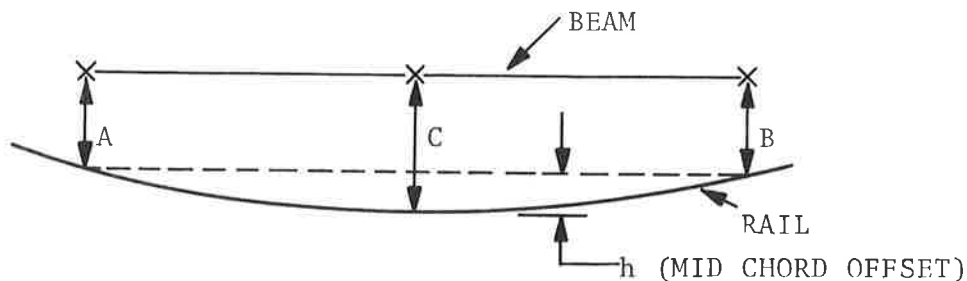


### Test Description

In this test series, midchord profile of each rail is measured continuously using capacitive proximity detectors. Three probes are mounted on straight beams that are located alongside the wheels of the instrumented truck. Each probe is centered over the top surface of the rail. The electronics associated with each probe puts out a voltage that is proportional to the distance between the probe and the rail. Thus, if the outputs of the two end probes are denoted A and B and the output of the center probe is denoted C, the mid-chord formula yields the midchord offset h as

$$h = \frac{A + B}{2} - C$$

(see Figure 3). The midchord offset is the actual output of this measurement. The beam length used in this test series was 9 ft. 10 in.



$$h = \frac{A + B}{2} - C$$

Figure 3 Measurement of Midchord Offset

## Data

The midchord profile data were recorded on analog tape during the test runs in the form of the outputs of each of the capacitance probe circuits as well as the computed midchord value. The data was then digitized after passing it through a Butterworth low-pass four-pole filter set for 30 Hz and a unity gain amplifier. The tachometer pulses were divided down by a factor of 7810 and used to trigger the sampling of the Analog-to-Digital Converter. The resulting two samples-per-foot were used to scale the plotter output at 200 ft/inch. The chart copies in this Volume have been reduced to 75% of original size.

A total of 46 charts, corresponding to the 46 intervals between stations on a round trip between Riverside and Lechmere, are contained in this volume. To assure completeness, each set of data overlaps the adjoining sections. Distance on the horizontal scale is referenced from zero at Riverside Station.

Left and right midchord profiles are shown for the 10-foot beam. Vehicle speed (not shown) was intended to approximate typical revenue speed. The output of the automatic location detector indicates pulses where switches, grade crossings, etc, occur. Track gage is also plotted on this chart.

The sampled data were processed to locate the largest profile perturbations. See Volumes III and IV of this report. The magnitude of the profile was divided according to zones of perturbation. The nominal zone within  $\pm 0.25$  inches midchord is defined as zone zero. Positive mid-chord measurements greater than 0.25 inches are defined by even numbered zones (e.g., 2 and 4).

Negative midchord measurements less than 0.25 inches are defined by odd numbered zones. The size at the zones used here are defined as follows:

<u>Zone</u>	<u>Mid-chord Reading</u>
4	0.75 in. $\leq P$
2	+0.25 in. $\leq P < +0.75$ in.
0	-0.25 in. $< P < +0.25$ in.
1	-0.75 in. $< P \leq -0.25$ in.
3	$P \leq -0.75$ in.

The complete profile printout data, pages A, B, and C for the 46 sections of track are presented in Volume III and IV of this report. Pages A on the printout charts in Volumes III and IV show the location each time the profile reading enters a new zone. Pages B on the printout summarize the locations at which the peaks are reached in the extreme zones, 3 and 4. The magnitude of the peak is also given. Pages C on the printout summarize the section of track in terms of number of times each zone occurs and total number of feet in each zone.

The summary page, C, of each group, can be used for comparison of one section of track with another. Pages B, by giving the location of the most severe perturbations, can be used for locating areas for investigation and possible repairs.



MBTA Green Line Tests, Riverside Branch

December, 1972

SEQUENCE NO. 12-72-602

PROCEDURE NO. PCC-TGC-6008-MBTA

OBJECTIVE:

To measure track gage on the Riverside Branch of the Green Line, prior to initiation of track rehabilitation. These data will help establish which sections of track most severely require rework. It will also be used to classify track according to gage specifications in the IRT Safety Guidelines for Urban Rapid Transit Systems. These results will subsequently be compared with data collected after rehabilitation.

STATUS:

Gage data has been collected and processed for the Riverside Branch Track. The twenty-six-plus miles of track is presented in forty six sections of data in the form of gage versus distance plots and computer printout summaries.

Manual measurement of the gage to verify the automatically measured gage has revealed that the gage changes significantly in some places due to the vehicle loading. Further measurements may be made to provide improved understanding of the dynamic effects of vehicle loading on the gage data.





### Test Description

In this test series, track gage is measured continuously using capacitive proximity detectors. The probes are located alongside the rails, one along each rail. The electronic circuit associated with each probe outputs a voltage proportional to the distance between the probe and the rail. By adding the two voltages, a sum voltage is obtained that is proportional to the difference between actual track gage and some known value of distance. The gage measuring system on this test put out zero volts for a track gage of 57 1/4 inches. This number is reached by measuring the distance between probe faces, 55 7/8 inches, and then adjusting the probe electronics so that an adequate displacement range is covered when the probes are mounted in the shadow of the wheel flange. Thus, each probe electronic system was set to operate to operate at a sensitivity of 10 volts/inch and to put out zero volts when the probe face was 11/16 inch from the rail gage point.

### Data

The gage data was recorded on analog tape in the form of capacitance probe circuit outputs, similar to the profile data. The statistical printout for the gage data is presented in the tabulated computer outputs on pages A, B and C of Figure groups in Volume V. The levels used for these outputs are summarized below along with the corresponding IRT track classification:

<u>Zone</u>		<u>Gage G</u>	<u>Institute for Rapid Transit Track Classification</u>
6		$G \geq 57 \frac{3}{4}$ in	Unclassified
4	$57 \frac{1}{4}$ in $\leq$	$G < 57 \frac{3}{4}$ in	Class 1 or 2
2	57 in $\leq$	$G < 57 \frac{1}{4}$ in	Class 3
0	$56 \frac{1}{4}$ in $<$	$G < 57$ in	Class 4
1	56 $<$	$G \leq 56 \frac{1}{4}$ in	Class 4
3		$G \leq 56$ in	Unclassified

Page C of the figure provides a quick indication of the track classification relative to the IRT requirements for gage. Page B gives the location and magnitude of occurrences in Zones 1, 3, 4 and 6. Page A shows the location that the gage changes from one zone to another.

The page C gage printouts for all 46 sections are summarized in Figure 4. The IRT class of each section is given based on a literal interpretation of the data. The section of track from Waban Station to Eliot Station is Class 3. Twenty-two sections are Class 2. The remaining 23 sections are below standard because of one or more places where the gage exceeds  $57 \frac{3}{4}$  inches or is less than 56 inches. However, of these sections, eleven have only one recorded defect. Many of the recorded defects occur in a region where extraneous metal such as guard rails may be affecting the recorded signal. A visual check of the track at these points is required to provide the final conclusion. The percentage of track-age that satisfies gage requirements provides a better measure of track quality. The percentage of the track in each section that meets the gage requirements for IRT Classes 2, 3 and 4 is also shown in Figure 4.

Track Section	IRT Class			Percentage of Track Meeting Gage Requirements		
	IRT Class	4	3	2	3	2
1. Riverside to Woodland	-	99.92	99.98	99.98	99.98	99.98
2. Woodland to Waban	-	99.13	99.99	99.99	99.99	99.99
3. Waban to Eliot	3	99.36	100			
4. Eliot to Newton Highlands	2	94.94	99.95	100		
5. Newton Highlands to Newton Ctr.	2	95.24	99.60	100		
6. Newton Center to Chestnut Hill	2	92.47	99.57	100		
7. Chestnut Hill to Reservoir	-	92.20	98.76	99.94		
8. Reservoir to Beaconsfield	2	78.53	95.37	100		
9. Beaconsfield to Brookline Hills	2	92.53	99.26	100		
10. Brookline Hills to Brookline Vil.	2	94.37	99.52	100		
11. Brookline Vil. to Longwood	2	95.98	99.73	100		
12. Longwood to Fenway	2	95.92	99.51	100		
13. Fenway to Kenmore	-	92.24	97.18	99.99		
14. Kenmore to Auditorium	-	75.30	89.75	99.98		
15. Auditorium to Copley	-	91.31	99.40	99.97		

Figure 4. Gage Data Summary

Track Section	IRT Class			Percentage of Track Meeting Gage Requirements
	4	3	2	
16. Copley to Arlington	99.26	99.96	99.99	99.99
17. Arlington to Boylston	93.48	99.31	99.96	99.96
18. Boylston to Park St.	83.46	99.07	99.93	99.93
19. Park St to Govt. Ctr.	85.62	98.46	100	100
20. Govt. Ctr. to Haymarket	97.64	99.71	100	100
21. Haymarket to No. Station	93.21	99.65	99.94	99.94
22. No. Station to Science Park	92.27	99.48	99.75	99.75
23. Science Park to Lechmere	95.06	99.95	99.98	99.98
24. Lechmere to Science Park	56.67	82.95	99.26	99.26
25. Science Park to No. Station	61.68	85.67	99.92	99.92
26. No. Station to Haymarket	59.21	82.66	97.34	97.34
27. Haymarket to Govt. Ctr.	52.39	78.69	99.94	99.94
28. Govt. Ctr. to Park St.	48.54	78.37	99.85	99.85
29. Park St. to Boylston	67.47	89.27	99.68	99.68
30. Boylston to Arlington	79.83	96.15	99.82	99.82

Figure 4. Gage Data Summary (Cont'd)

Track Section	IRT Class	Percentage of Track Meeting Gage Requirements		
		4	3	2
31. Arlington to Copley	2	92.08	99.4	100
32. Copley to Auditorium	2	91.67	97.48	100
33. Auditorium to Kenmore	-	81.94	94.02	99.86
34. Kenmore to Fenway	-	98.88	99.74	99.25
35. Fenway to Longwood	-	98.49	99.90	99.99
36. Longwood to Brookline Vil.	2	93.00	98.92	100
37. Brookline Vil. to Brookline Hills	2	88.70	98.32	100
38. Brookline Hills to Beaconsfield	2	88.12	98.06	100
39. Beaconsfield to Reservoir	2	94.70	99.95	100
40. Reservoir to Chestnut Hill	2	92.07	98.52	100
41. Chestnut Hill to Newton Ctr.	2	94.19	99.20	100
42. Newton Ctr. to Newton Highlands	2	97.75	99.94	100
43. Newton Highlands to Eliot	2	95.78	99.83	100
44. Eliot to Waban	2	99.49	99.98	100
45. Waban to Woodland	2	99.42	99.98	100
46. Woodland to Riverside	-	82.87	83.07	93.82

Figure 4. Gage Data Summary (Cont'd)



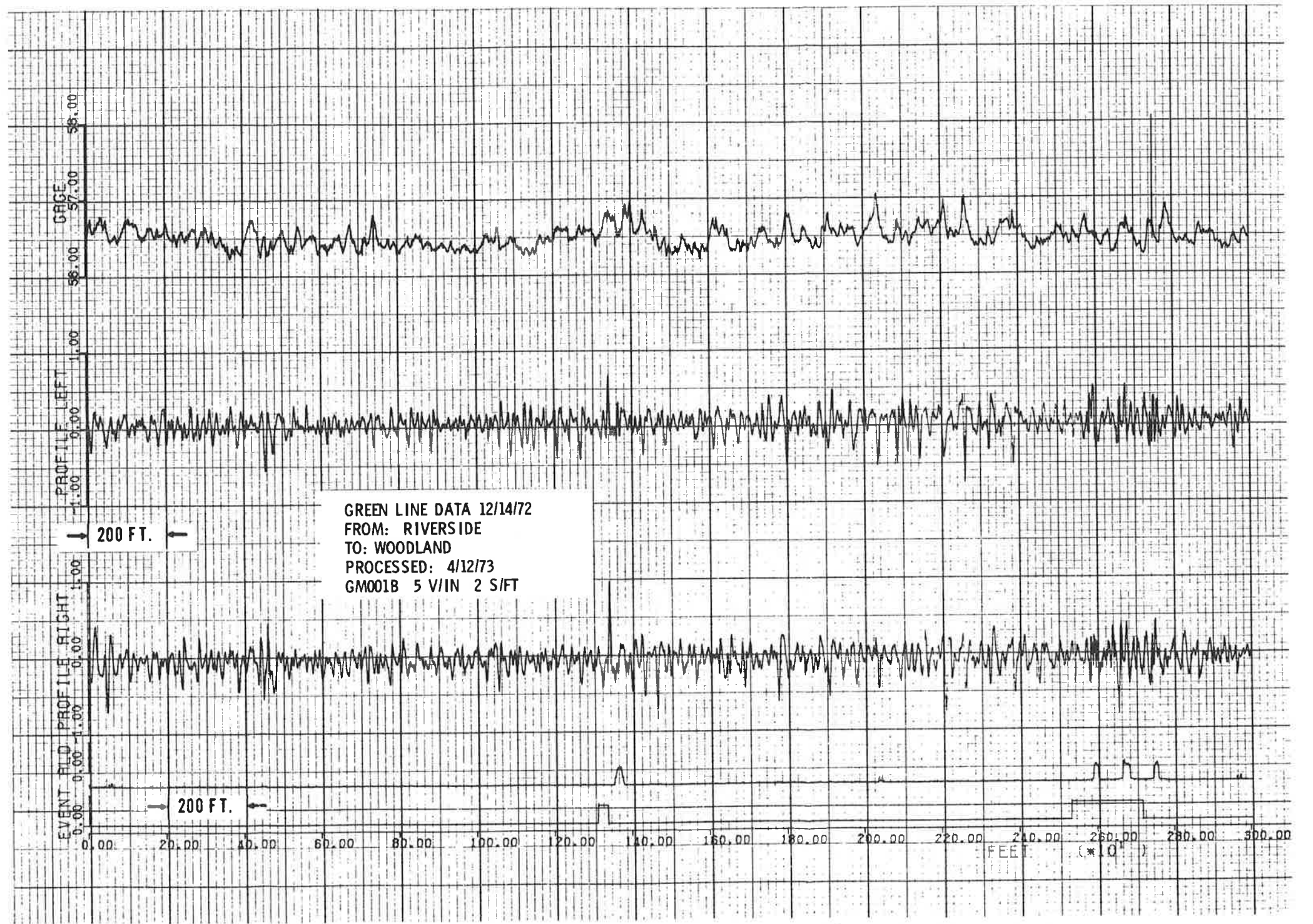


Figure 5. Riverside to Woodland Data

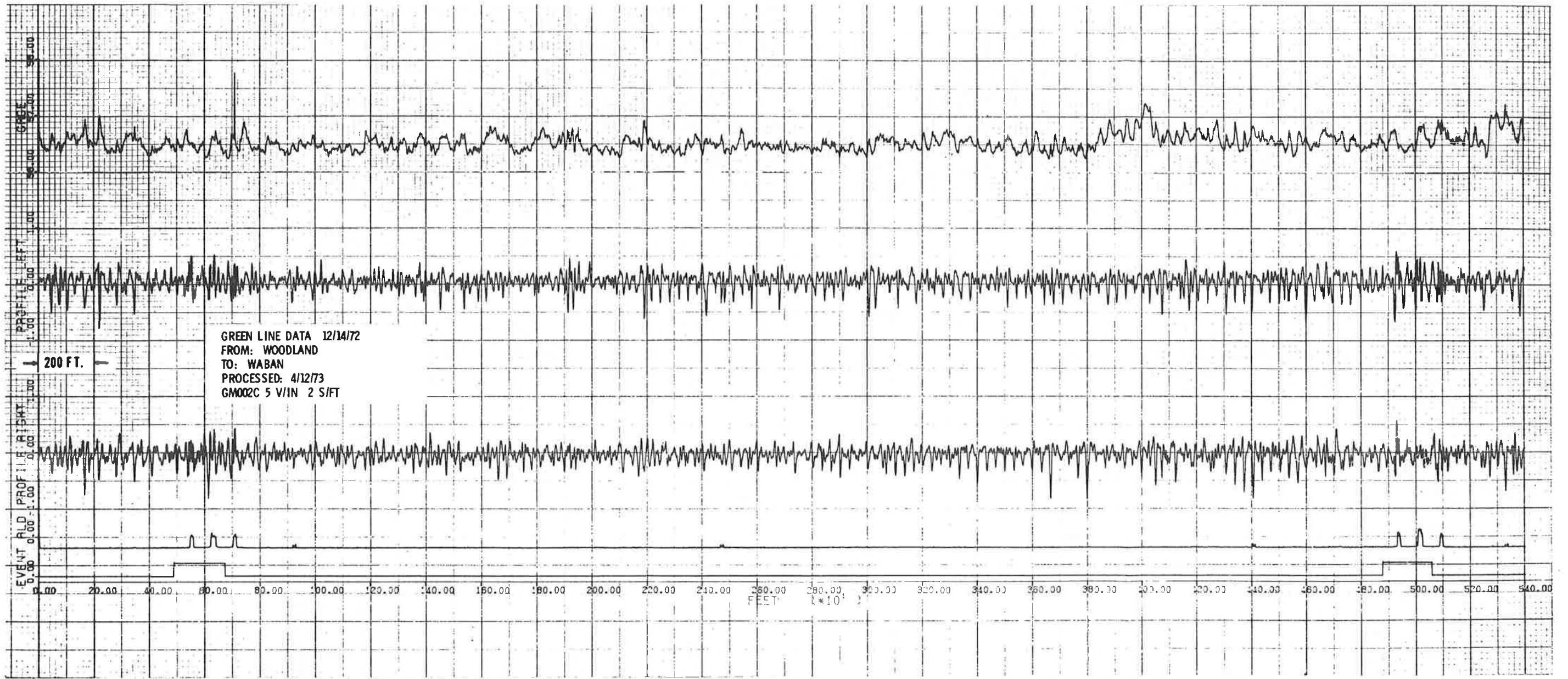


Figure 6. Woodland to Waban Data



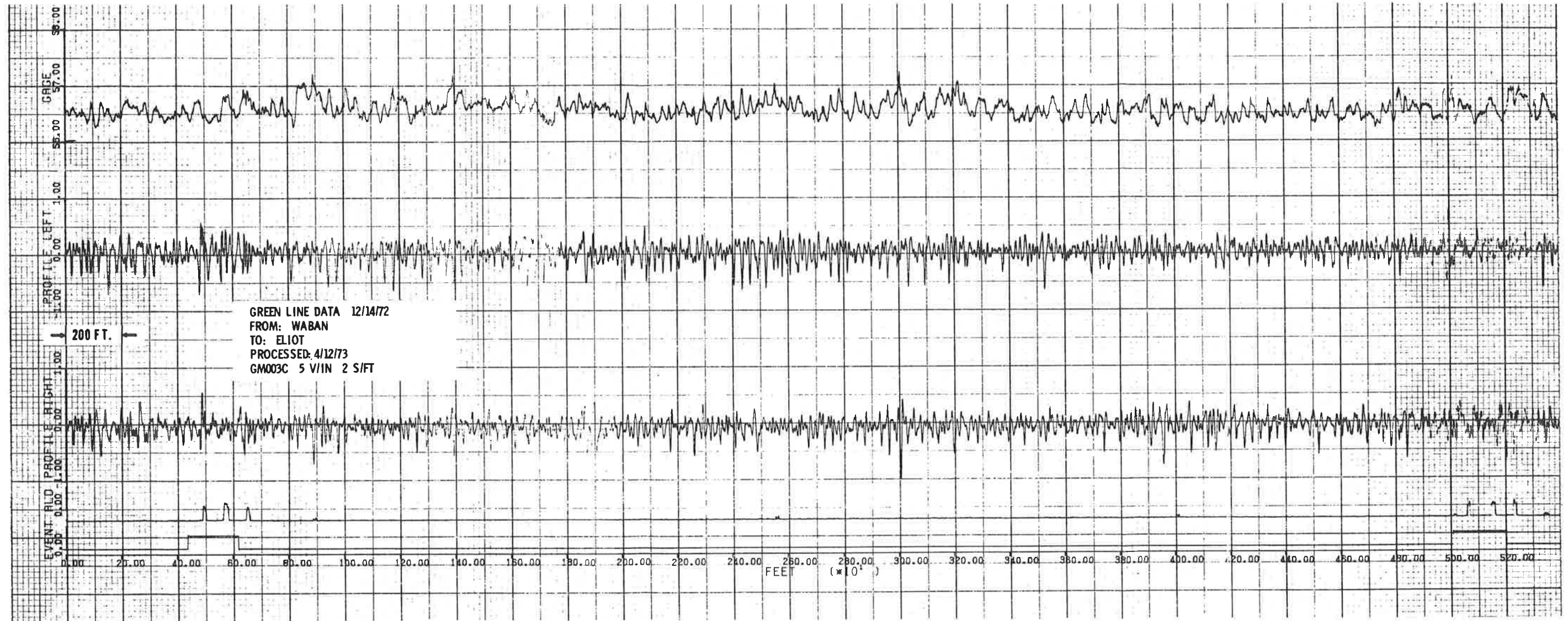


Figure 7. Waban to Eliot Data

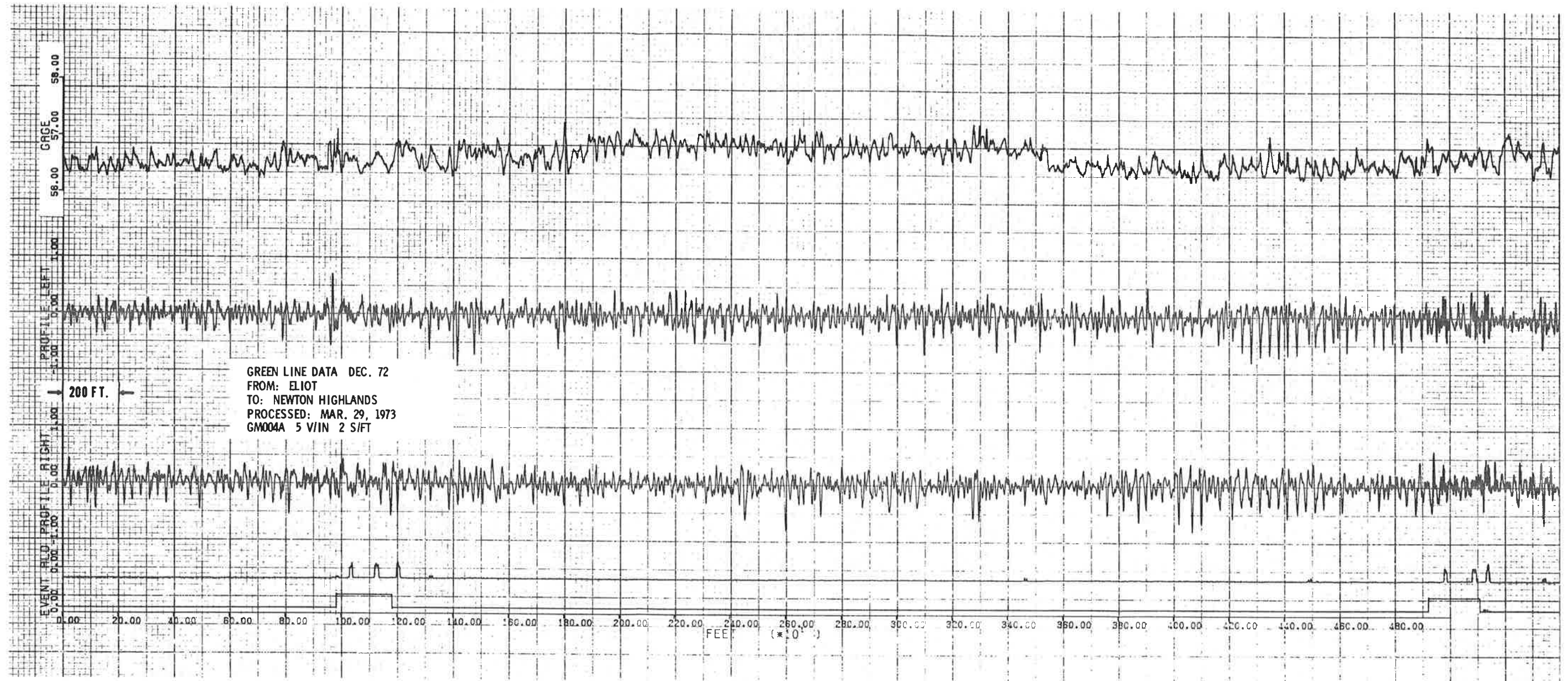


Figure 8. Eliot to Newton Highlands Data



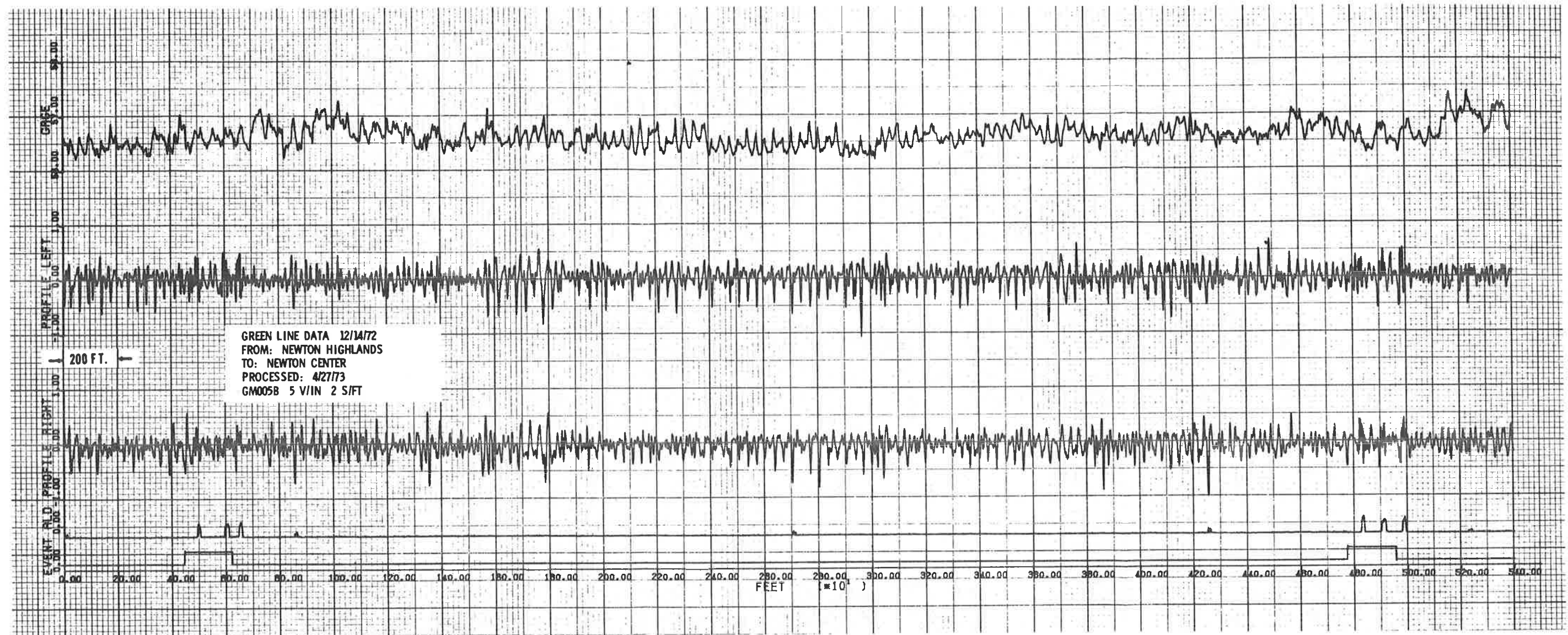


Figure 9. Newton Highlands  
to Newton Center Data



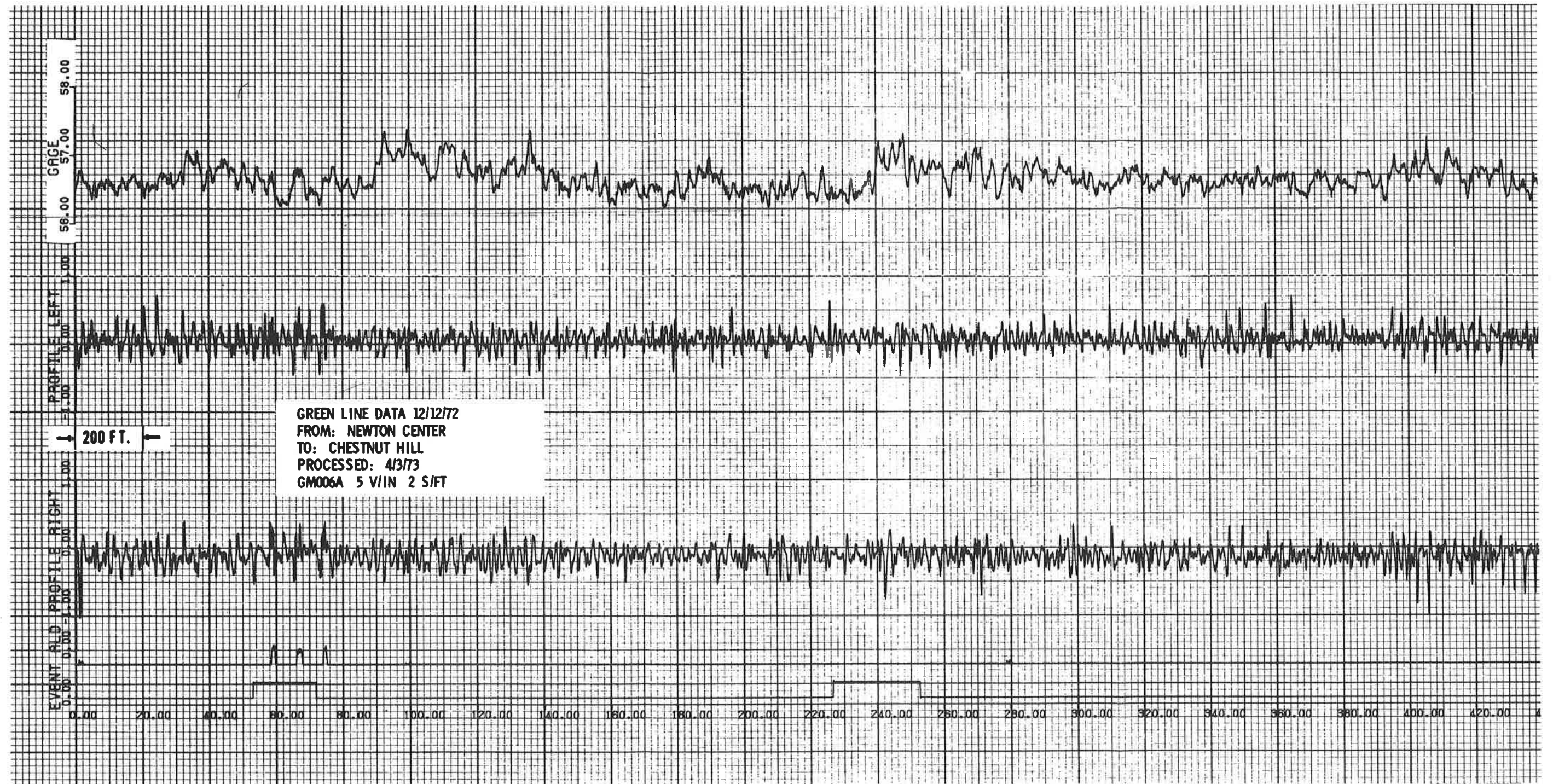


Figure 10. Newton Center to Chestnut Hill Data



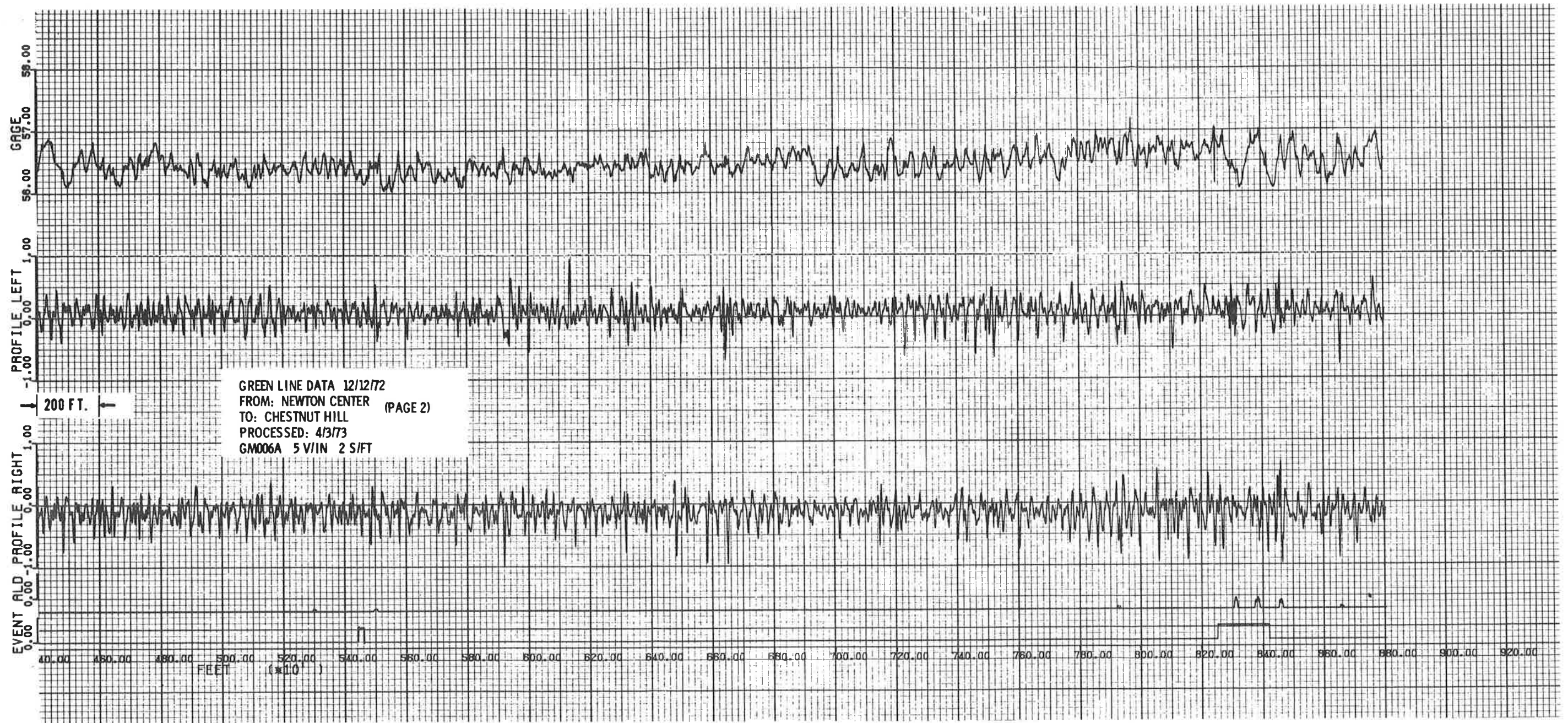


Figure 10. Newton Center to Chestnut Hill Data (cont'd)



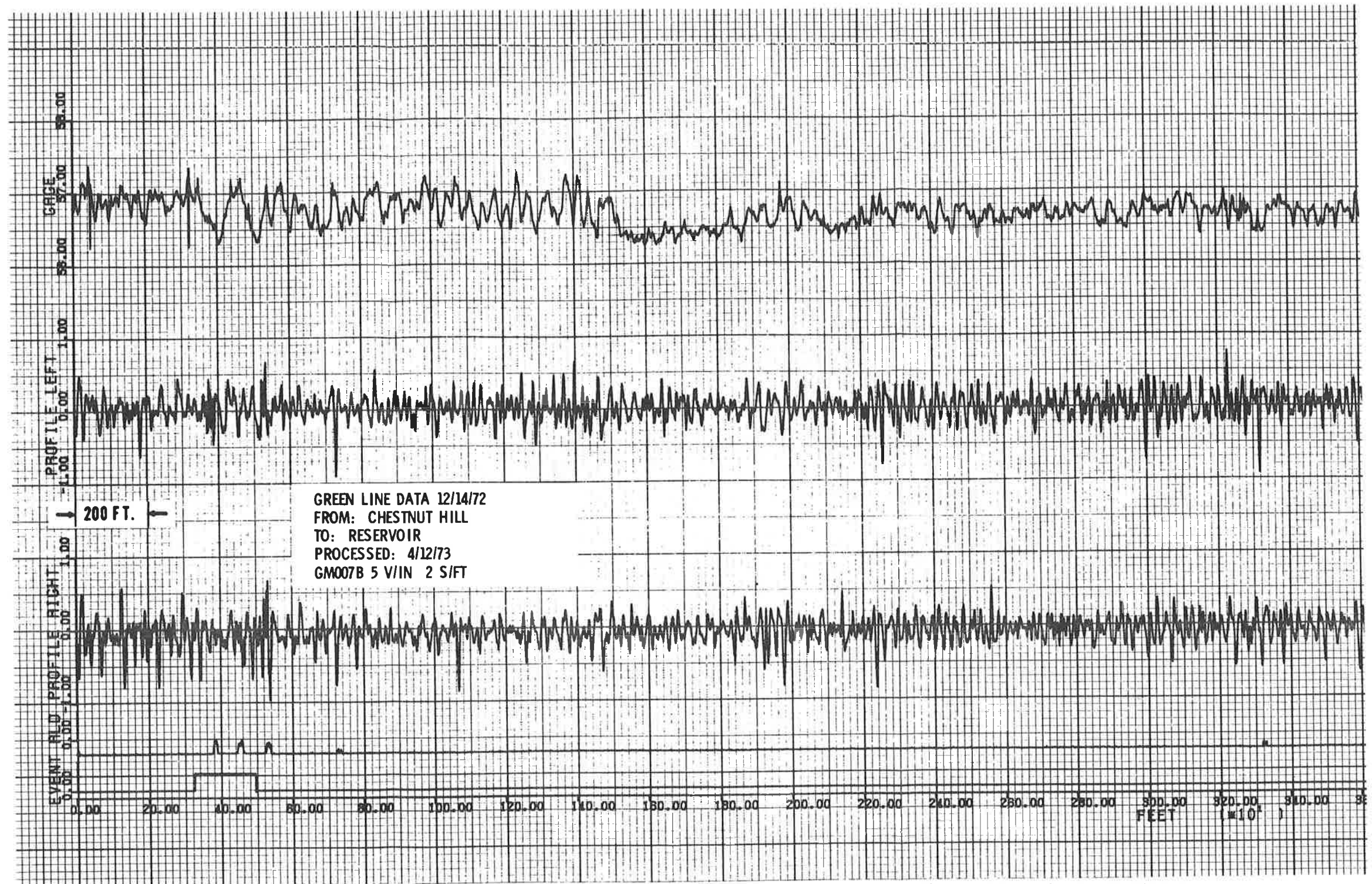


Figure 11. Chestnut Hill to Reservoir Data

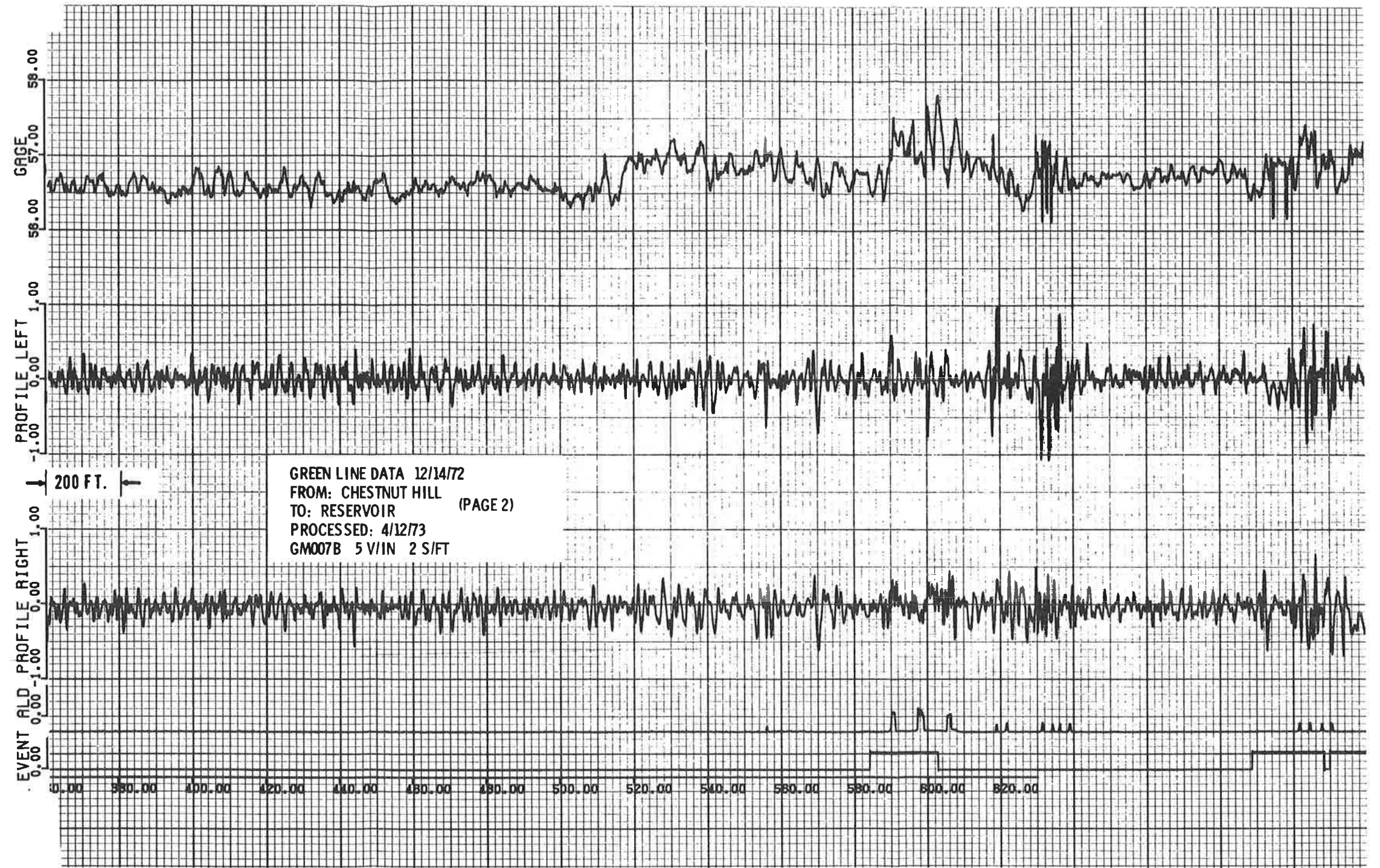


Figure 11. Chestnut Hill to Reservoir Data (cont'd)



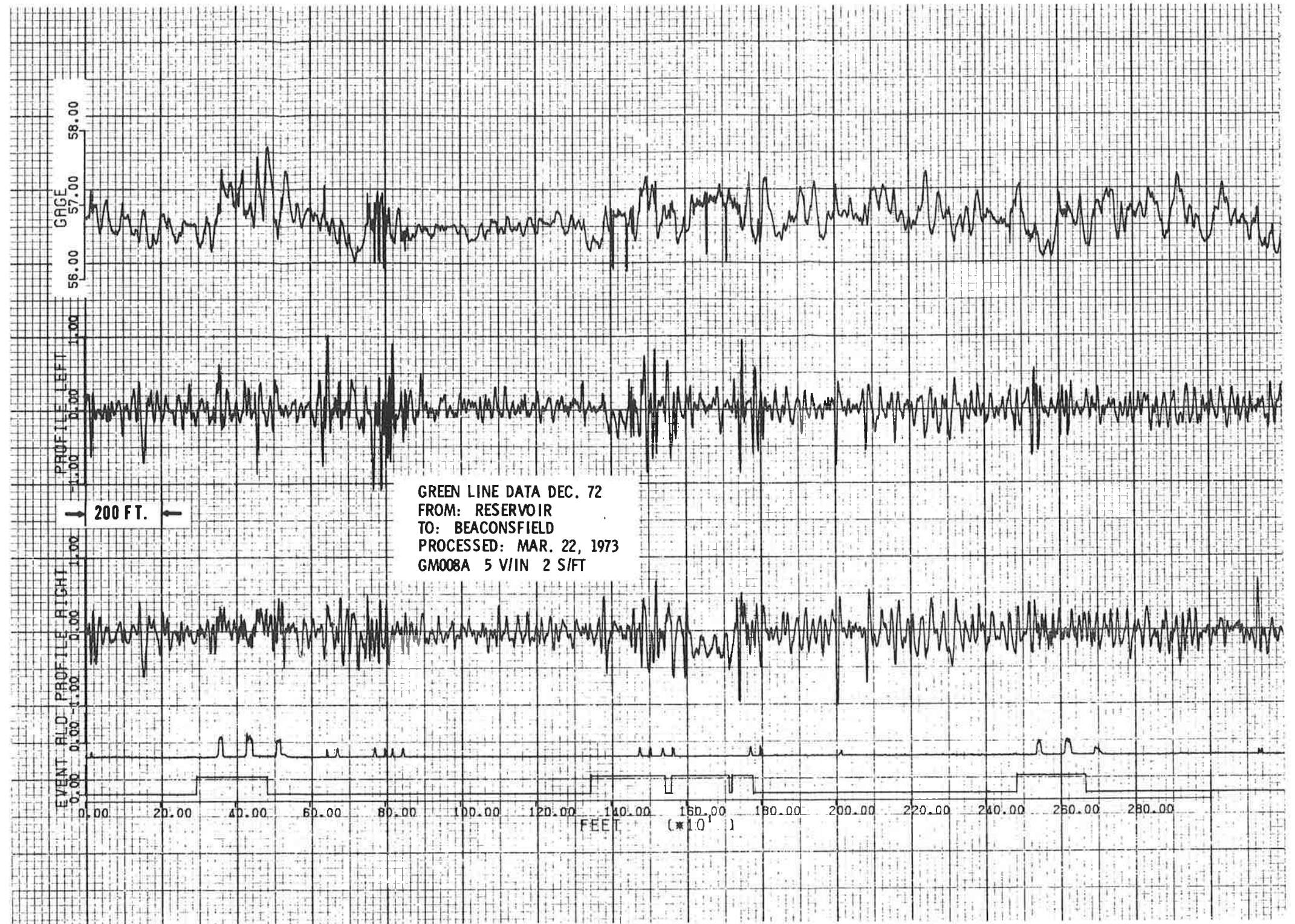


Figure 12. Reservoir to Beaconsfield Data



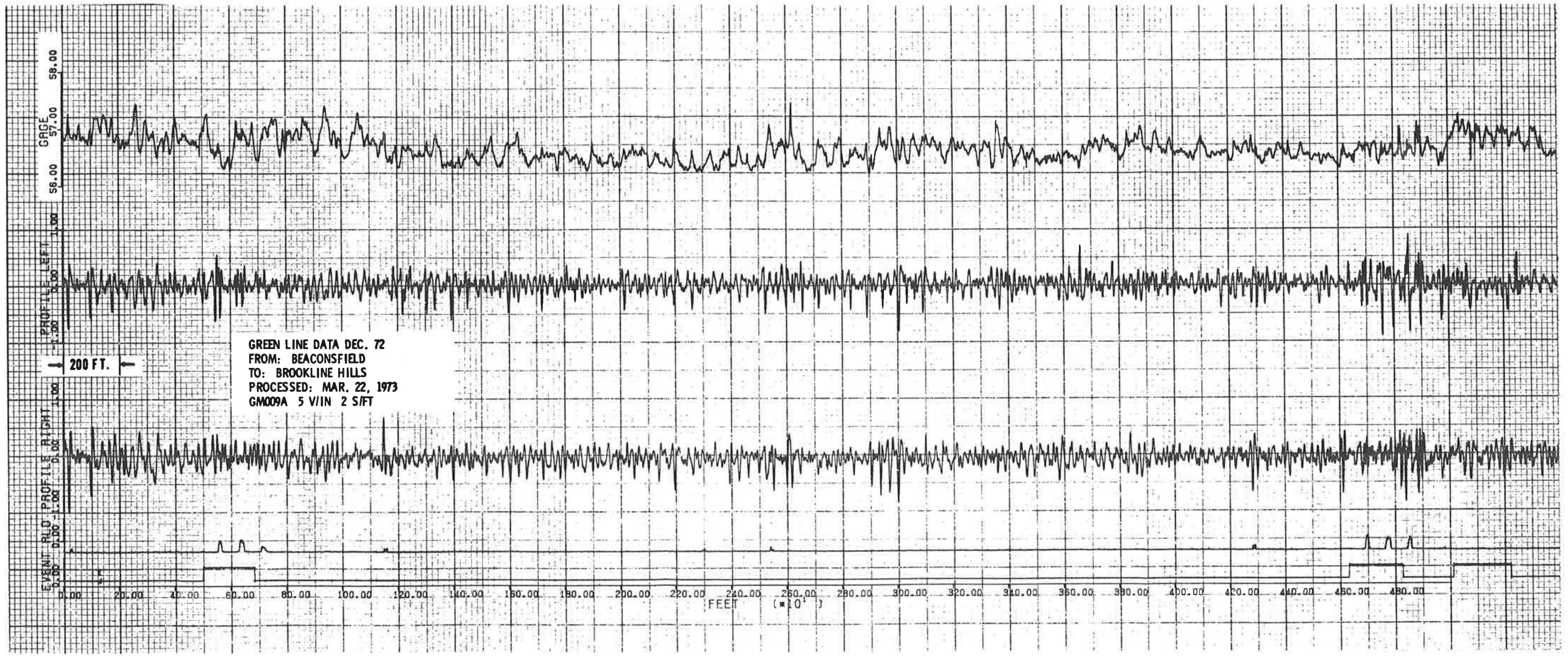


Figure 13. Beaconsfield to Brookline Hills Data

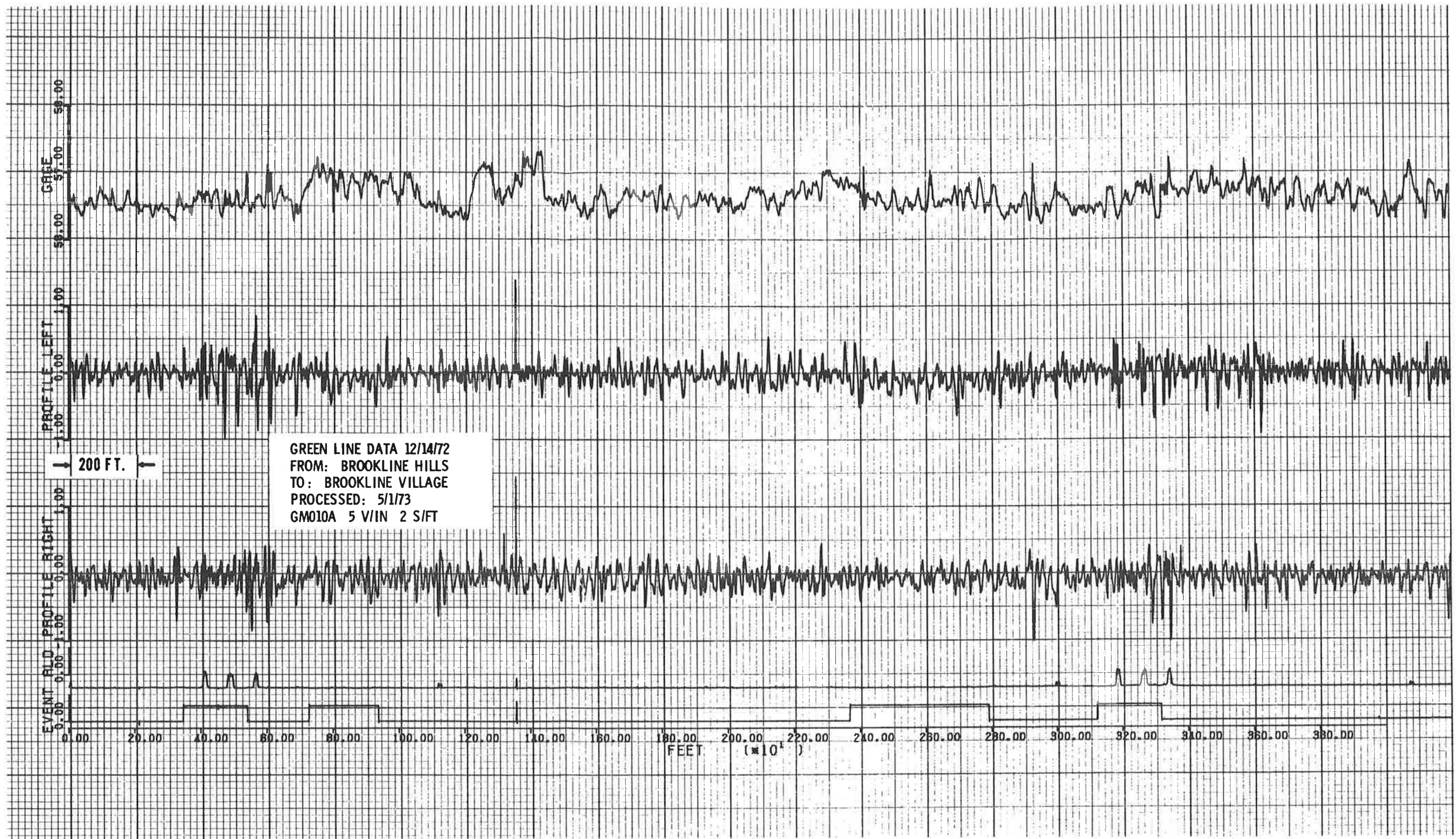


Figure 14. Brookline Hills to Brookline Village Data



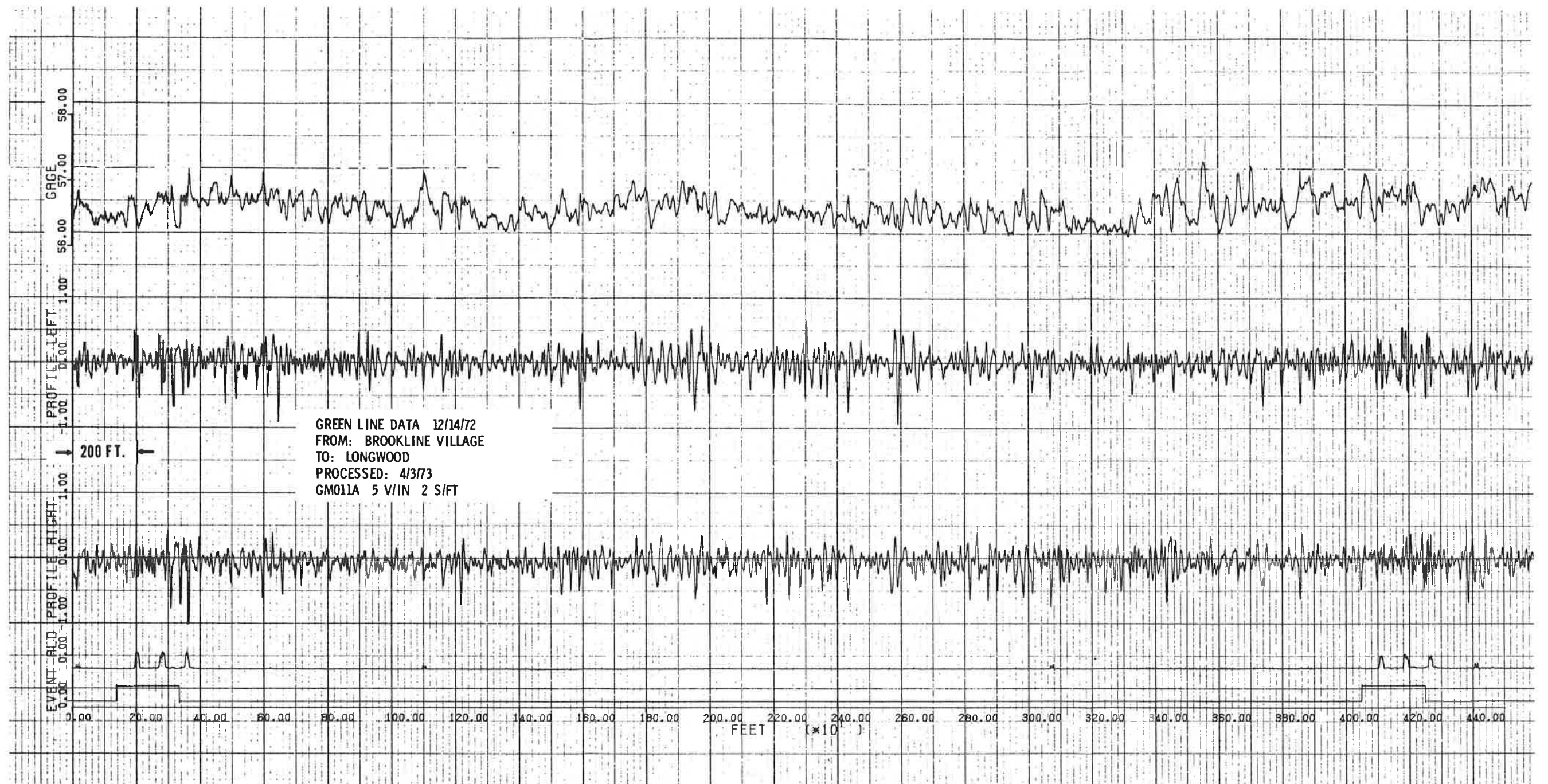


Figure 15. Brookline Village to Longwood Data

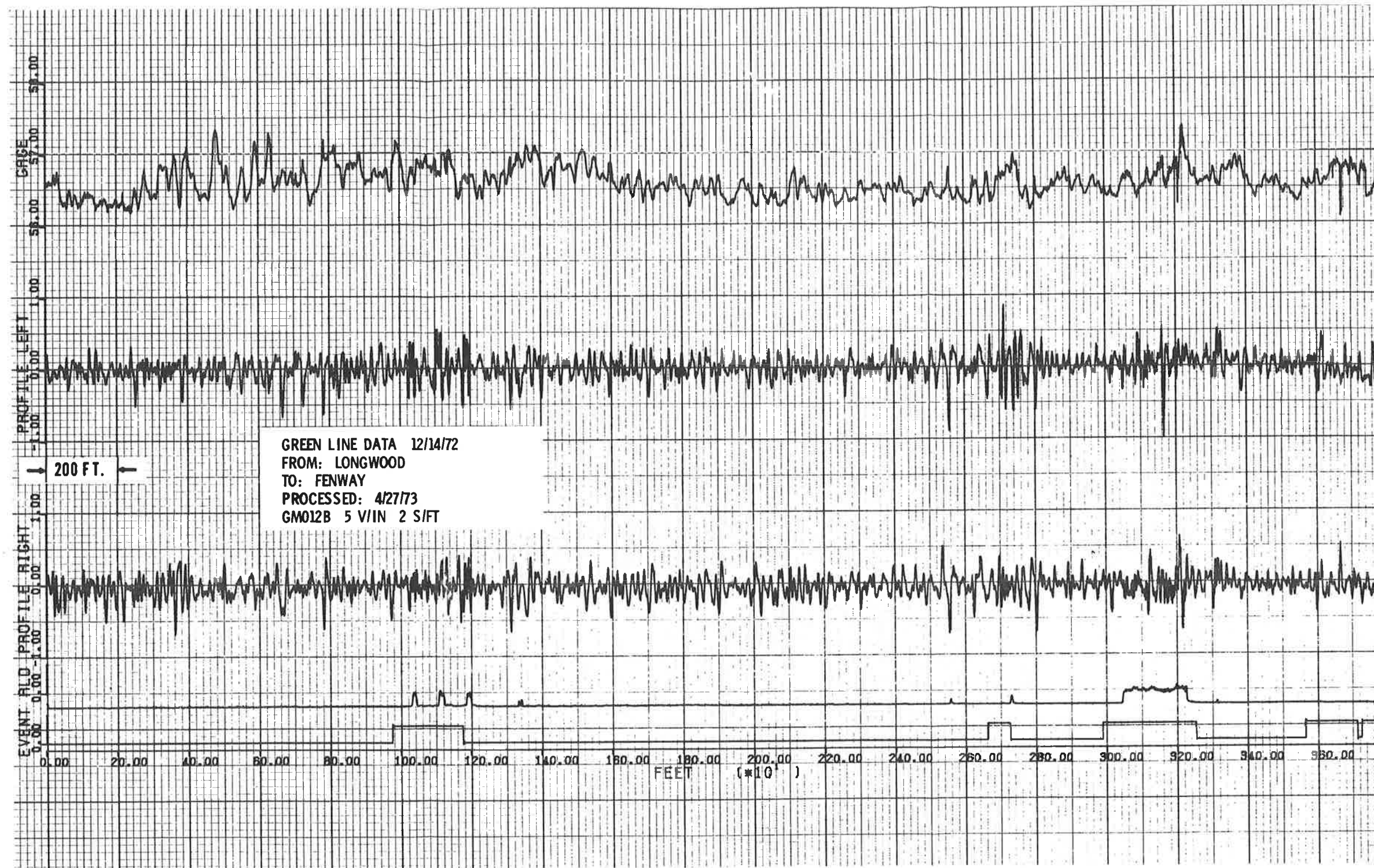


Figure 16. Longwood to Fenway Park Data



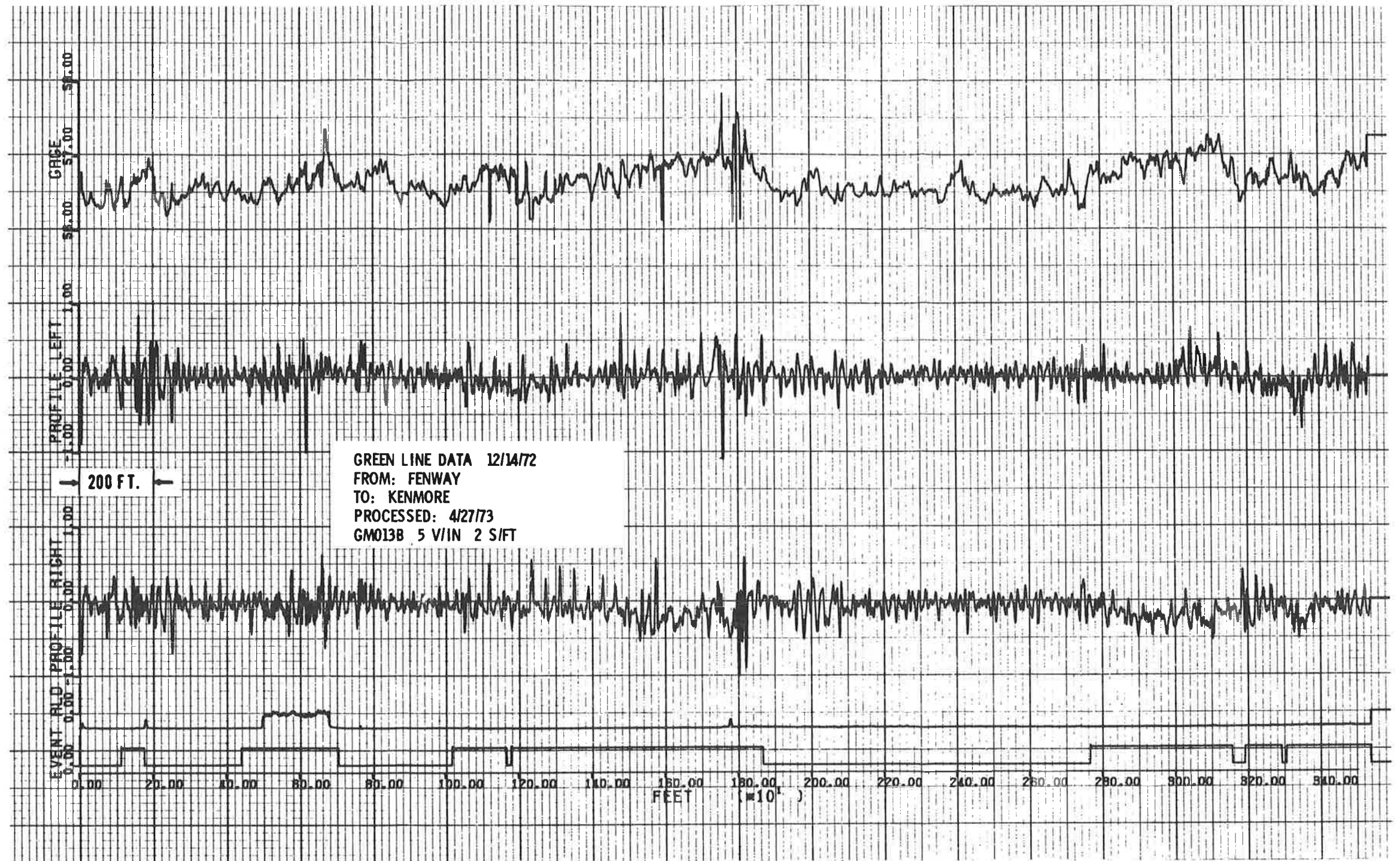


Figure 17. Fenway Park to Kenmore Data

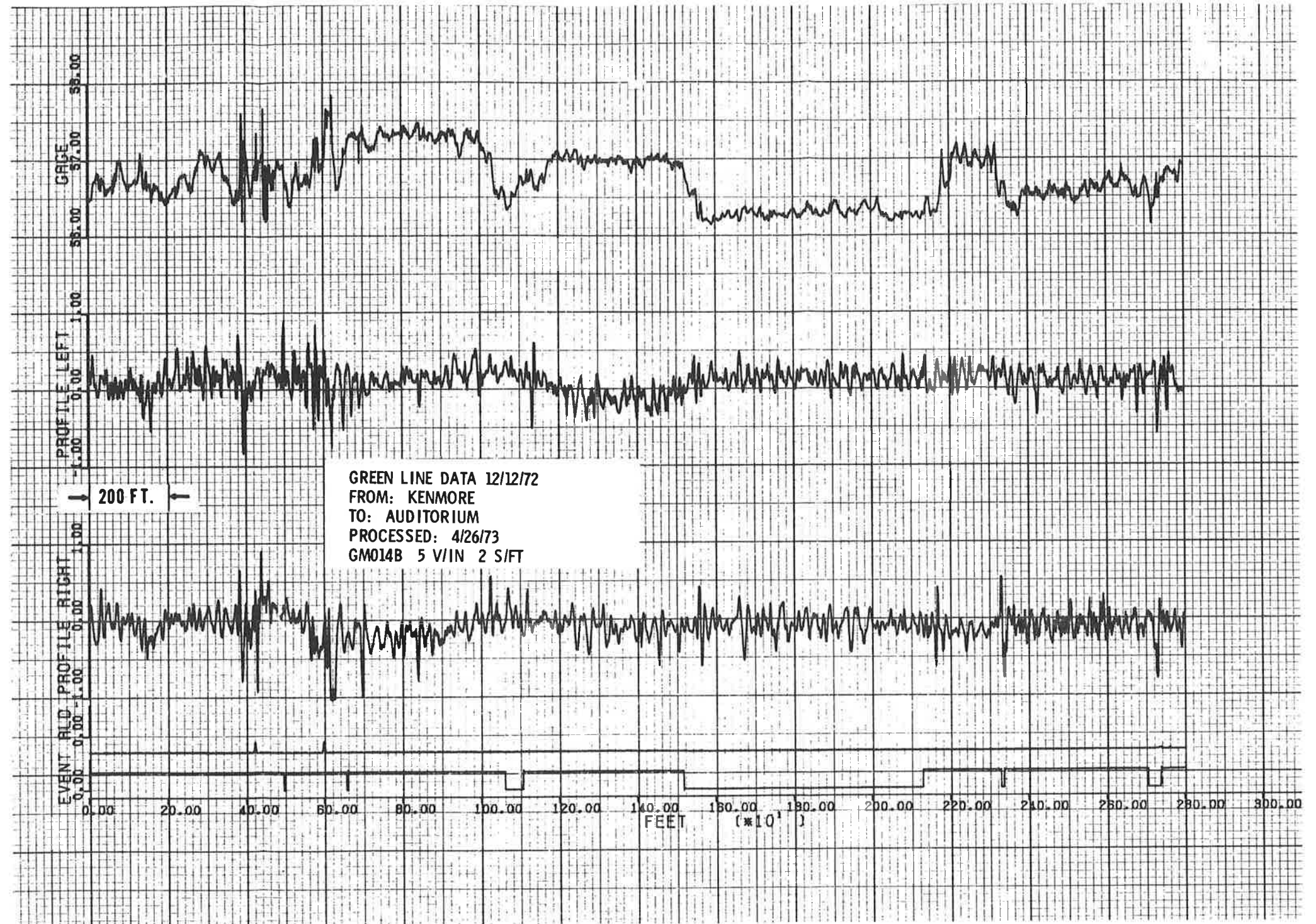


Figure 18. Kenmore to Auditorium Data



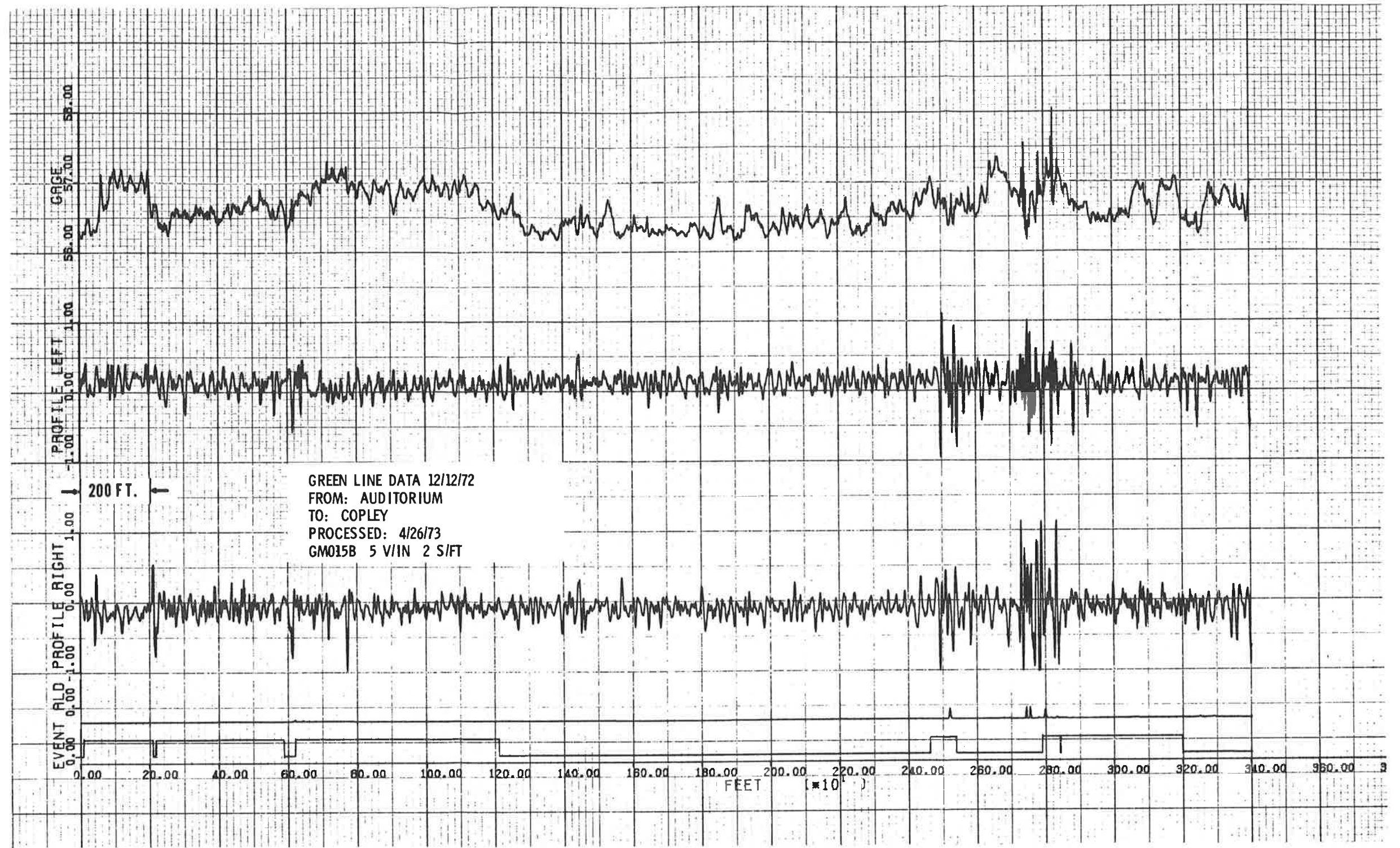


Figure 19. Auditorium to Copley Data

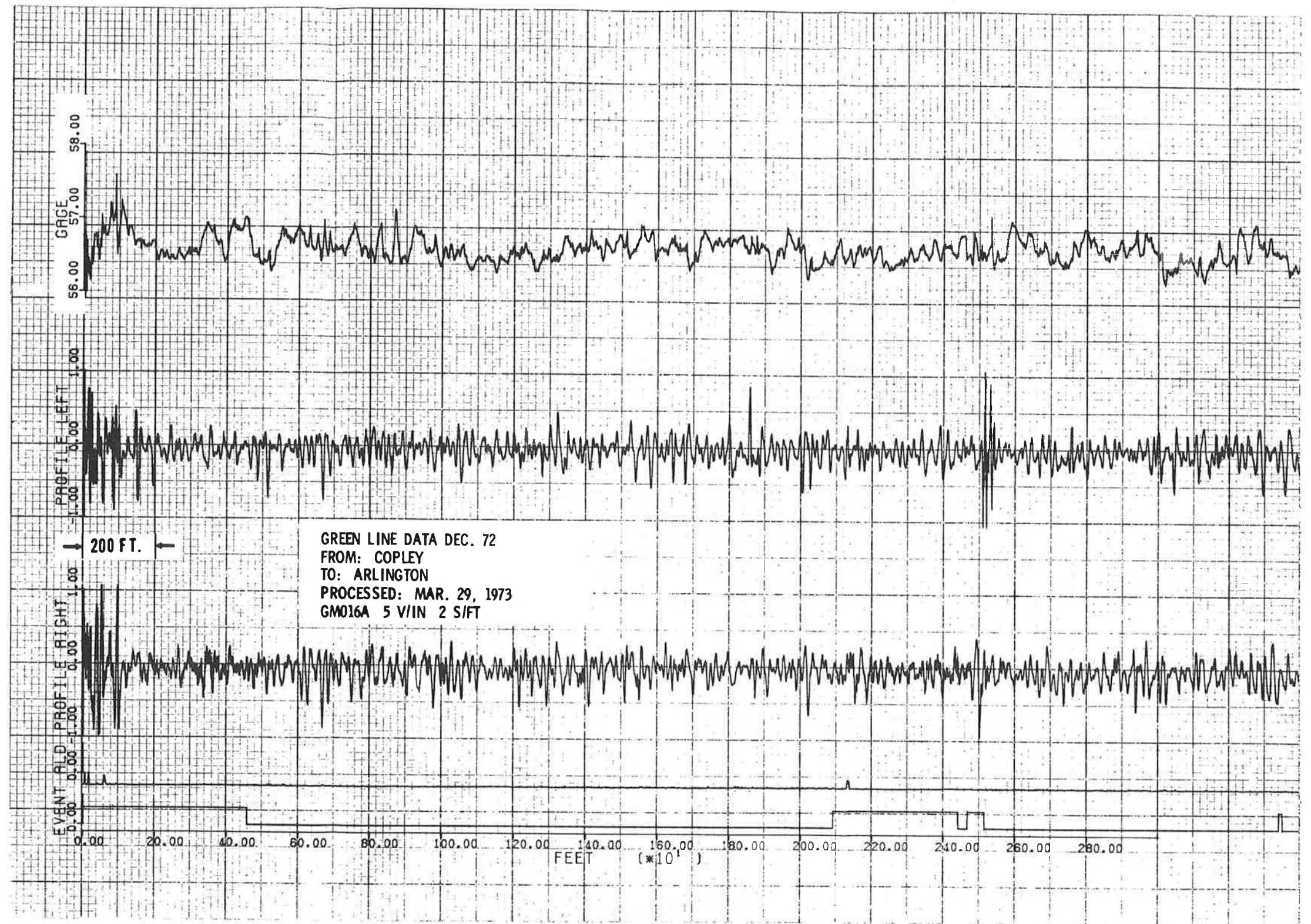


Figure 20. Copley to Arlington Data



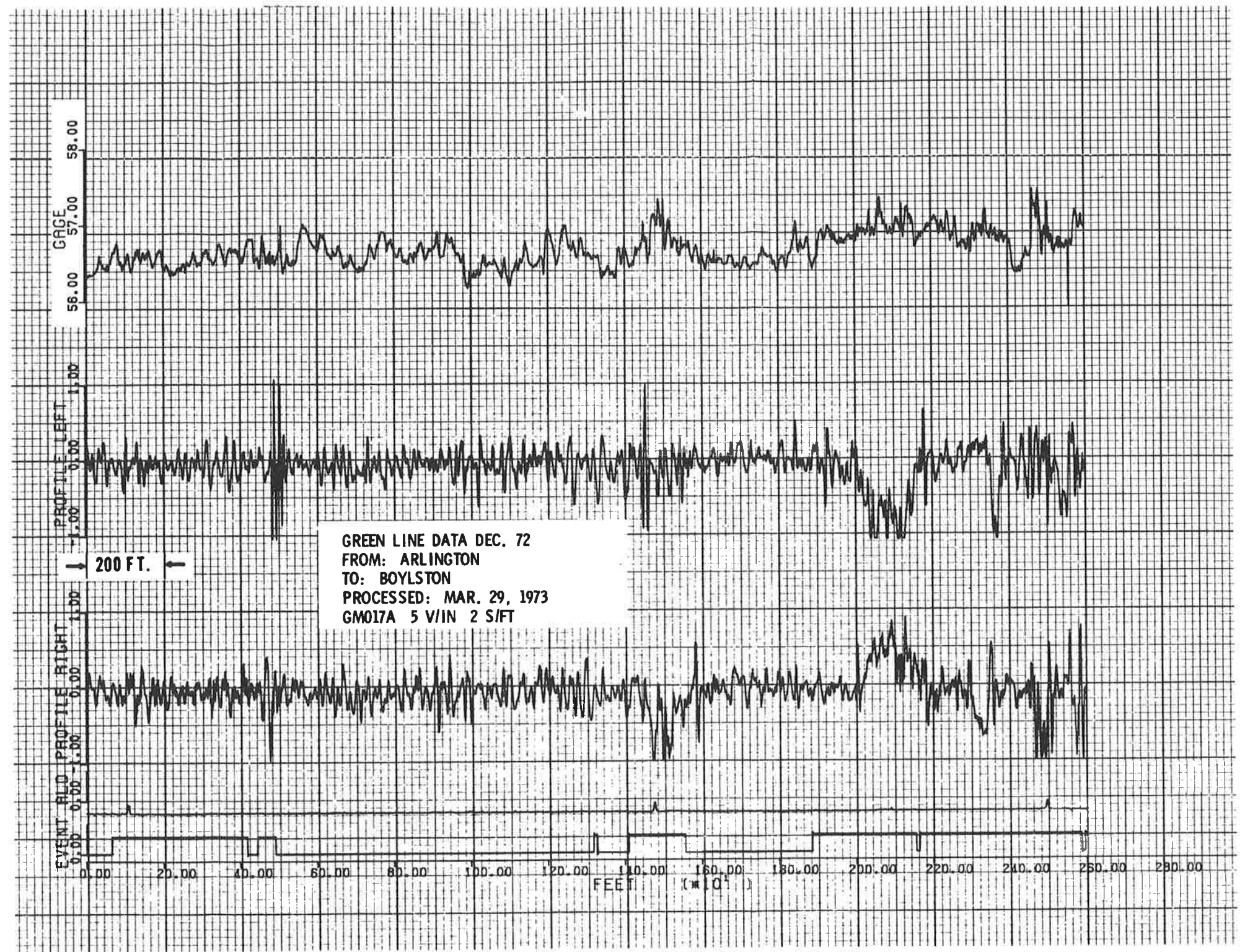


Figure 21. Arlington to  
Boylston Data

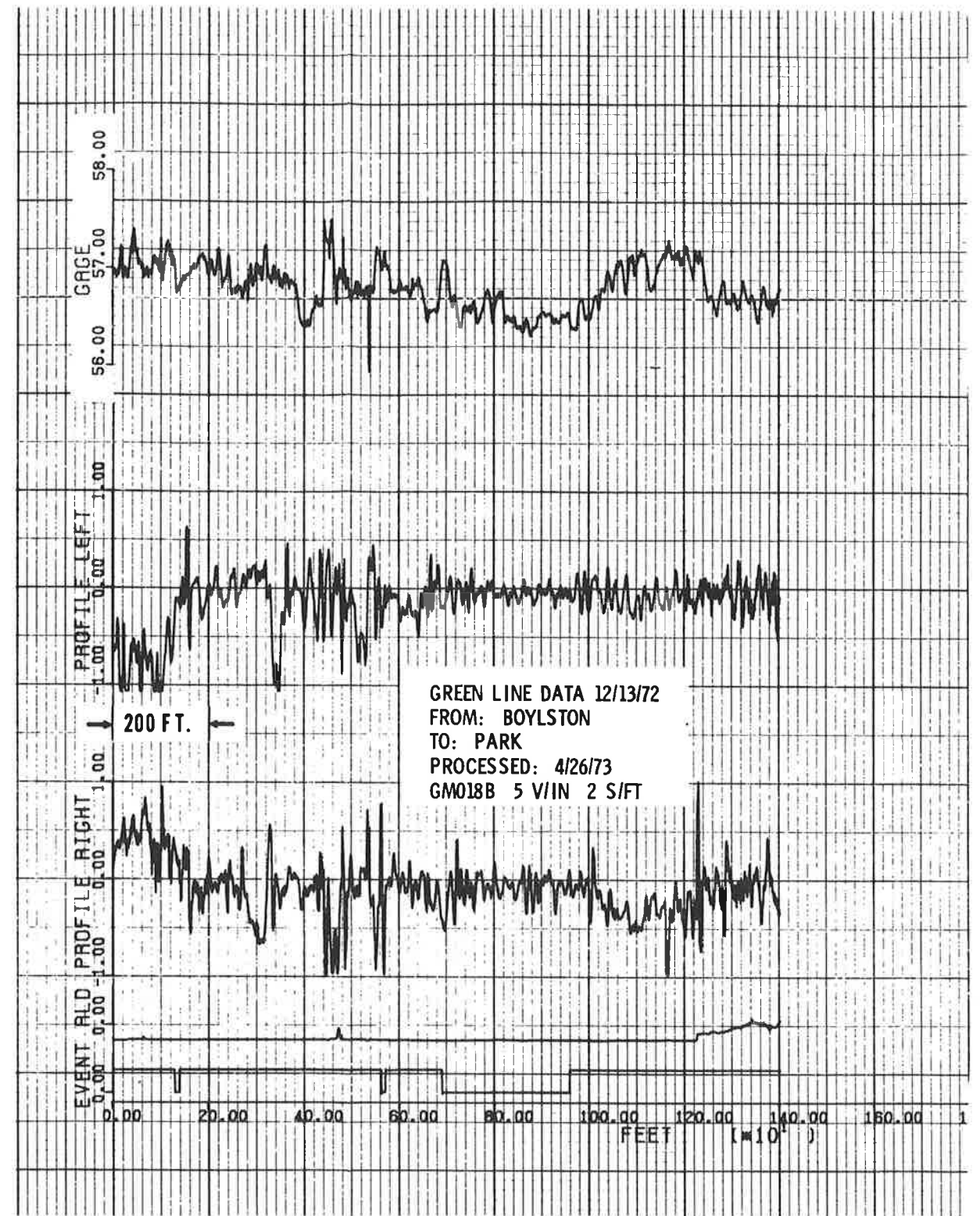


Figure 22. Boylston to Park Data



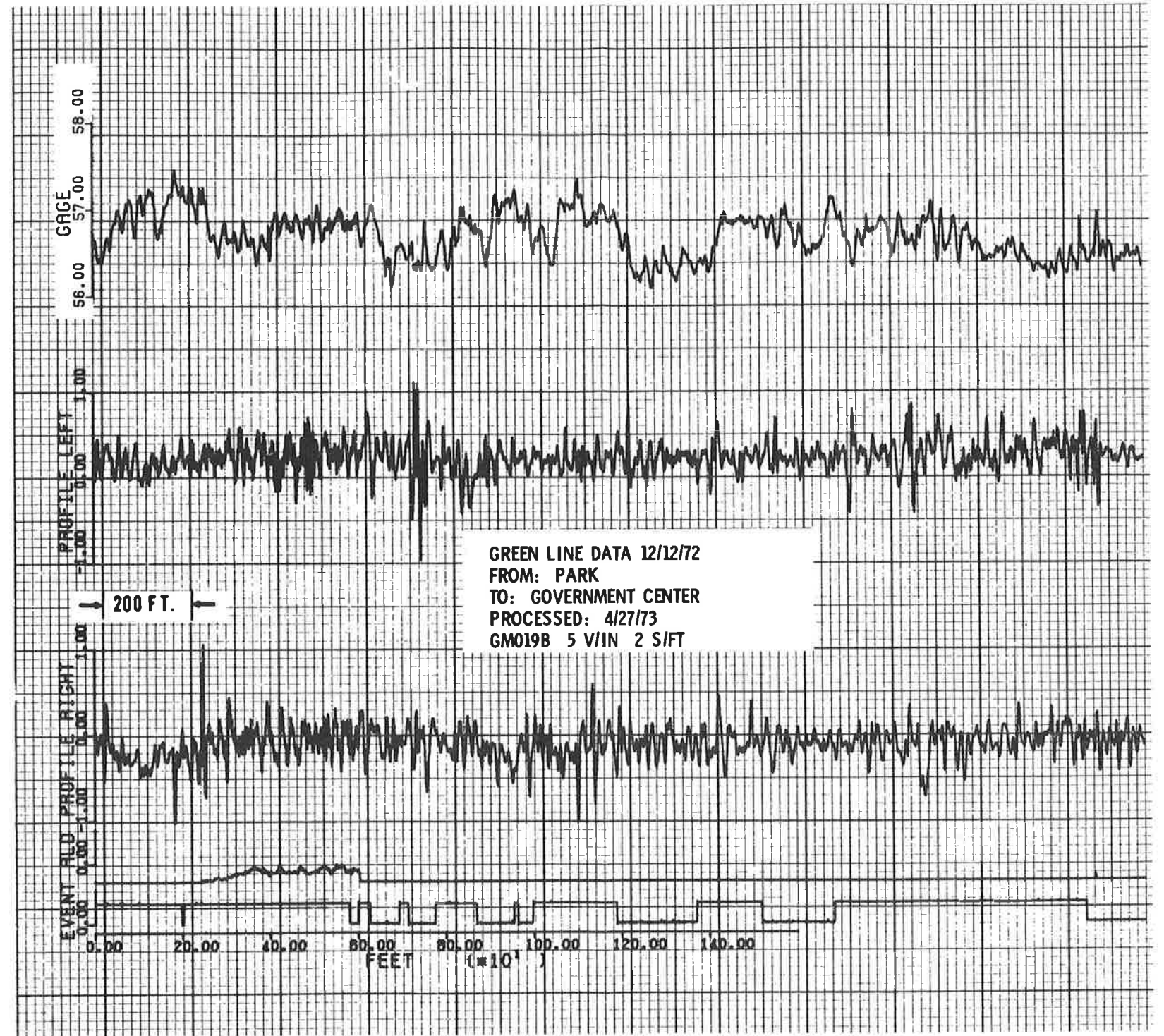


Figure 23. Park to Government Center Data

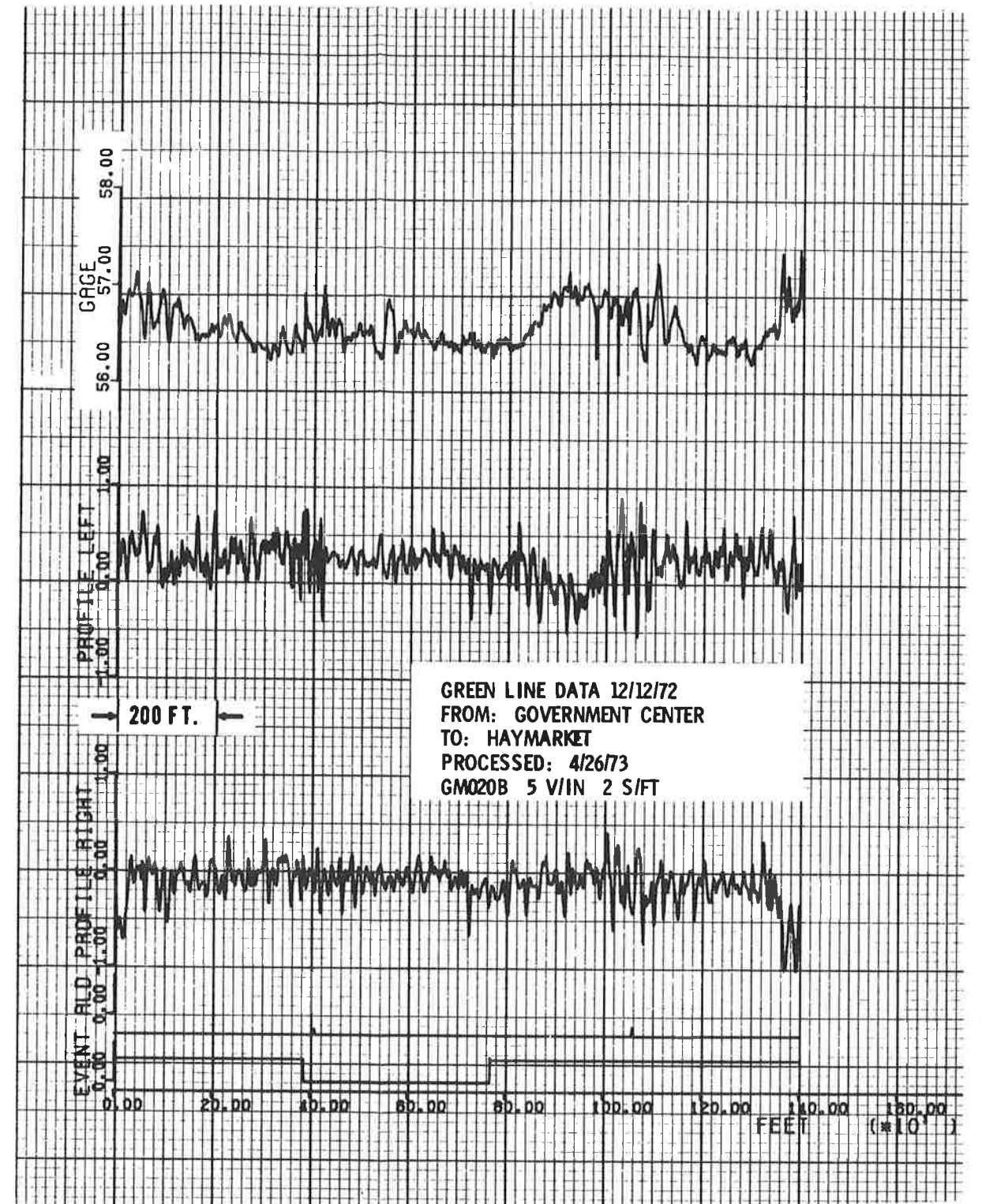


Figure 24. Government Center to Haymarket Data



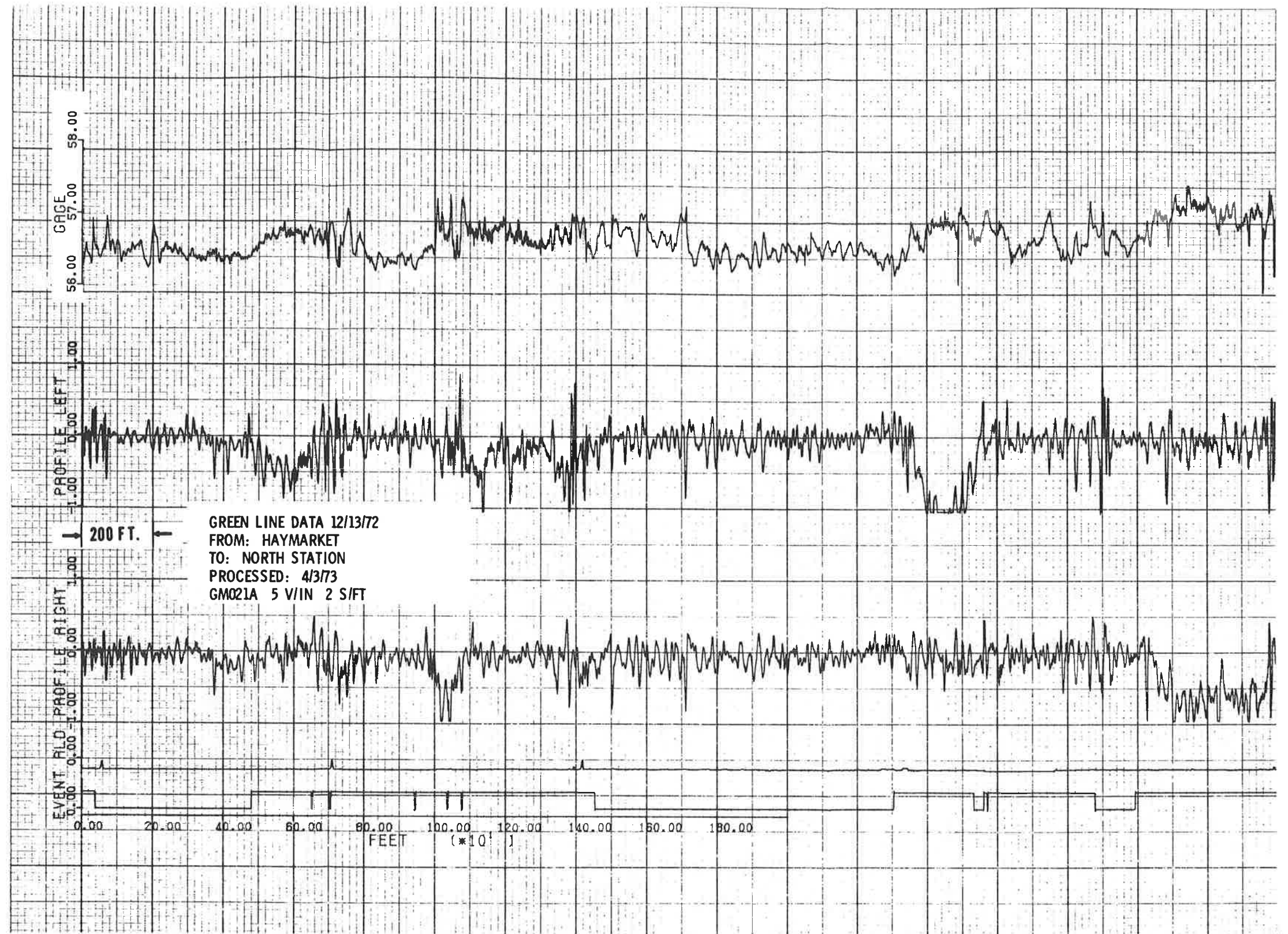


Figure 25. Haymarket to North Station Data

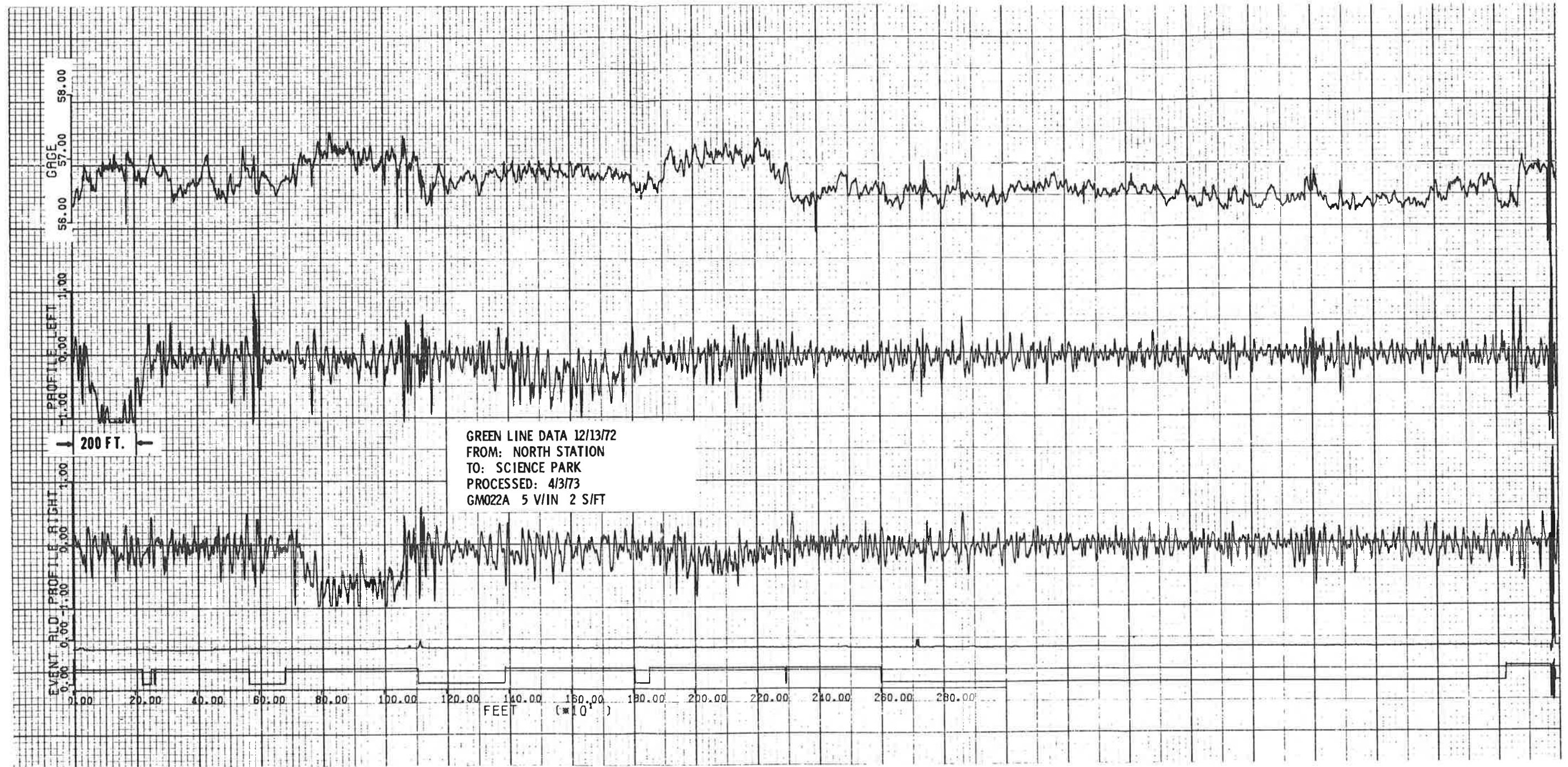


Figure 26. North Station to Science Park Data



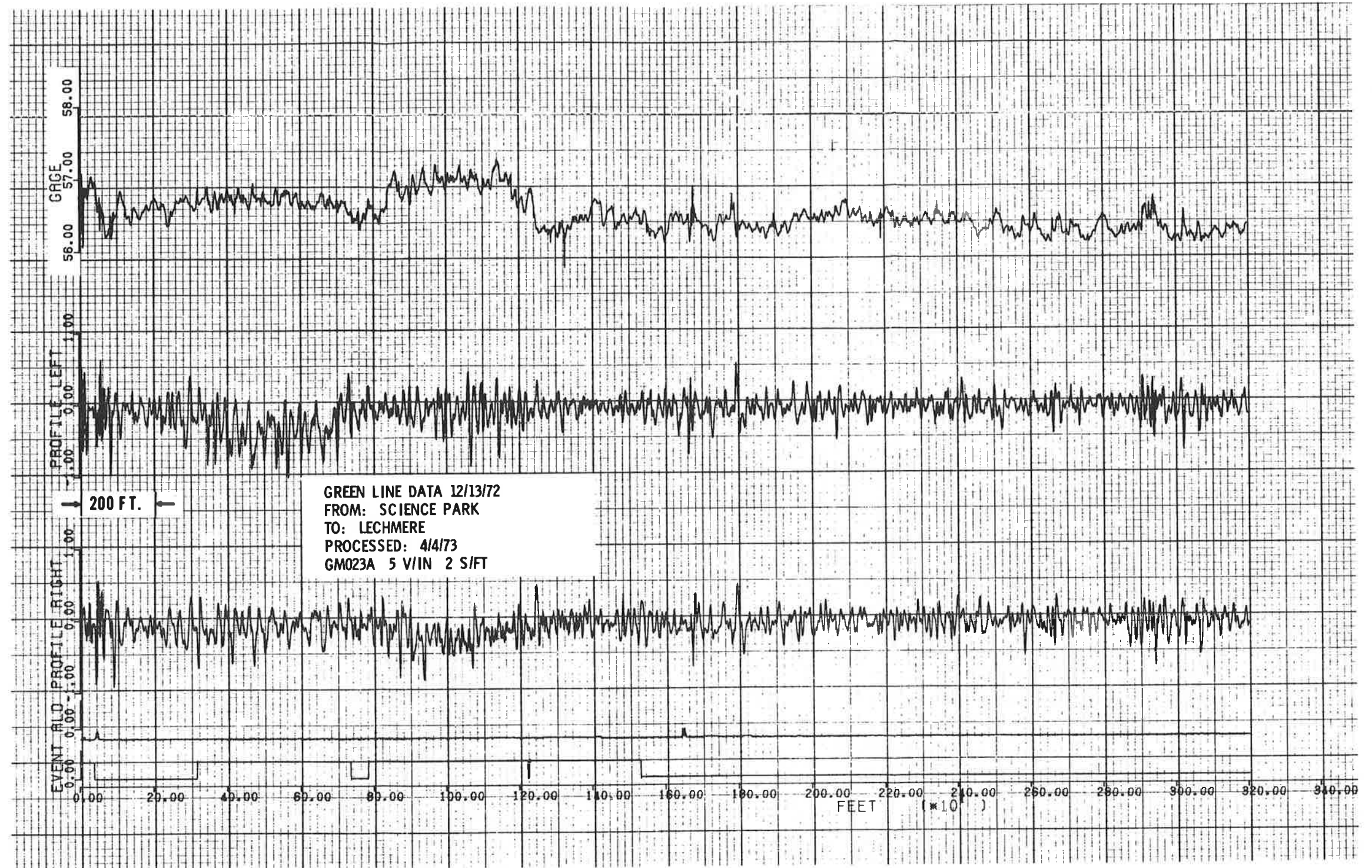


Figure 27. Science Park to Lechmere Data



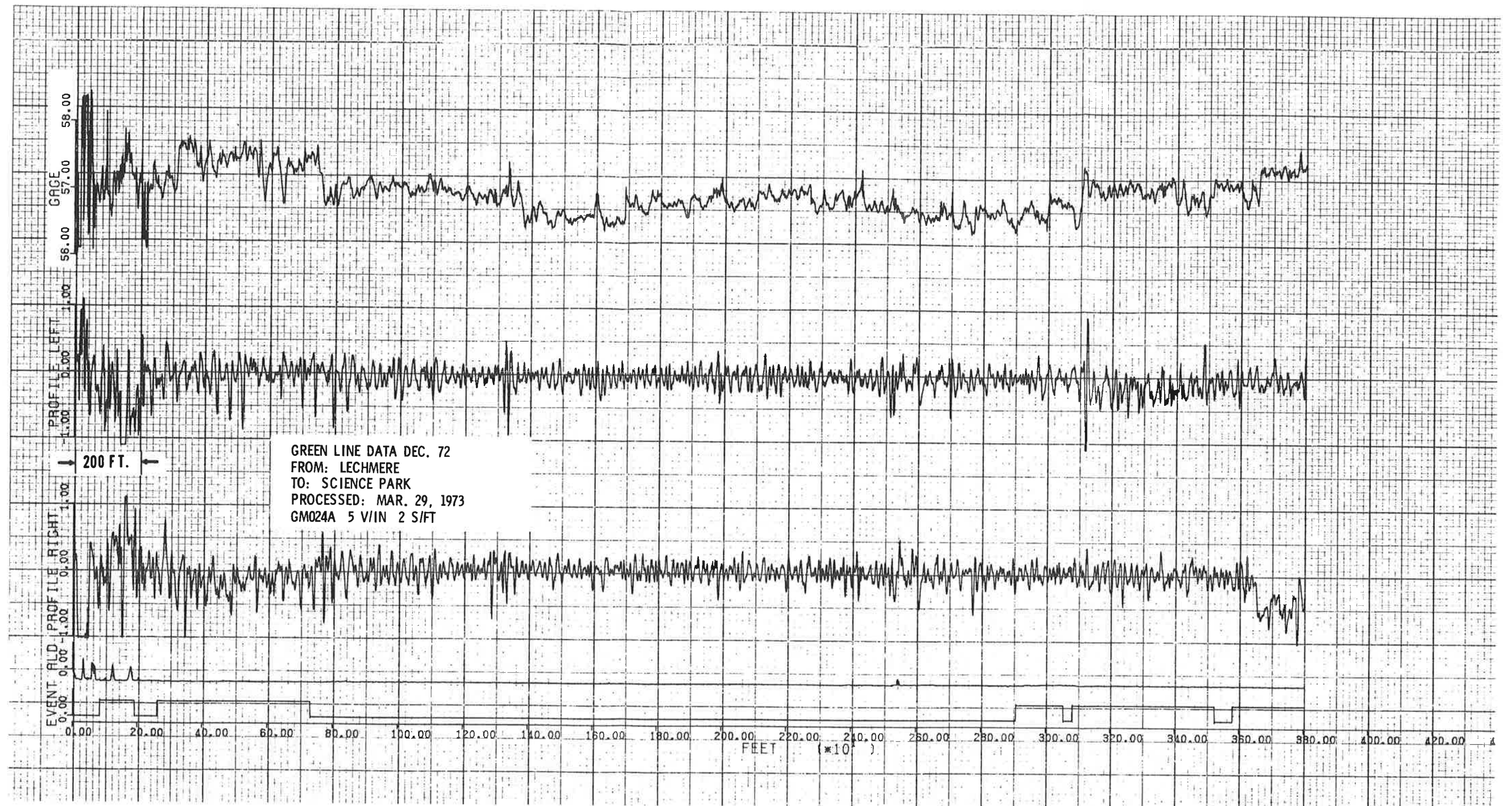


Figure 28. Lechmere to Science Park Data



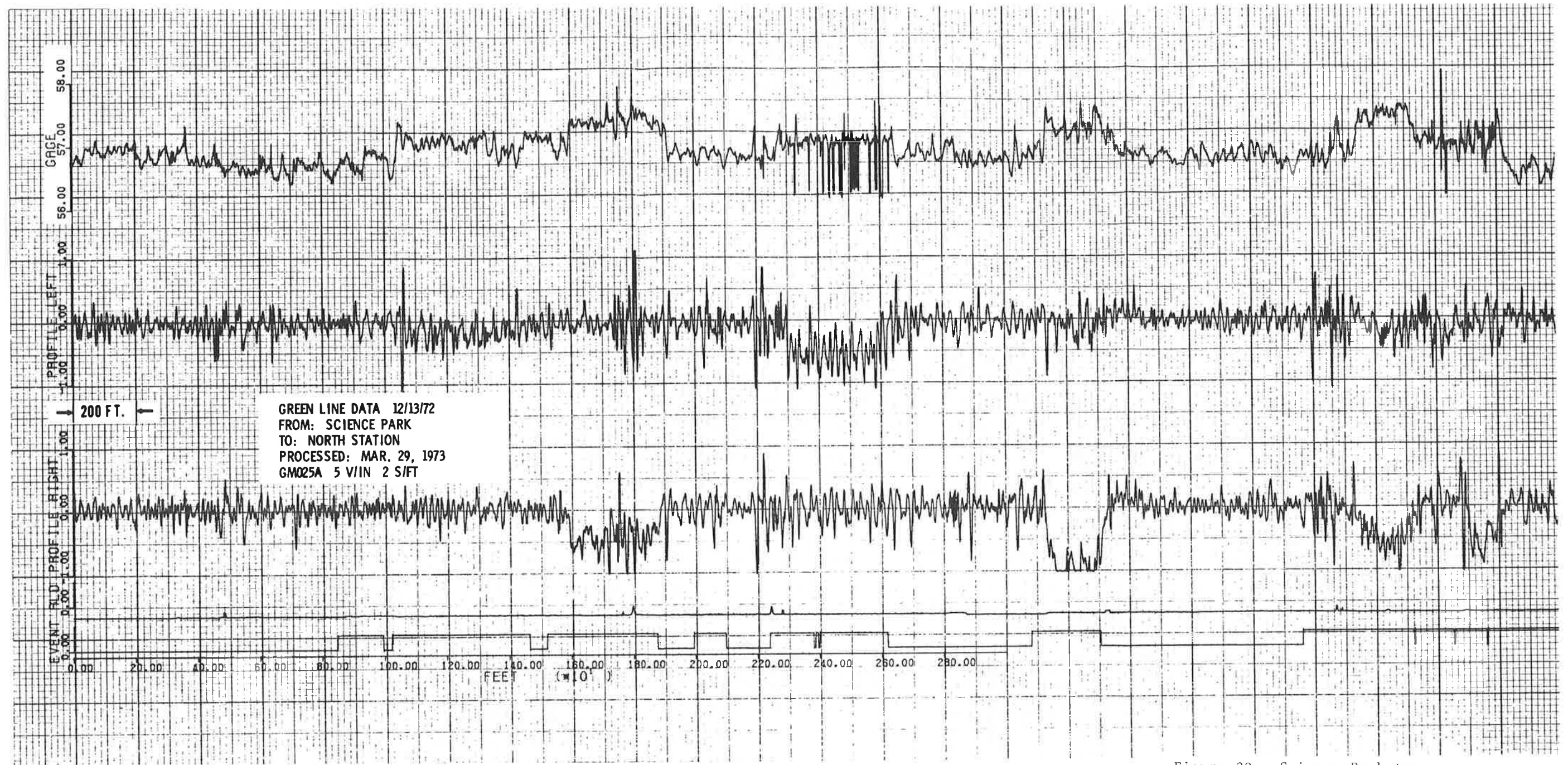


Figure 29. Science Park to North Station Data

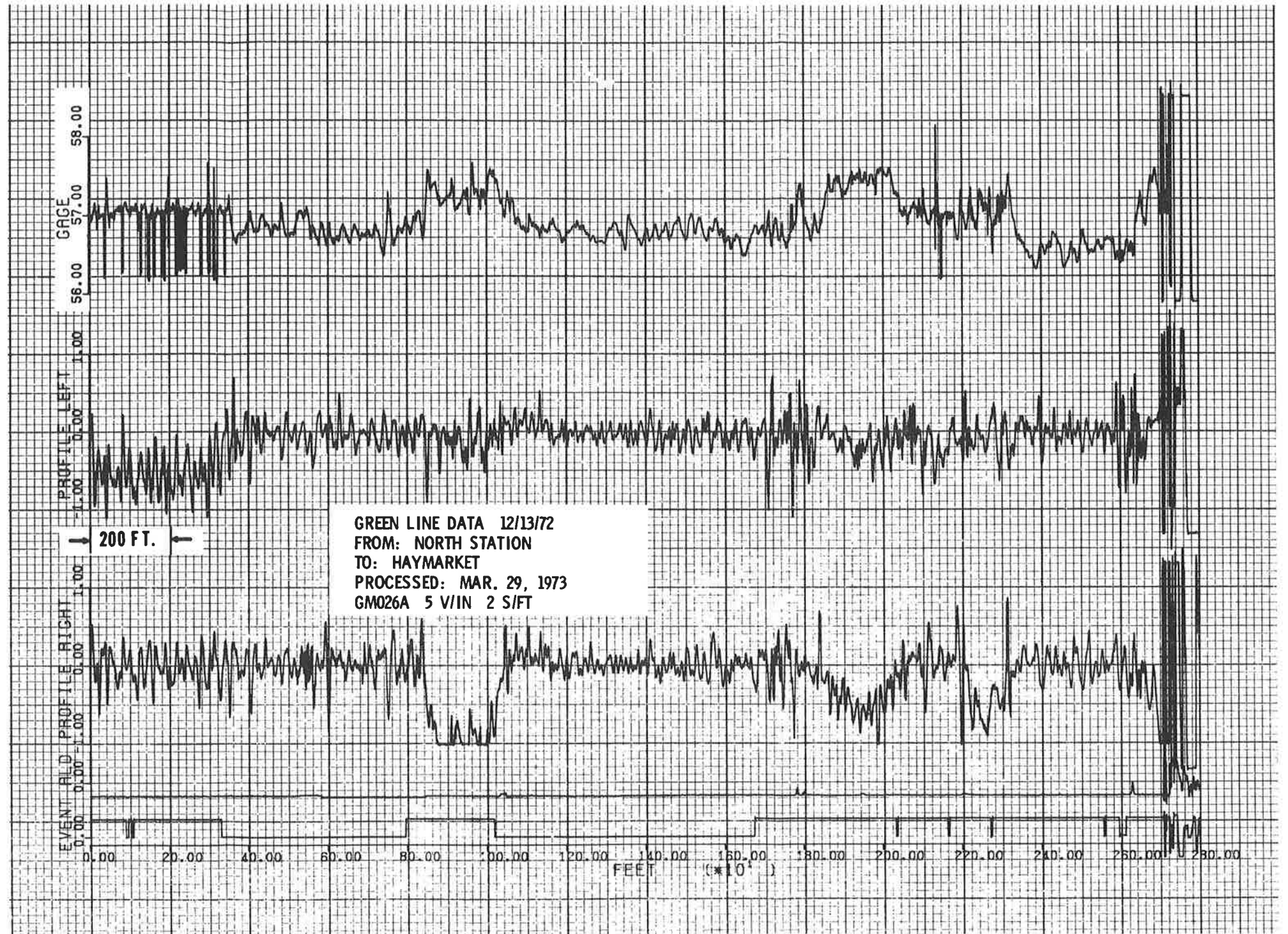


Figure 30. North Station to Haymarket Data



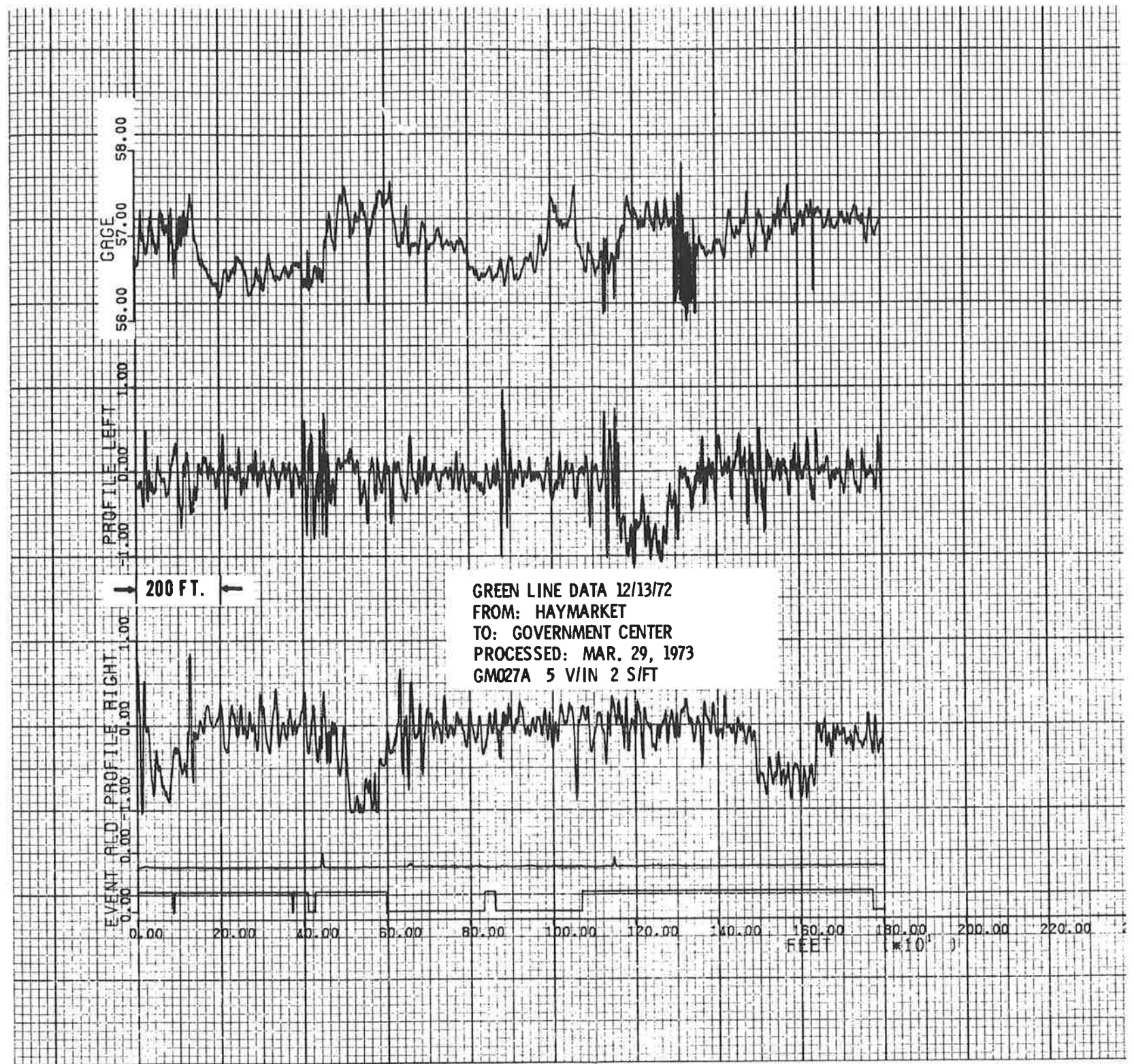


Figure 31. Haymarket to Government Center Data

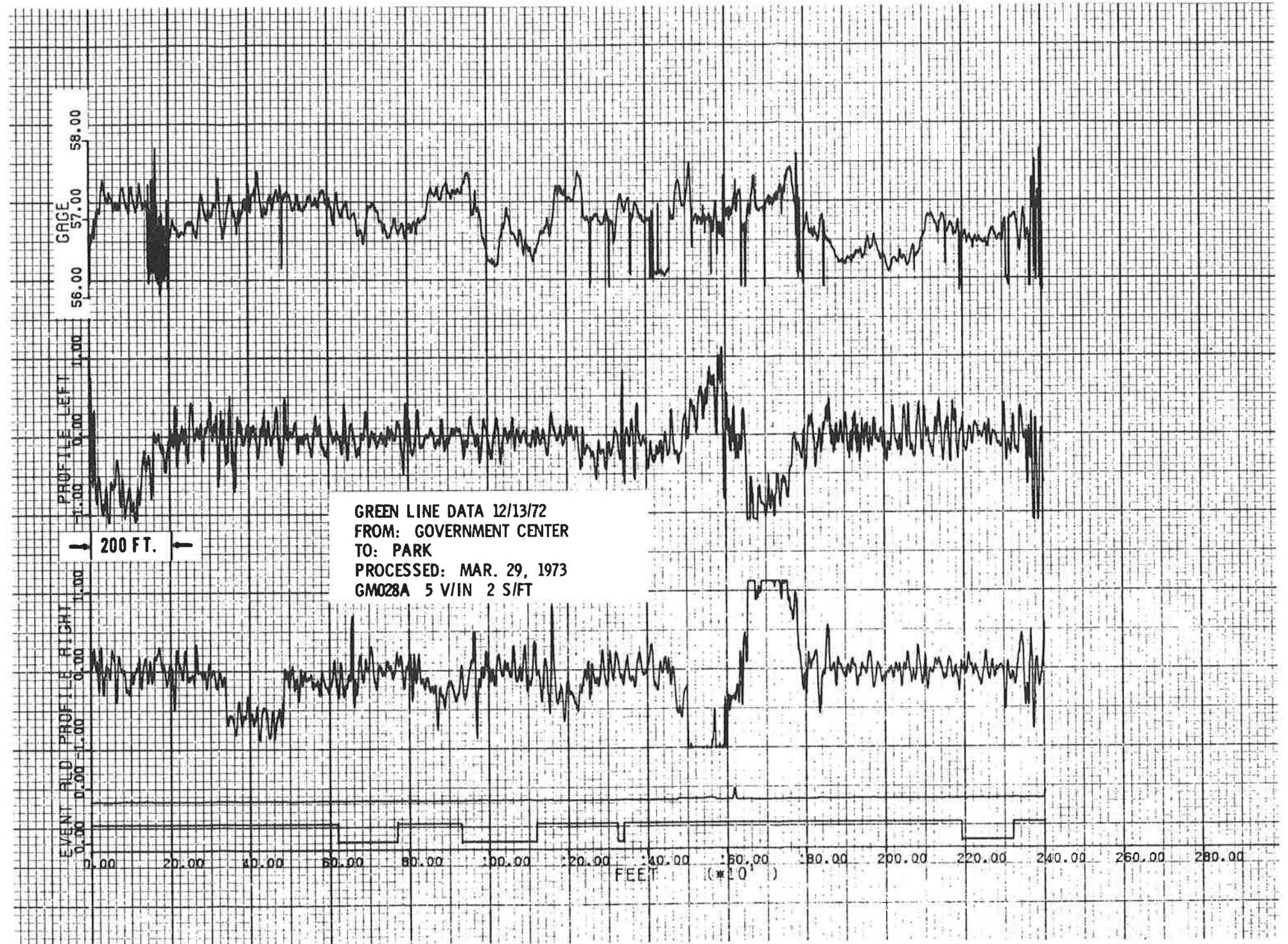


Figure 32. Government Center to Park Data



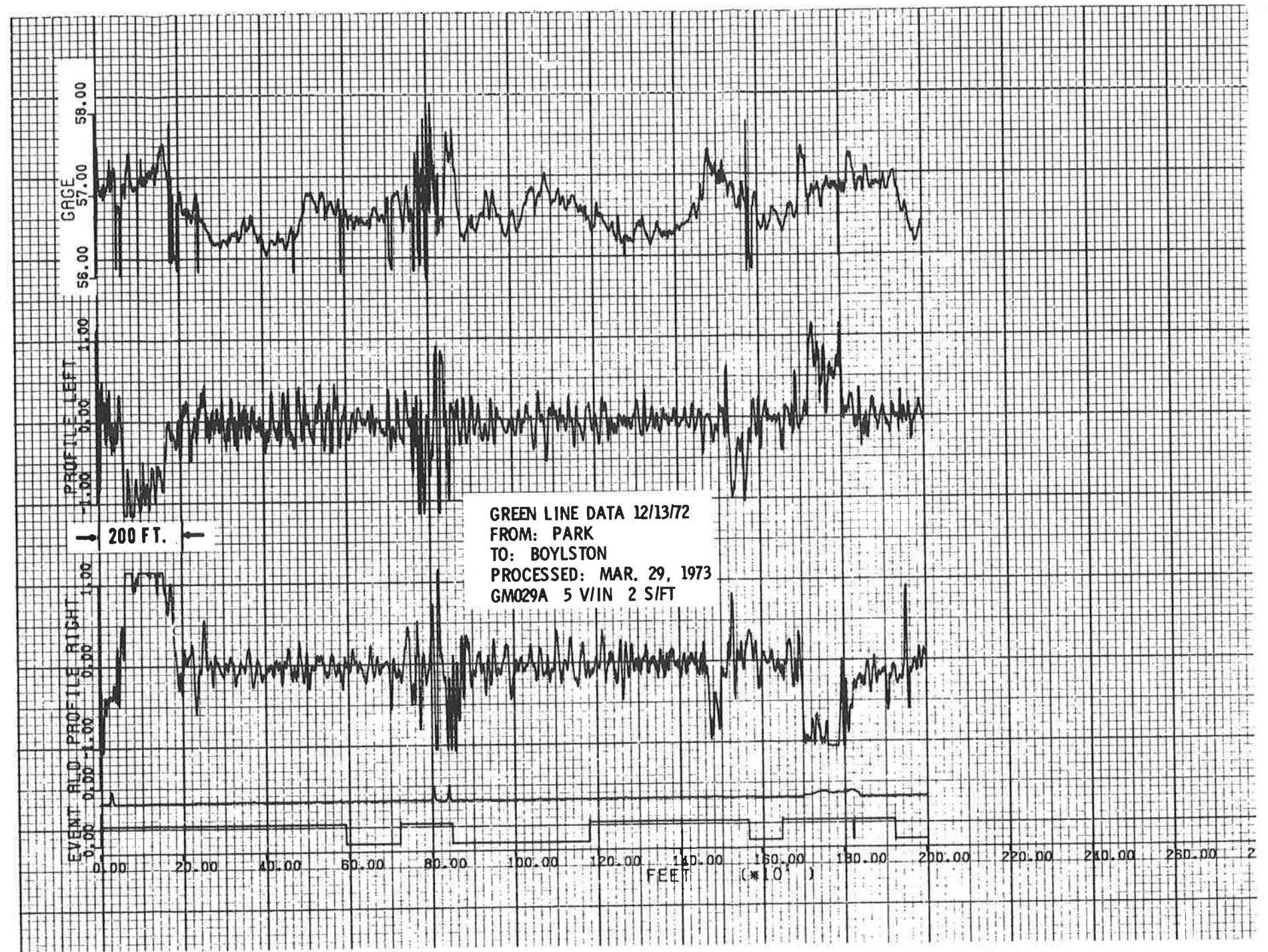


Figure 33. Park to Boylston Data

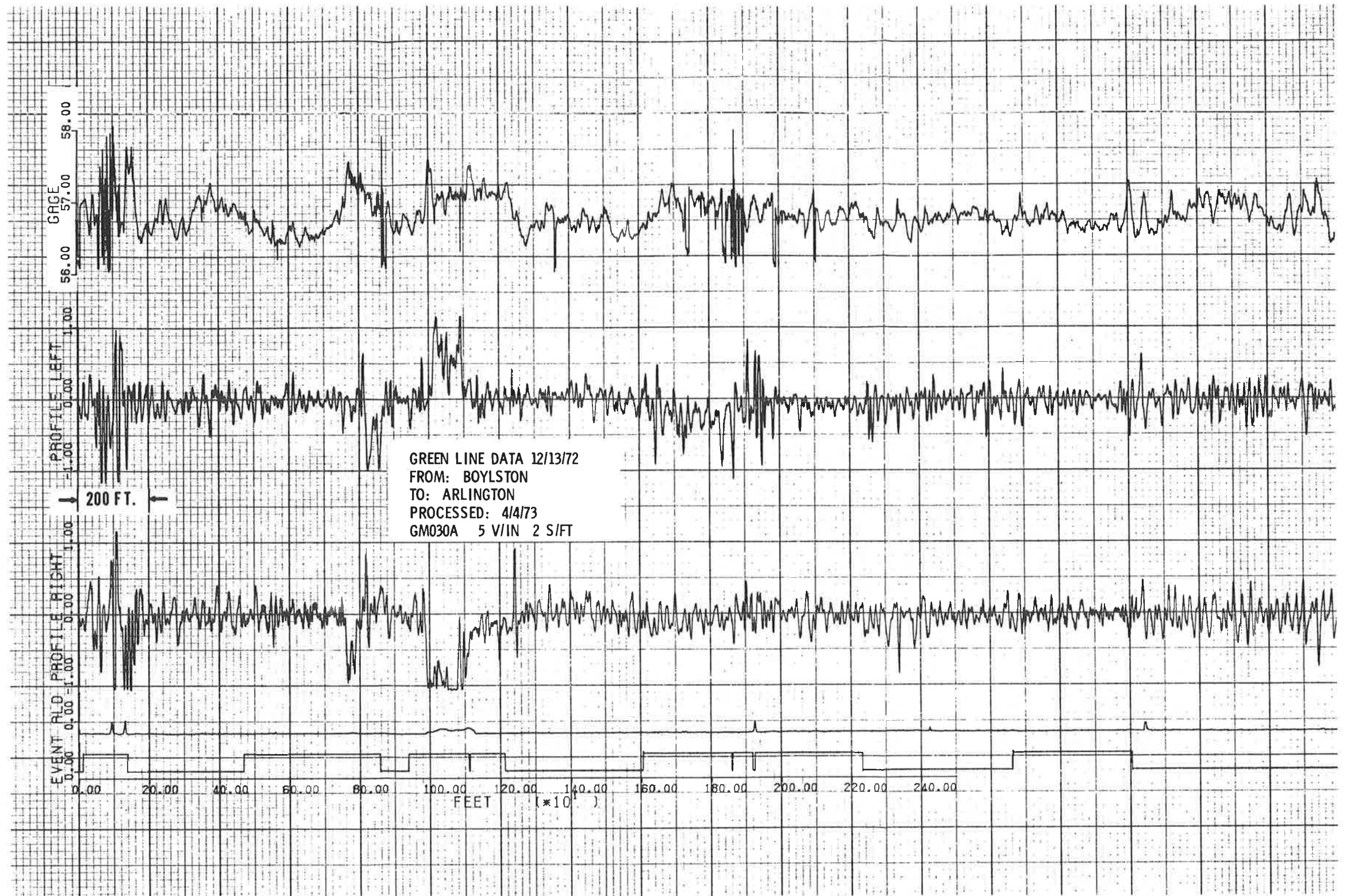


Figure 34. Boylston to Arlington Data



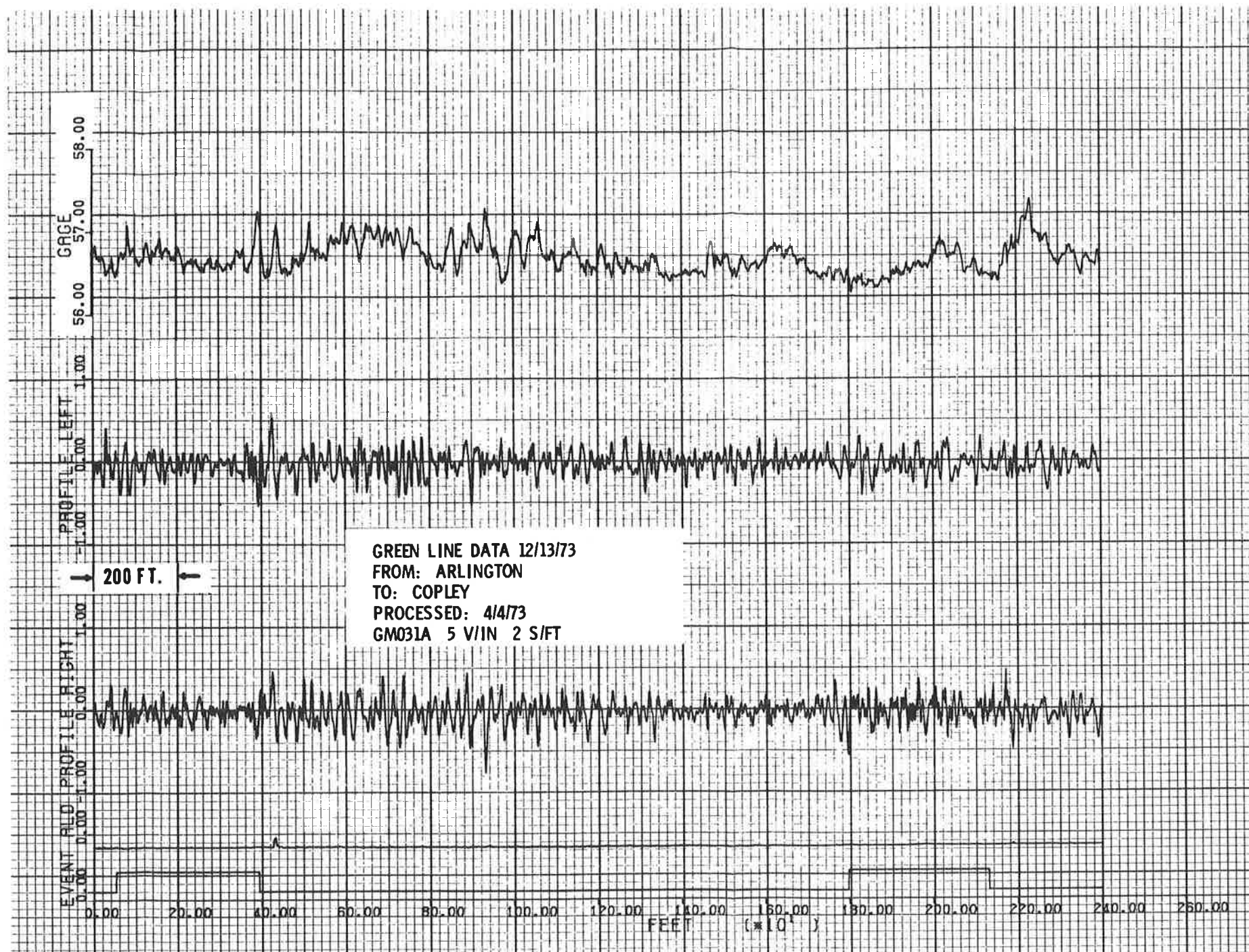


Figure 35. Arlington to Copley Data

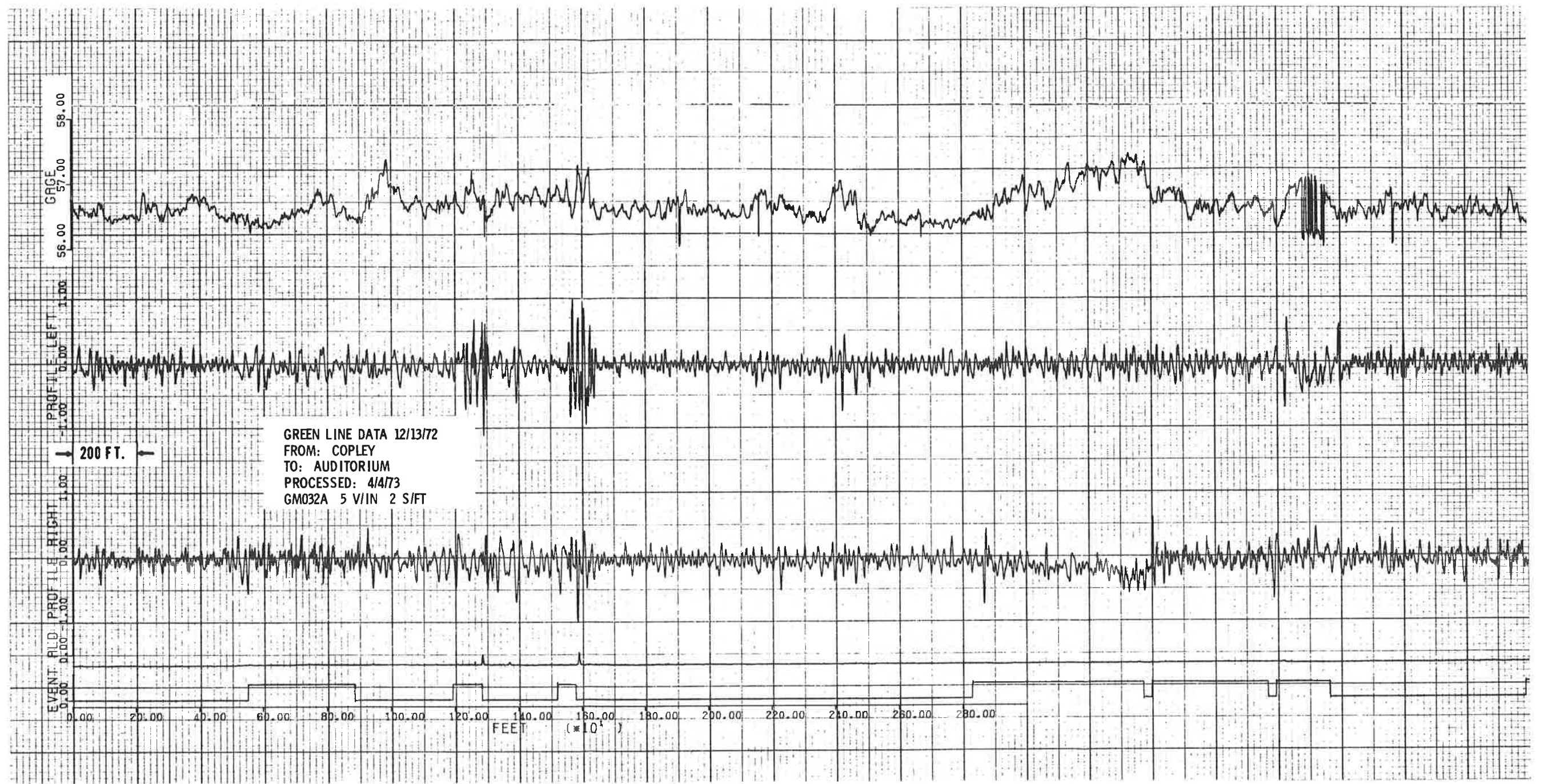
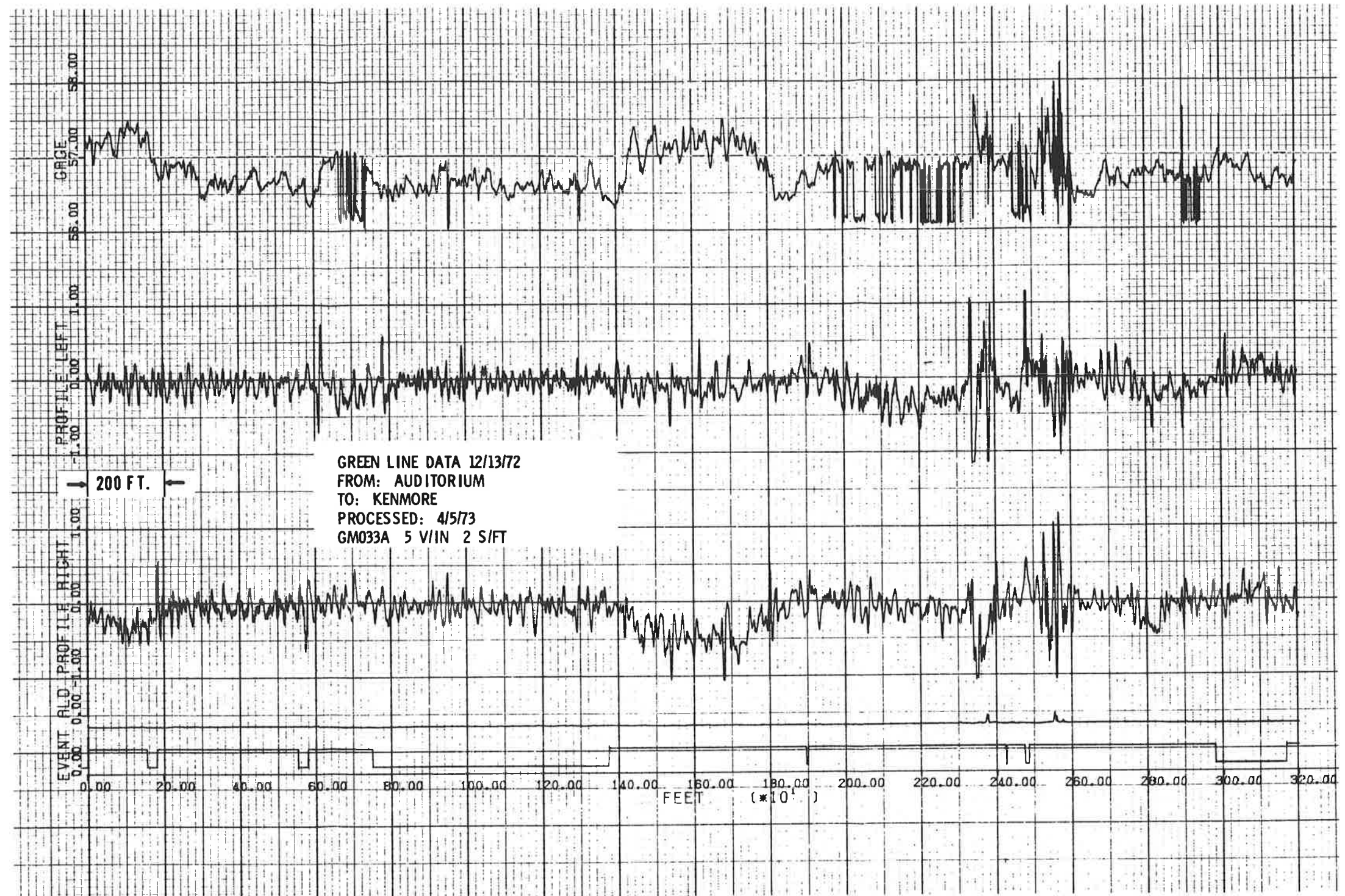


Figure 36. Copley to Auditorium Data





GREEN LINE DATA 12/13/72  
 FROM: AUDITORIUM  
 TO: KENMORE  
 PROCESSED: 4/5/73  
 GM033A 5 V/IN 2 SIFT

Figure 37. Auditorium to Kenmore Data

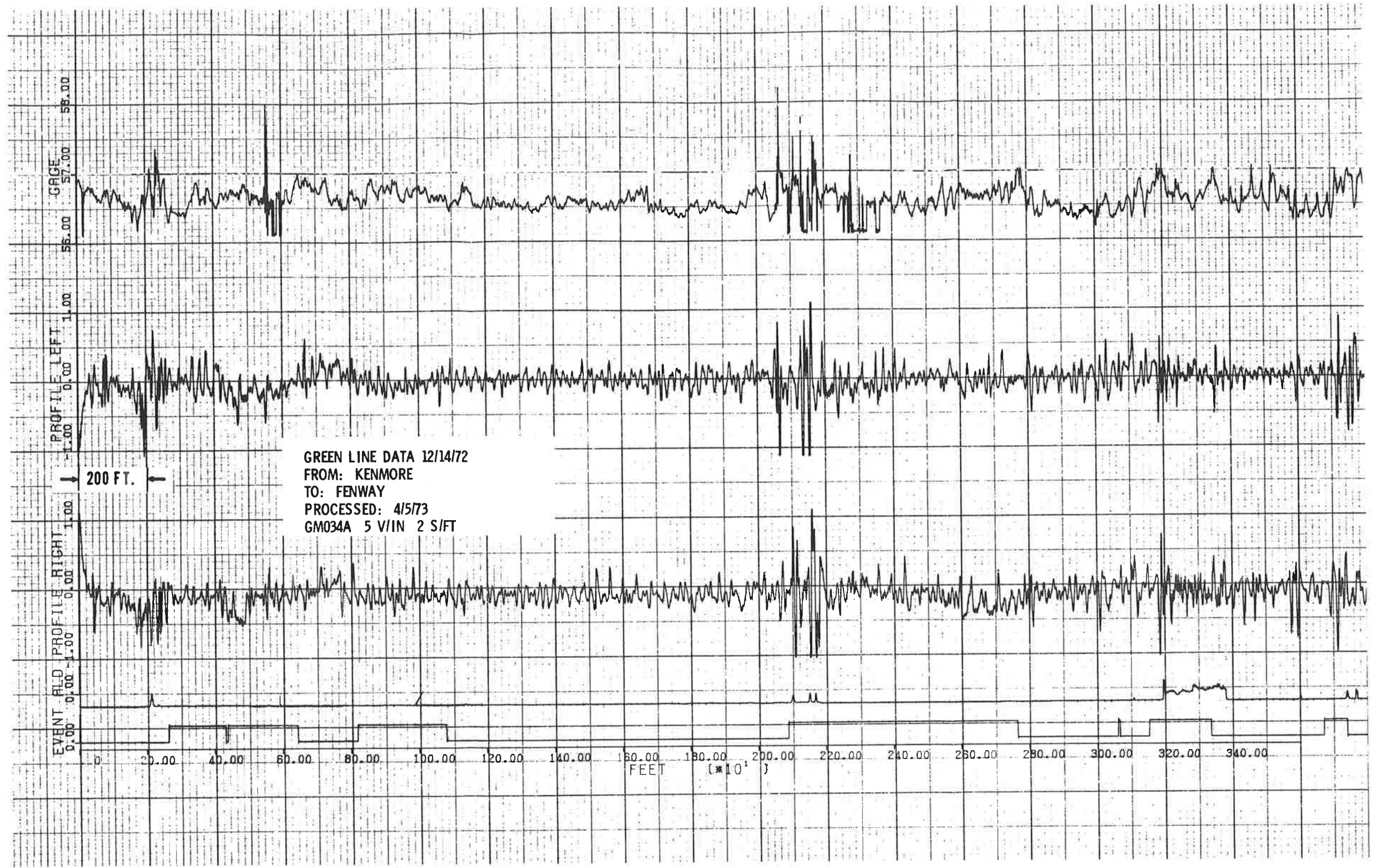


Figure 38. Kenmore to Fenway Park Data



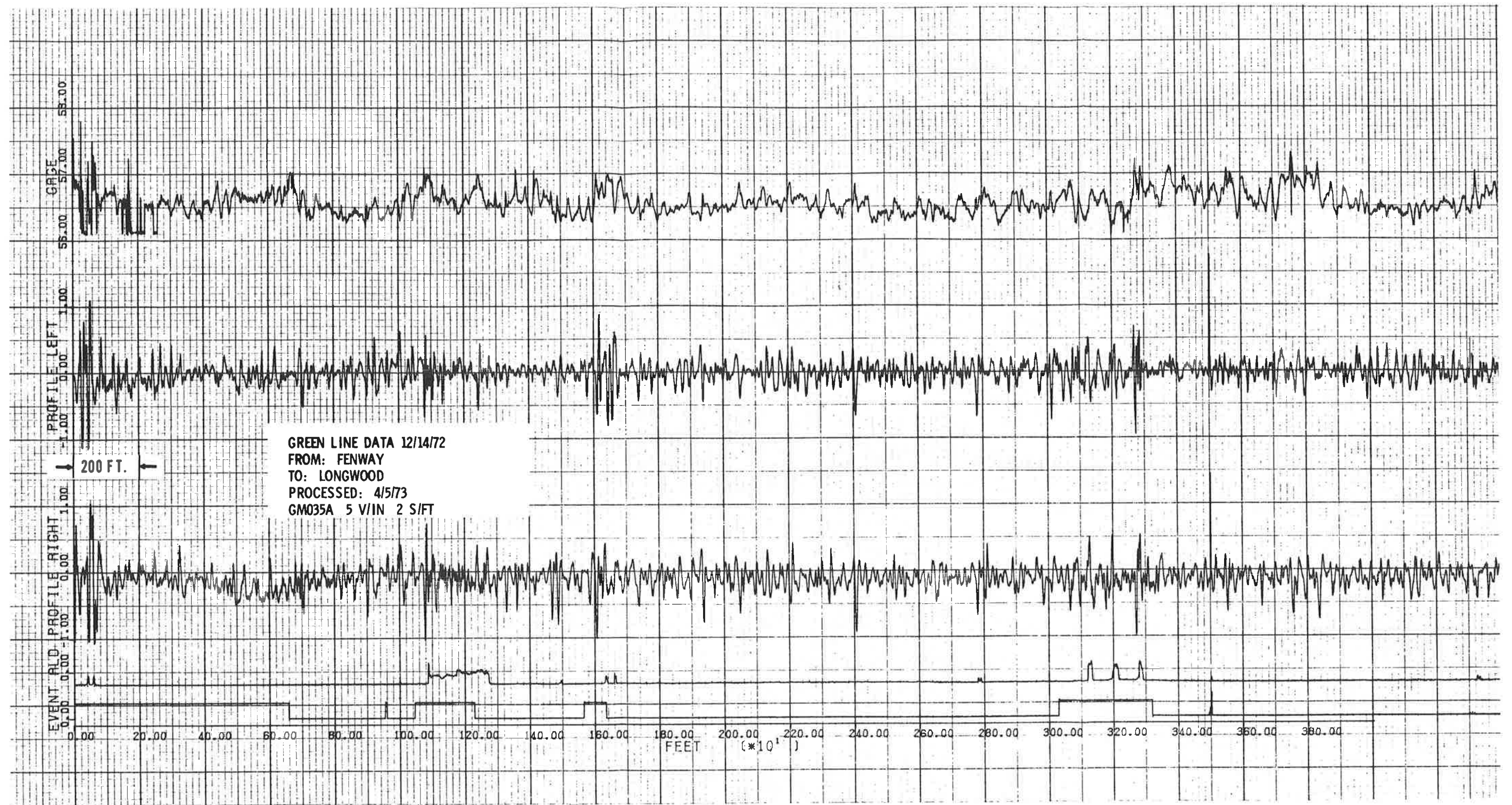


Figure 39. Fenway Park to Longwood Data



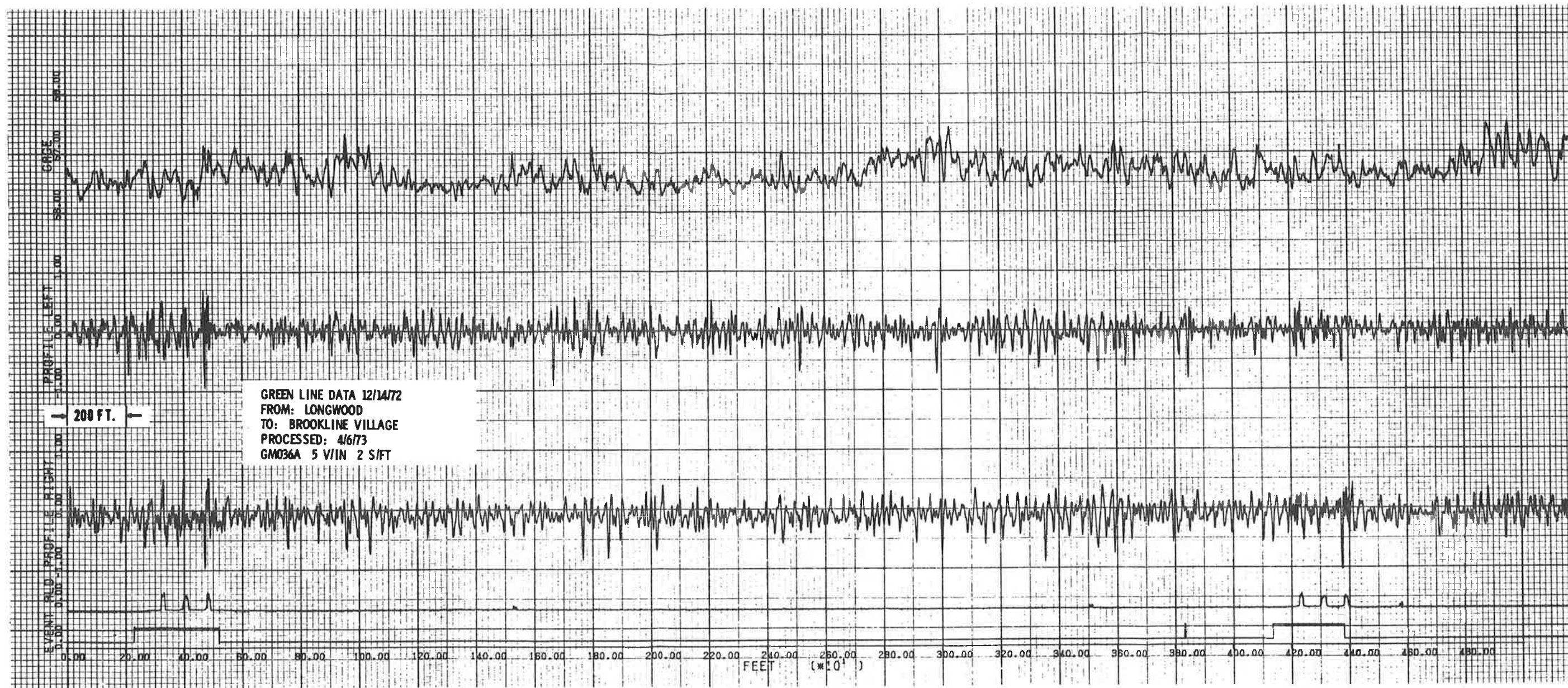


Figure 40. Longwood to  
Brookline Village  
Data



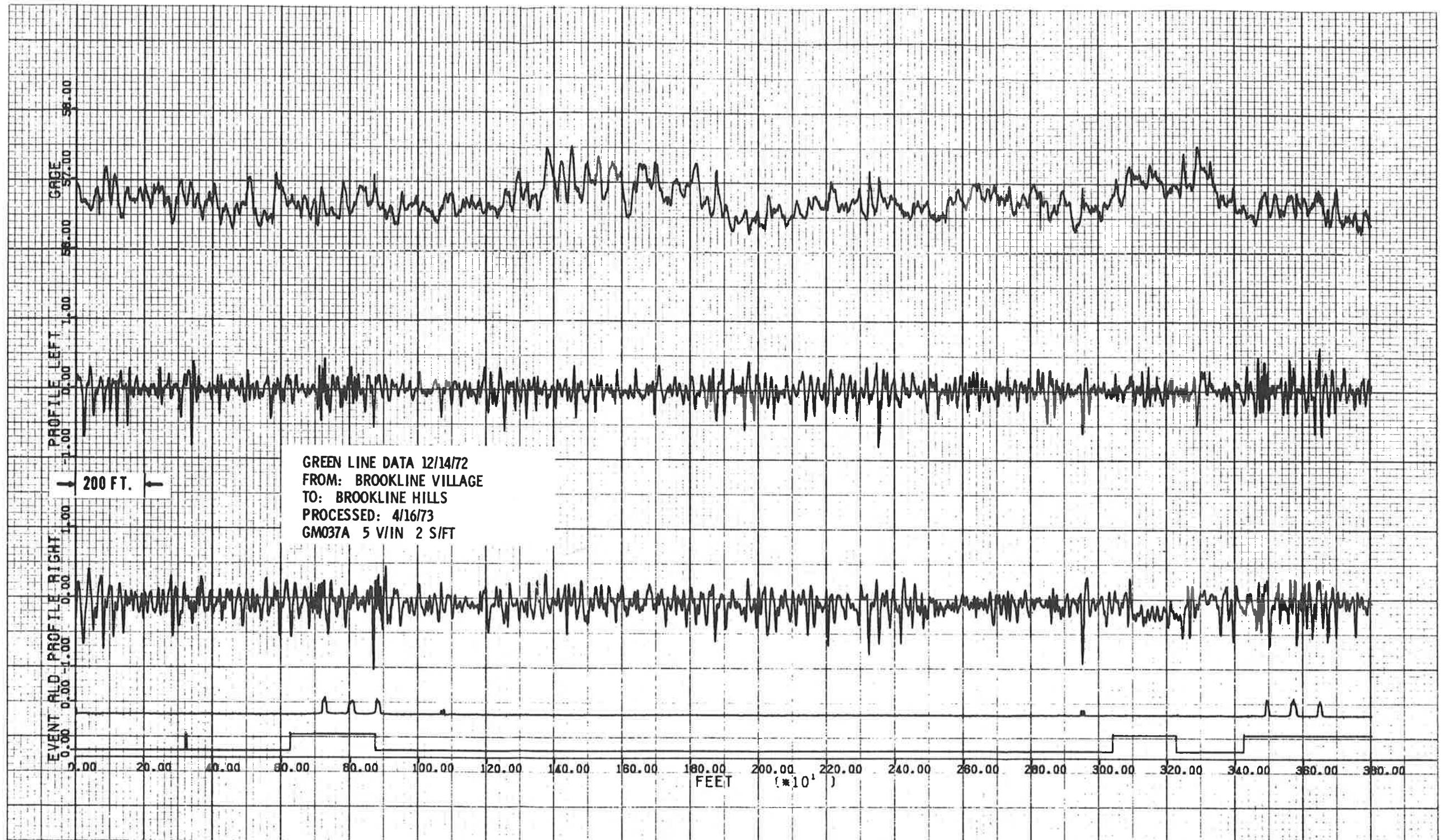


Figure 41. Brookline Village to Brookline Hills Data





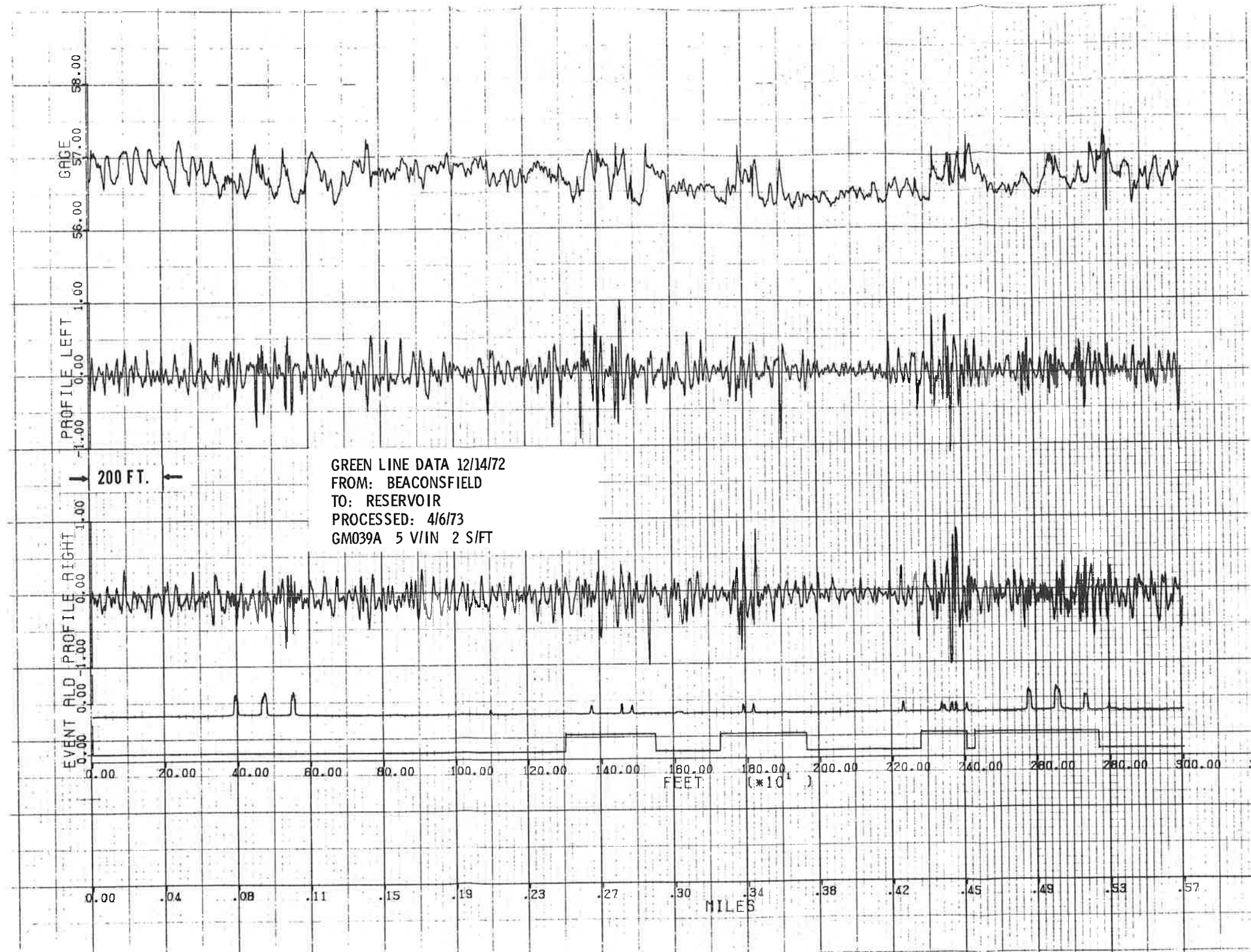


Figure 43. Beaconsfield to Reservoir Data



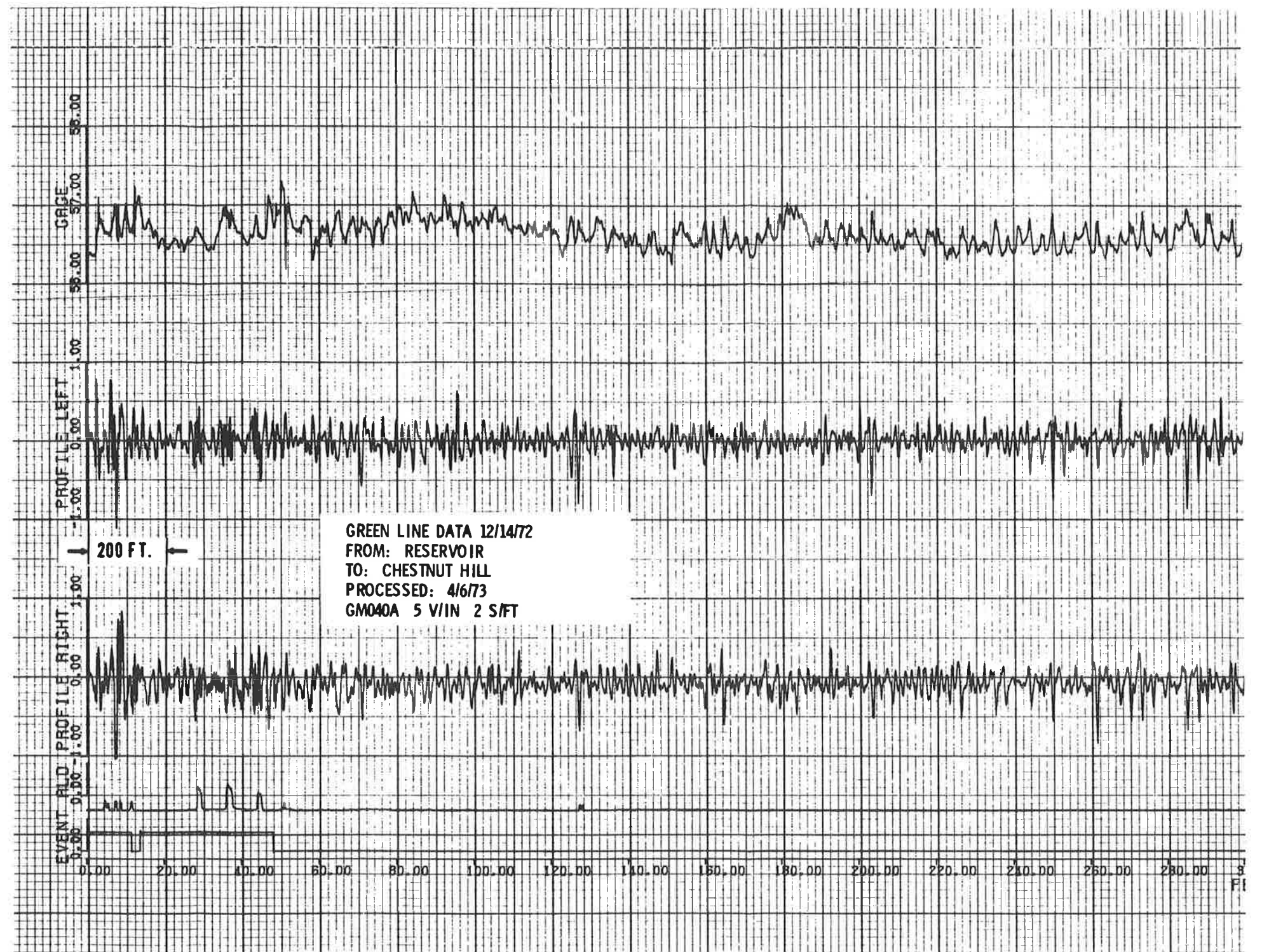


Figure 44. Reservoir to Chestnut Hill Data

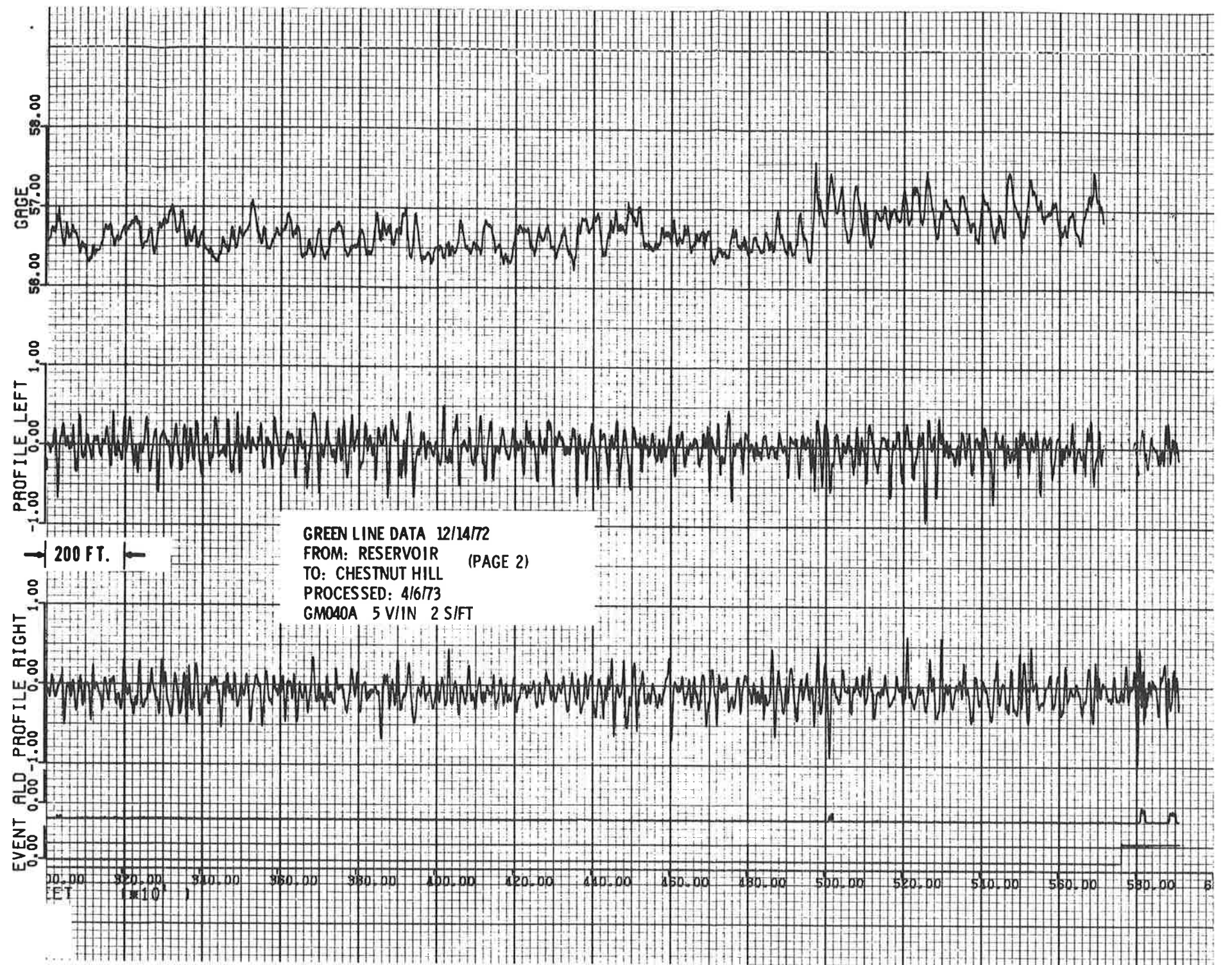


Figure 44. Reservoir to Chestnut Hill Data (cont'd)



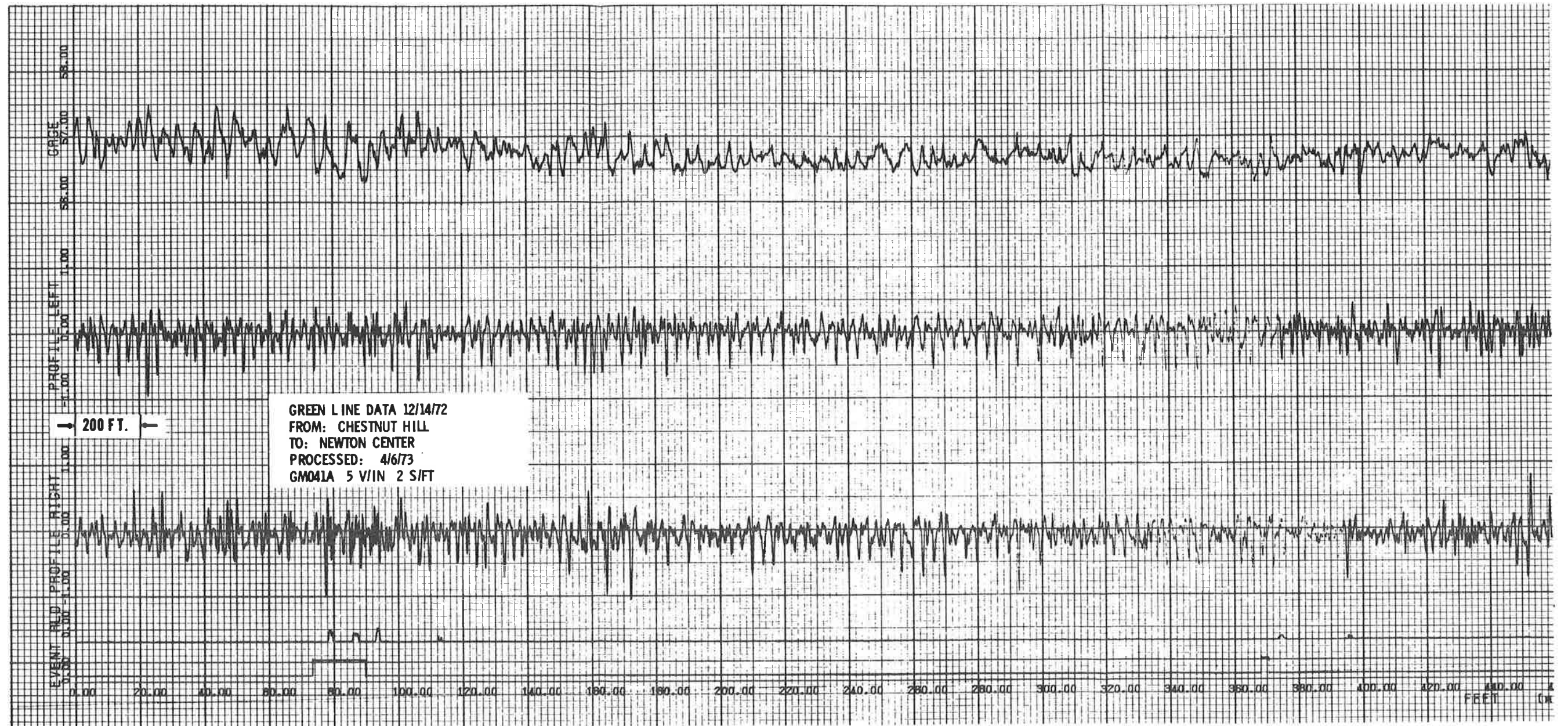


Figure 45. Chestnut Hill to Newton Center Data



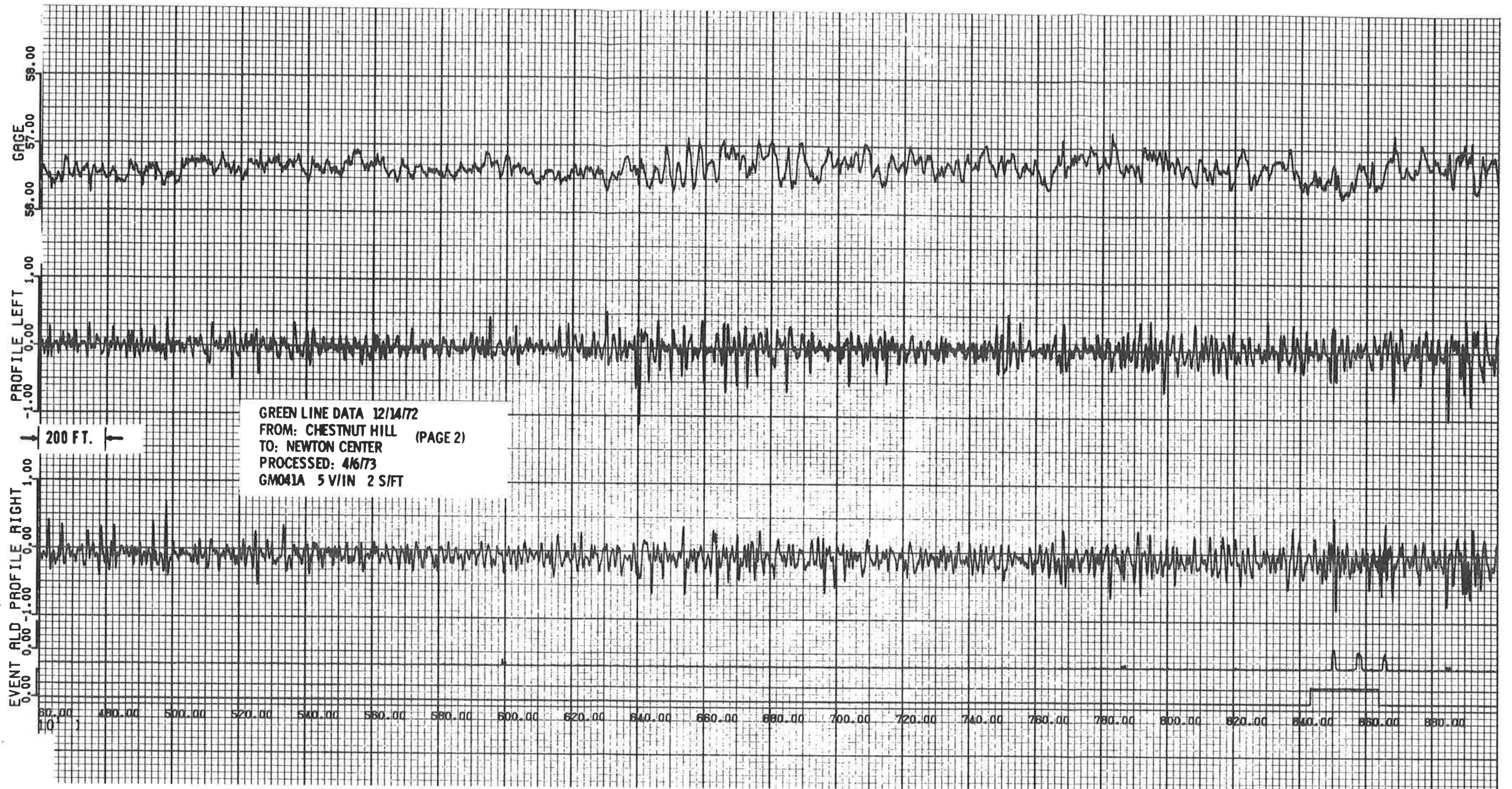


Figure 45. Chestnut Hill to Newton Center Data (cont'd)

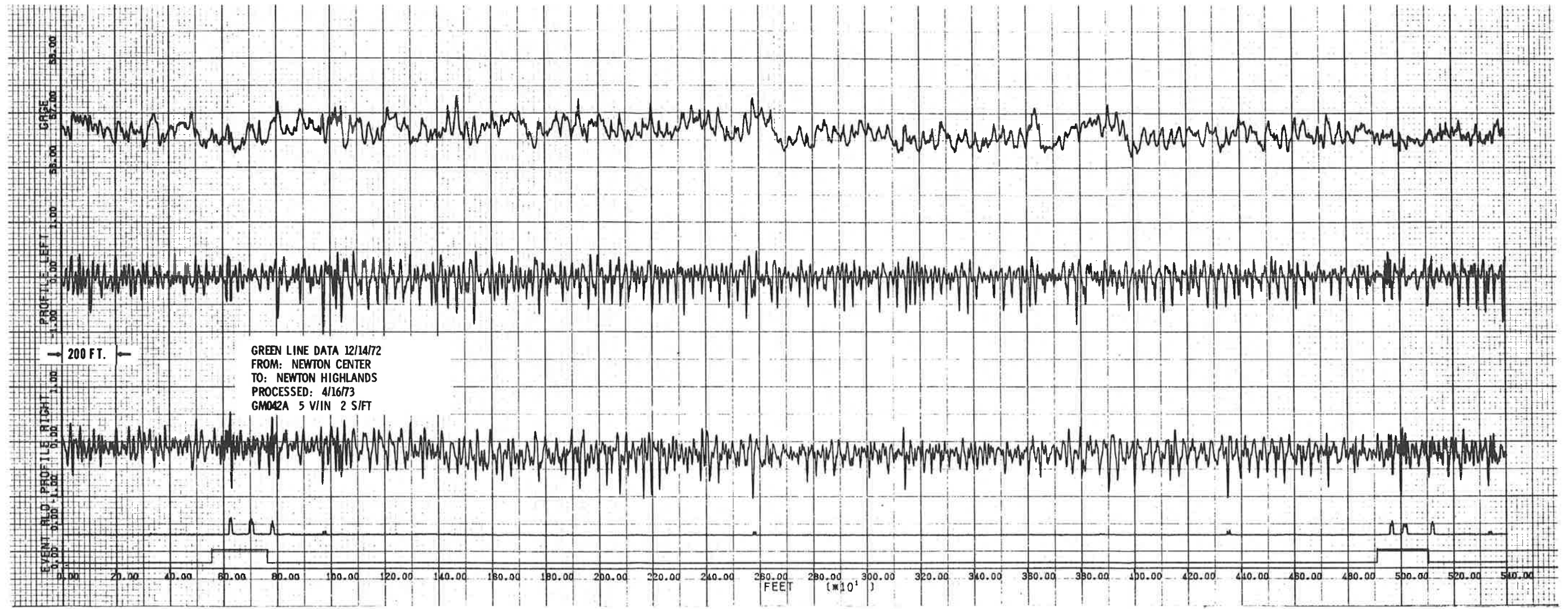


Figure 46. Newton Center to  
 Newton Highlands  
 Data



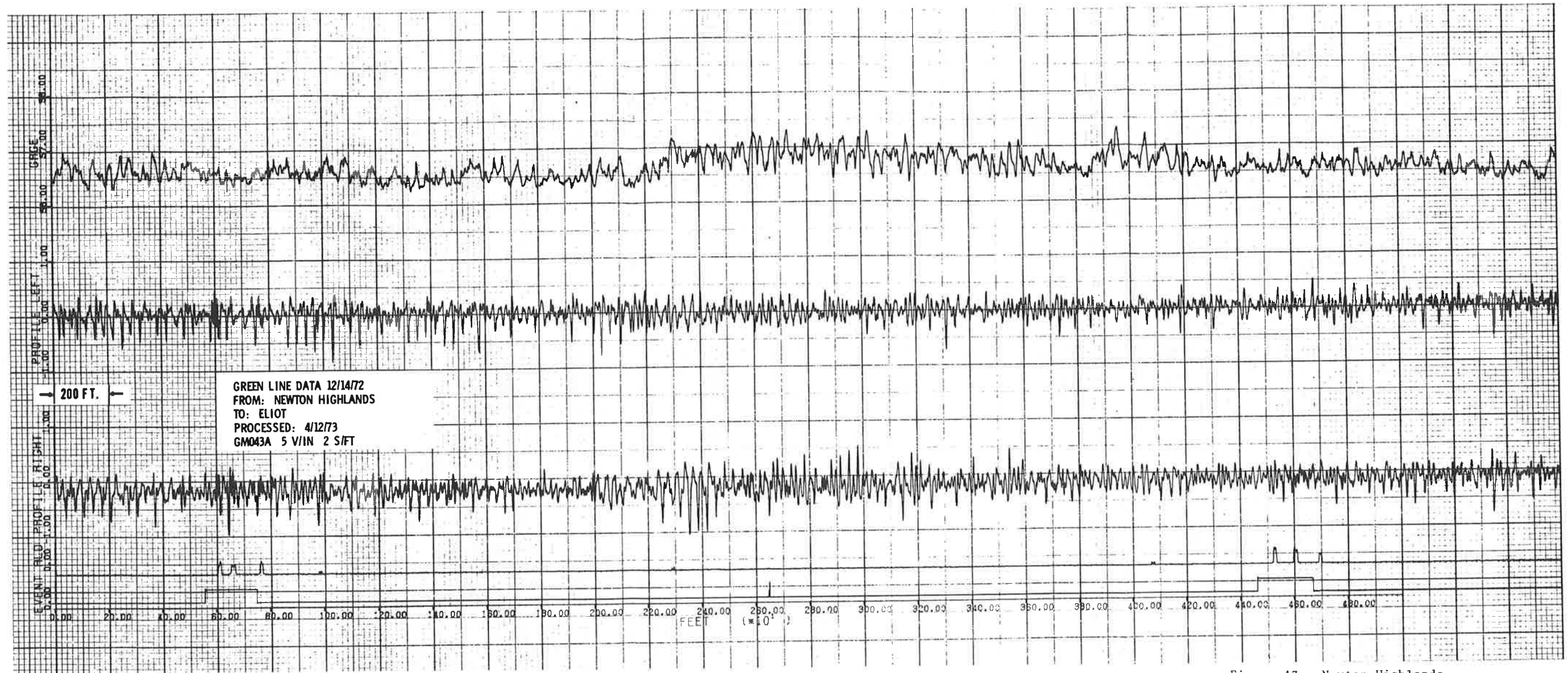


Figure 47. Newton Highlands to Eliot Data



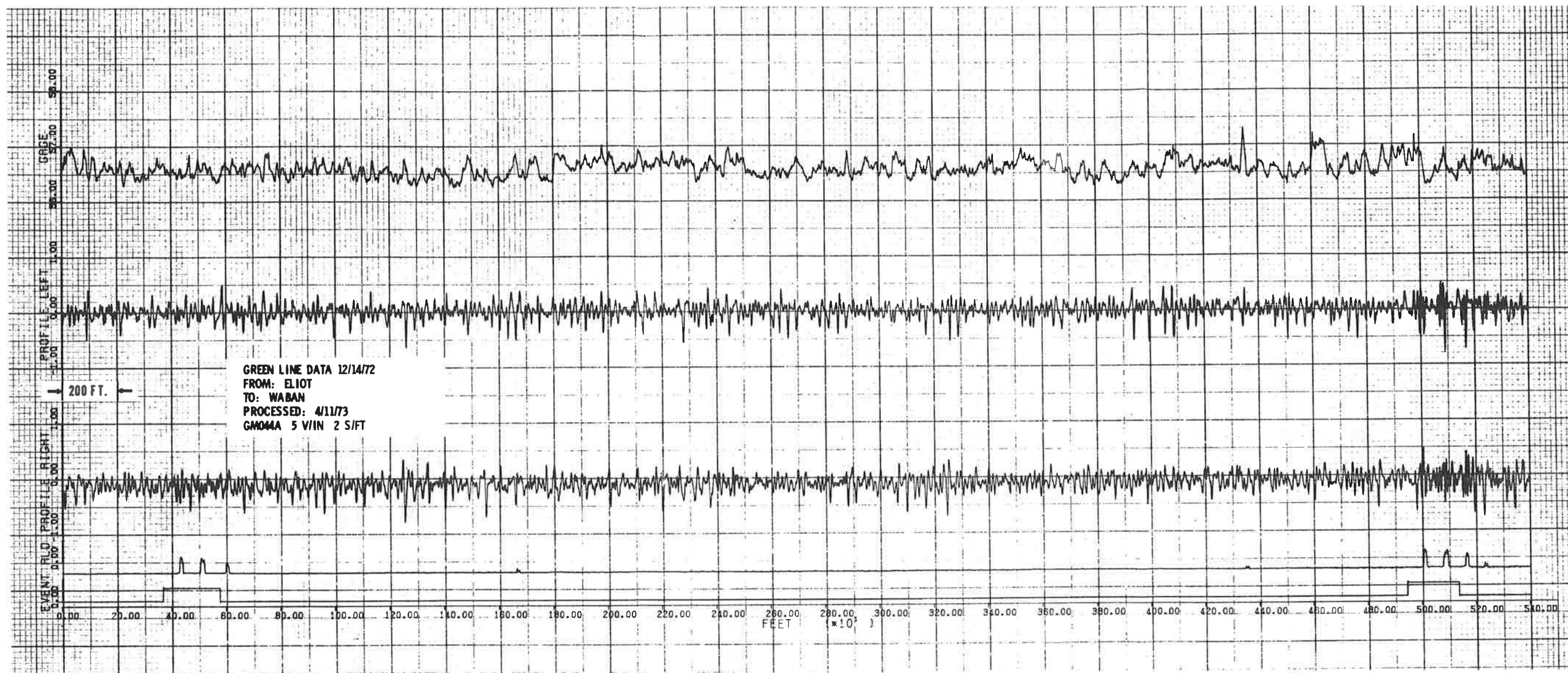


Figure 48. Eliot to Waban Data

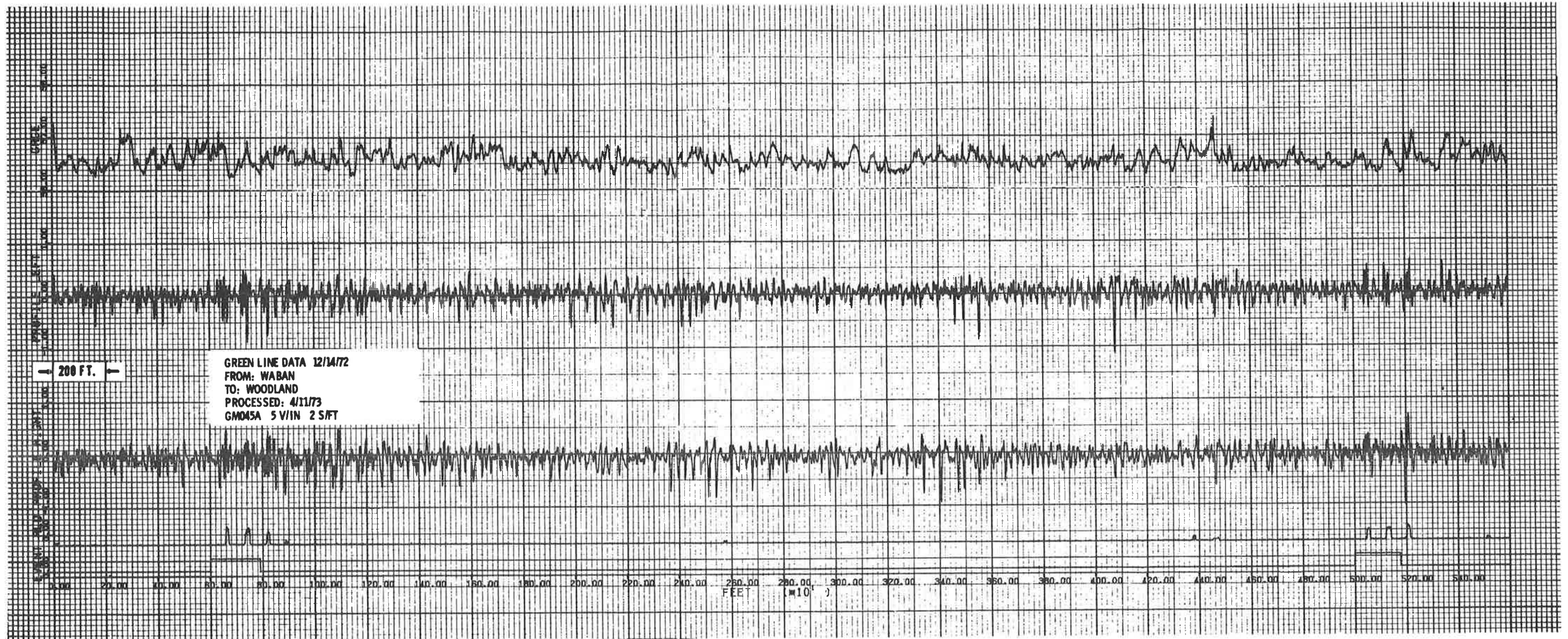


Figure 49. Waban to Woodland Data



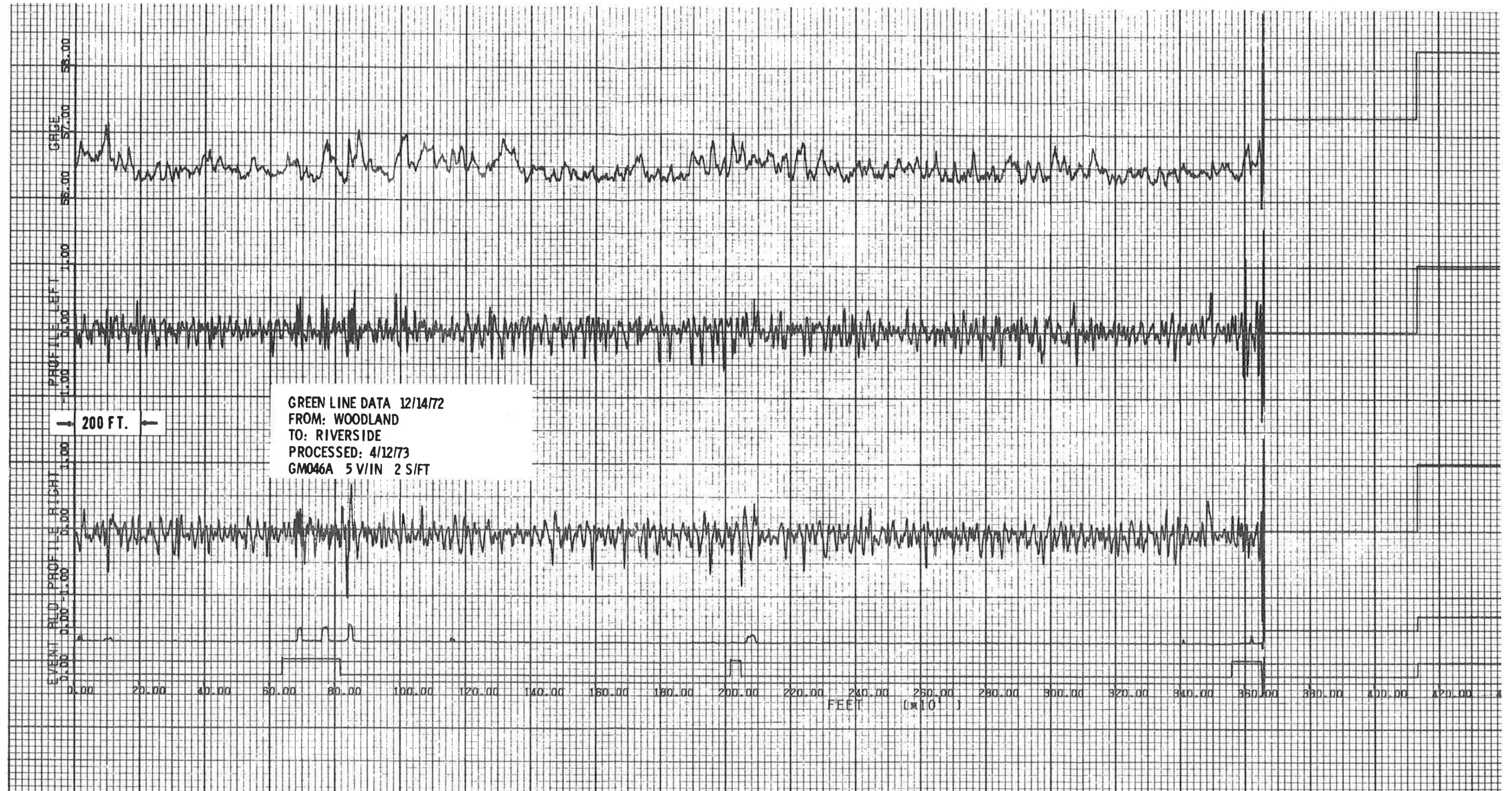


Figure 50. Woodland to Riverside Data



