PAP-817

Analysis of Acoustic Doppler Current Profiler Data Collected Near Tracy Fish Facility, March 24-25, 1999

July 19, 1999

by

Tony L. Wahl

WATER RESOURCES
RESEARCH LABORATORY
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PAP-817

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D-8560
RES-3.50

JUL 22 1999

MEMORANDUM

To: Arthur Glickman, D-8140

From: Tony Wahl
Hydraulic Engineer

Subject: Hydraulic Data Collected in the Vicinity of Tracy Fish Facility, March 24-25, 1999

Please find attached my peer-reviewed report on hydraulic data collected in the vicinity of the Tracy Fish Facility on March 24-25, 1999, using an acoustic Doppler current profiler. This report has been peer reviewed by Tracy Vermeyen, Research Hydraulic Engineer. The report presents velocity, discharge, and channel cross-section data near the fish facility intake and in the Old River channel for a distance of about 1 mile upstream and downstream of the fish facility. In addition to this report, channel cross-section data have been provided in electronic format to Cassie Klumpp, D-8540, for her use in future analyses. If you have questions regarding this report or need additional information, please contact me at 303-445-2155.

TONY L. WAHL

Attachment

cc: D-8540 (Klumpp)

bc: D-8560 (Wahl, file)

WBR:TWahl:rlc:7/20/99:303/445-2155
(j:\wpfiles\wahl\transmit.wpd)

DATE	PEER REVIEWER(S)	CODE
7/19	Signature Tracy B. Vermeyen Printed Name	D-8560
	Signature Printed Name	
Author initials	PEER REVIEW NOT REQUIRED	

Analysis of Acoustic Doppler Current Profiler Data Collected Near Tracy Fish Facility, March 24-25, 1999

Tony L. Wahl, D-8560, July 19, 1999

BACKGROUND

Cassie Klumpp and Kent Collins from the Bureau of Reclamation's Sedimentation and River Hydraulics Group (D-8540) and Tony Wahl from the Water Resources Research Laboratory (WRRL; D-8560) visited the Tracy Fish Facility during the week of March 22-26, 1999 for the purpose of collecting sediment samples, velocity data, and channel cross-section data in the vicinity of the fish facility. This work was performed to support studies of alternatives for future modifications to the facility. This report presents the velocity and channel cross-section data obtained by the WRRL using an acoustic Doppler current profiler (ADCP) on March 24 and 25.

DATA COLLECTION AND ANALYSIS

Data were collected using a 1200-kHz, boat-mounted, broadband ADCP, manufactured by RD Instruments. This particular instrument was borrowed from the U.S. Geological Survey-Biological Resources Division, and is similar to the 300-kHz and 600-kHz units owned by the WRRL. The 1200-kHz instrument has improved depth resolution for shallow-water applications.

The ADCP measures nearly continuous three-dimensional velocity profiles and average channel depth along transect lines traveled by the boat. The instrument uses the Doppler shift principle to measure velocities along four acoustic beams projected downward below the moving boat. The instrument sends out a precise acoustic signal and then listens for backscattered acoustic signals reflected by acoustic scatterers in the water column (e.g., suspended sediment). The Doppler shift of the backscattered signal is proportional to the velocity of the scattering particle. The beams diverge both longitudinally and laterally as shown in figure 1, so that the velocity reported by the instrument is the average of measurements made along each of four different acoustic beams, rather than a measurement at a single point beneath the instrument. Individual velocity measurements are made within discrete vertical depth cells, or bins, configured for a height of 25 centimeters each, yielding a velocity profile from near the surface to near the bed. Velocities cannot be measured very near the surface because the transducer must be submerged and because there is some time delay between the send and receive modes of operation for the instrument. Velocities also cannot be measured very near the bed (approximately the last 10 percent of the depth) due to a phenomenon called side-lobe interference. Three orthogonal components of velocity are measured, and internal compass and tilt sensors allow the velocities to be referenced to the Earth coordinate system (east/north/up). In addition to the velocity data, the ADCP measures the bathymetry along the transect. One ping in each measurement ensemble is also used to track the motion of the ADCP relative to the channel bottom using the same Doppler shift technique used to measure velocity. This measurement allows the water velocity measurements to be corrected for the relative boat motion, and permits tracking of the position of the instrument during the transect. A laptop computer was used to configure the ADCP and collect the data. A portable global positioning system (GPS) was

also connected to the laptop computer so that continuous GPS data were recorded simultaneously with the velocity data. The GPS was also used to record waypoints at the beginning and end of each transect.

The instrument was operated in two configurations, one optimized for best velocity measurement performance (TRA transects) and one optimized for measurement of the channel bottom profile (TRAX transects). Both velocity and channel profile data were obtained in each configuration. The general procedure for data collection was to record a transect in the TRA configuration, then switch to the TRAX configuration and repeat the transect (usually with the boat traveling in the opposite direction). The boat was operated by Wayne Ford of the Tracy Fish Facility staff.

The majority of the transects were collected between about noon and 3:00 p.m. PST on Wednesday March 24, 1999; three additional transects were recorded from 10:00 to 10:15 a.m. on Thursday March 25. Water levels and flow conditions in the vicinity of the fish facility are tidally affected, as shown in figure 2 illustrating the variation of water levels at the fish facility during the periods in which transects were recorded. The transects recorded on March 24 were collected at maximum tide or on the recession of the daily maximum tide. The transects recorded on March 25 were associated with the rising tide preceding the daily maximum. Table A1 in appendix A lists all of the transects and the associated water levels and GPS waypoint information. The integrated discharge across the transect line is also listed in the table. This is computed by the ADCP data-collection software. In steady-state flow situations, these

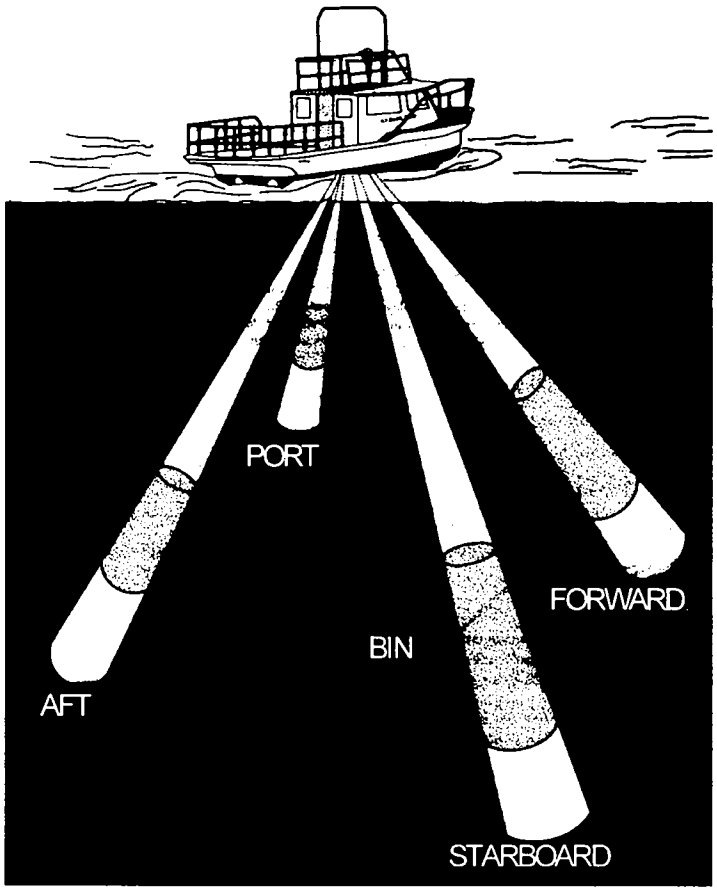


Figure 1. — Typical acoustic beam configuration for a boat-mounted ADCP.

discharge measurements provide a check on the quality of the data if they can be compared to known values from independent measurements of discharge (e.g., pumping rates), but this is not possible in this case due to the tidally-induced transience of the flow conditions.

Transects were run in front of the boom and trashrack structure at the fish facility, in the interconnected channels surrounding the islands upstream (east) of the fish facility intake, and for a distance of about 1 mile upstream and downstream of the fish facility along the Old River channel. Maps of the transect locations are shown in appendix A, along with corresponding maps on which vectors have been plotted to indicate the depth-averaged velocity vectors in the horizontal plane. There are a few anomalous readings visible on the maps (e.g., velocity vectors pointed toward shore, etc.), most often near the ends of the transects, but the majority of the data appear to be very reasonable. A dot on each transect line indicates the end at which the total distance traveled along the transect is zero in the accompanying cross-section plots contained in appendix B. These dots do not necessarily indicate the physical starting point of the transect; some transects were processed in reverse-order from the direction in which they were recorded so as to orient all cross-section plots to present a view looking downstream (toward Clifton Court Forebay).

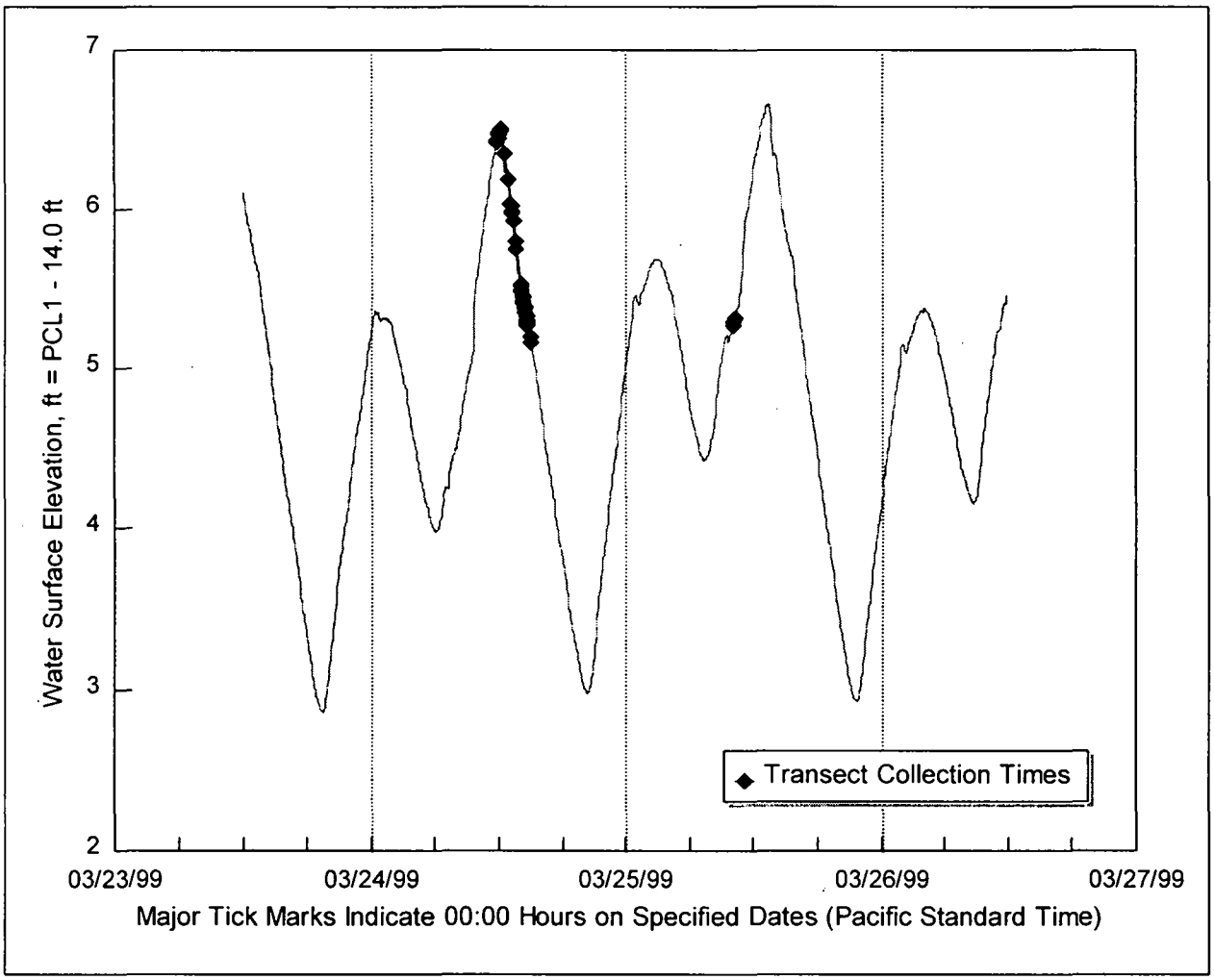


Figure 3. — Water levels recorded at the Tracy Fish Facility during collection of ADCP transects.

The map of depth-averaged velocities for the TRA transects illustrates the variation in flow conditions that occurred during the data collection on March 24. Transects TRAX003-TRAX007 were recorded between 11:50 a.m. and 12:10 p.m. (very near maximum tide) in the Old River reach between Clifton Court forebay and the junction of Old River, Grant Line, and Fabian and Bell Canals. Depth-averaged velocities of about 1.5 to 2 ft/s were measured, directed southward toward the fish facility intake. In contrast, transect TRAX019 was recorded beginning at 3:03 p.m., about 3 hours after maximum tide. This transect followed the Old River channel, beginning about 1 mile upstream (southeast) of the fish facility, and ending near the Clifton Court Forebay. Where transect TRAX019 crosses the paths of TRAX003-TRAX007, the figure shows that velocities had reversed due to the falling tide and were now directed northward, away from the fish facility with a magnitude of about 1 ft/s.

Approximate locations of channel boundaries and fish facility features are indicated on the maps in appendix A. These features were located on the maps by digitizing them as a group from the 7.5-minute USGS quadrangle map of the area (Clifton Court Forebay, Calif., 1978), and then manually fitting the digitized map to the collection of mapped transects. An attempt was made to directly correlate the transect locations (mapped by the GPS to coordinates in UTM/UPS Zone 10S, WGS-84 datum) to the corresponding UTM grid ticks shown on the quadrangle map, but this yielded a misalignment error of about 1100 ft between the transect locations and the known physical features at the site. The reason for this misalignment is not known. All GPS measurements were corrected for the magnetic declination at the site (15.45° east).

Plots of channel cross-section shapes for both the TRA and TRAX series of transects are contained in appendix B. The TRAX series should provide the most accurate representation of the channel geometry, but cross-sections for the TRA series of transects are also presented because some of the TRA transects do not have corresponding TRAX transects in close proximity. Bed elevations were computed by subtracting the average depth measured by the ADCP from the known water surface elevation at the fish facility. For those transects located a significant distance from the fish facility, no attempt was made to adjust for water surface slope in these calculations; i.e., the water surface was assumed to be level. The average depth measured by the ADCP is corrected for the submergence depth of the acoustic transducers, which was measured after the ADCP was installed on the boat and provided as an input to the transect-collection software. Cross-section plots do not carry completely to the banks due to the inability of the ADCP to measure very shallow depths, and the fact that is was difficult to manuever the boat very close to shore. The cross-section data have also been provided to D-8540 in spreadsheet format for future use. This spreadsheet also contains a column providing the magnitude of the velocity in the horizontal plane at each point along the transect lines (the same velocity as that plotted in the maps in appendix A).

Appendix C contains plots of velocity profiles for each of the TRA transects. The TRAX transect velocities were not plotted in this manner, although this information is available and similar plots could be produced should they be needed. The plots show total velocity magnitudes; velocity direction can be determined from the maps in appendix A. Maximum velocities for transects in the Old River channel and close to the fish facility intake were in the range of 2 to 2.25 ft/s. In the side channels around Hammer and Middleton Islands, maximum velocities were in the range of 1 ft/s.

APPENDIX A

TRANSECT SUMMARY INFORMATION AND MAPS

Table A1. - Transect Summary

D:\TRACY\TRANSUM WK4

Velocity Transects (TRA) — UTM/UPS Zone 10S coordinates, WGS-84 datum

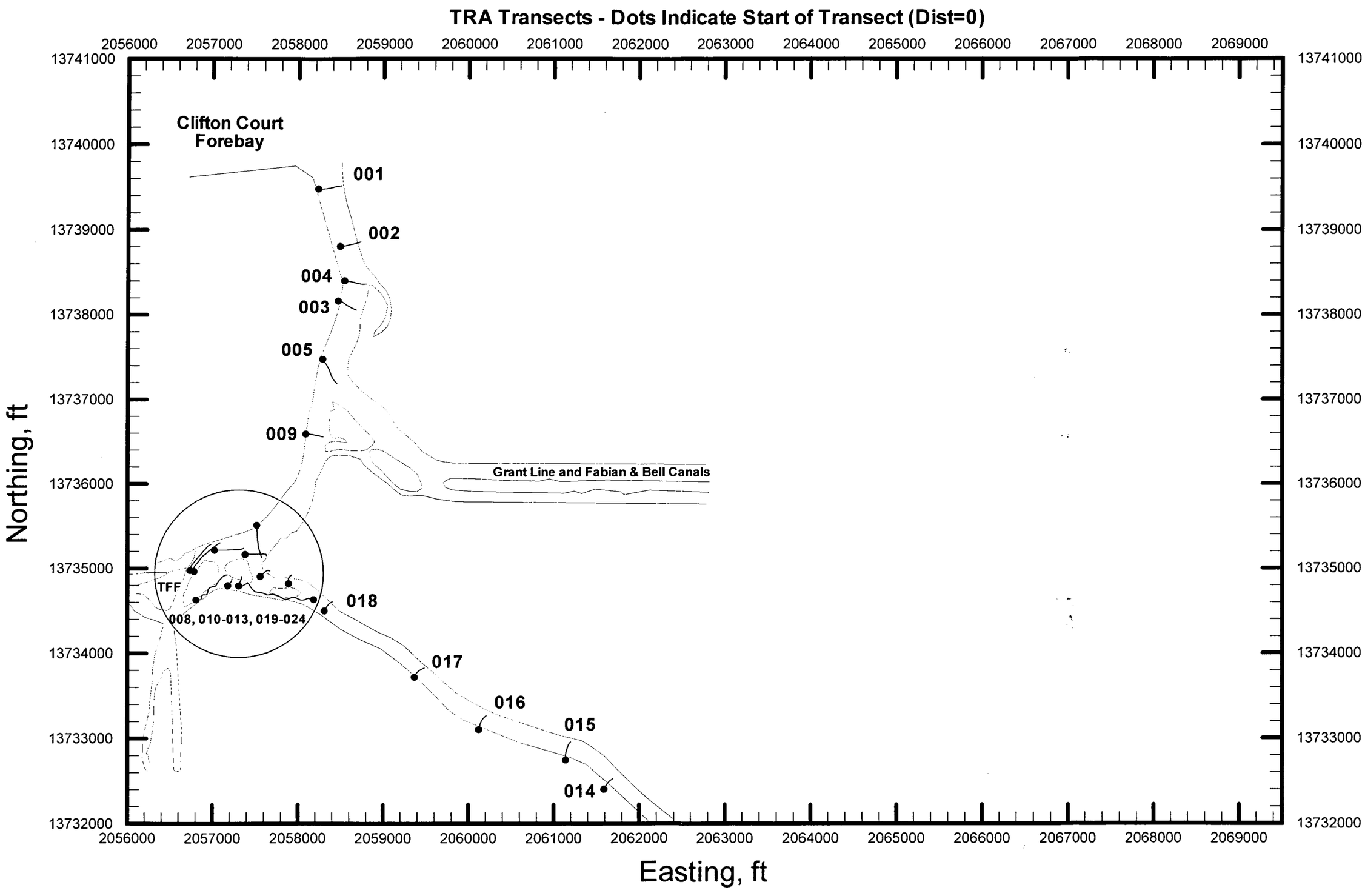
Transect ID	Date	Time (PST)	W. S. Elev., ft	Initial Waypoint Waypoint ID	Initial Waypoint Easting, ft	Initial Waypoint Northing, ft	Ending Waypoint Waypoint ID	Ending Waypoint Easting, ft	Ending Waypoint Northing, ft	Measured Discharge, cfs	Corresponding TRAX Transect
TRA001	03/24/99	11:55 AM	6.452	10	2058228.3	13739481.6	11	2058520.3	13739540.7	8103	TRAX003/004
TRA002	03/24/99	11:58 AM	6.468	12	2058487.5	13738805.8	13	2058743.4	13738868.1	7358	TRAX005
TRA003	03/24/99	12:04 PM	6.489	16	2058464.6	13738162.7	17	2058704.1	13738070.9	7142	TRAX006
TRA004	03/24/99	12:08 PM	6.500	20	2058540.0	13738402.2	21	2058815.6	13738372.7	6476	TRAX007
TRA005	03/24/99	12:55 PM	6.185	28	2058284.1	13737477.0	29	2058477.7	13737175.2	2445	TRAX008
TRA008	03/24/99	01:07 PM	6.038	32	2056735.6	13734977.0	33	2056994.8	13735295.3	-3666	
TRA009	03/24/99	01:17 PM	5.988	37	2058087.3	13736591.2	38	2058303.8	13736558.4	1874	TRAX009
TRA010	03/24/99	01:18 PM	5.979	39	2057516.4	13735511.8	40	2057595.1	13735118.1	1385	TRAX010
TRA011	03/24/99	01:32 PM	5.808	43	2056807.7	13734629.3	44	2057155.5	13734918.0	-265	
TRA012	03/24/99	01:36 PM	5.756	45	2057336.0	13734908.1	46	2057306.4	13734780.2	432	
TRA013	03/24/99	02:05 PM	5.529	47	2057365.5	13735239.5	48	2056984.9	13735193.6	26	
TRA014	03/24/99	02:07 PM	5.519	49	2061696.2	13732526.2	50	2061584.6	13732388.5	2467	TRAX011
TRA015	03/24/99	02:12 PM	5.490	53	2061200.8	13732959.3	54	2061148.3	13732736.2	2524	TRAX012
TRA016	03/24/99	02:18 PM	5.450	57	2060210.0	13733267.7	58	2060098.4	13733087.3	2567	TRAX013
TRA017	03/24/99	02:24 PM	5.412	61	2059484.9	13733828.7	62	2059347.1	13733707.3	2484	TRAX014
TRA018	03/24/99	02:30 PM	5.374	65	2058405.5	13734606.3	66	2058290.7	13734484.9	2220	TRAX015
TRA019	03/24/99	02:36 PM	5.337	69	2057926.5	13734921.3	70	2057880.6	13734813.0	1592	TRAX016
TRA020	03/24/99	02:42 PM	5.299	73	2057670.6	13734970.5	74	2057516.4	13734881.9	1654	TRAX017
TRA021	03/24/99	02:46 PM	5.274	77	2057631.2	13735150.9	78	2057352.4	13735147.6	1950	TRAX018
TRA022	03/25/99	10:04 AM	5.277	89	2058182.4	13734632.5	90	2057299.9	13734767.1	-268	
TRA023	03/25/99	10:08 AM	5.293	91	2057178.5	13734796.6	92	2057250.7	13734895.0	-108	
TRA024	03/25/99	10:16 AM	5.317	93	2056784.8	13734963.9	94	2057044.0	13735383.9	-4212	

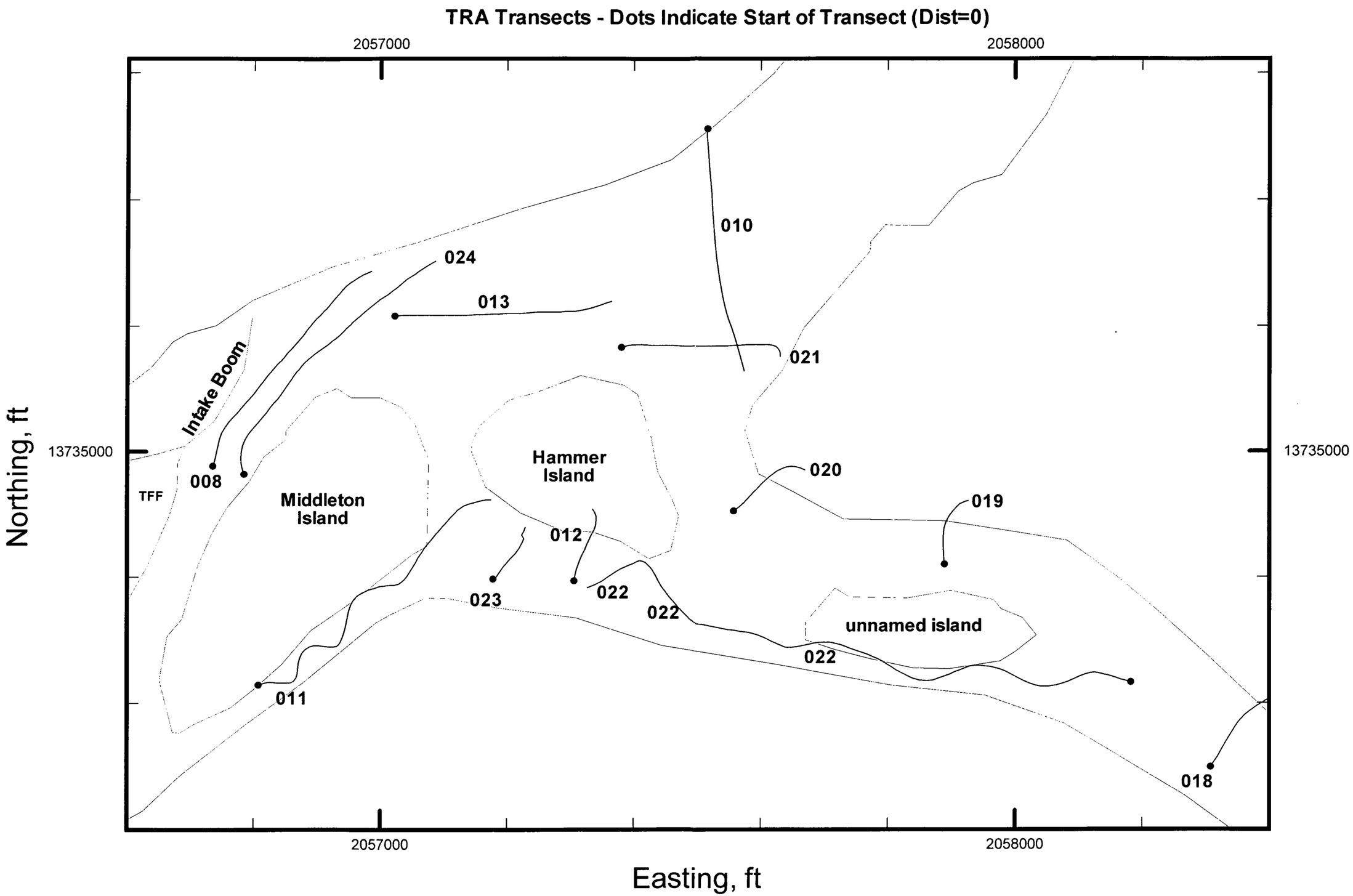
Bottom-Profile Transects (TRAX) — UTM/UPS Zone 10S coordinates, WGS-84 datum

Transect ID	Date	Time (PST)	W. S. Elev., ft	Initial Waypoint Waypoint ID	Initial Waypoint Easting, ft	Initial Waypoint Northing, ft	Ending Waypoint Waypoint ID	Ending Waypoint Easting, ft	Ending Waypoint Northing, ft	Measured Discharge, cfs	Corresponding TRA Transect
TRAX003	03/24/99	11:50 AM	6.431	6	2058520.3	13739534.1	7	2058231.6	13739491.5	-7901	TRA001
TRAX004	03/24/99	11:52 AM	6.440	8	2058520.3	13739560.4	9	2058231.6	13739494.8	-7763	TRA001
TRAX005	03/24/99	12:00 PM	6.479	14	2058736.9	13738828.7	15	2058454.7	13738789.4	-6909	TRA002
TRAX006	03/24/99	12:07 PM	6.496	18	2058684.4	13738080.7	19	2058458.0	13738169.3	-6425	TRA003
TRAX007	03/24/99	12:10 PM	6.506	22	2058802.5	13738392.4	23	2058526.9	13738399.0	-6234	TRA004
TRAX008	03/24/99	12:27 PM	6.357	26	2058484.3	13737191.6	27	2058264.4	13737490.2	-2290	TRA005
TRAX009	03/24/99	01:11 PM	6.023	35	2058287.4	13736568.2	36	2058077.4	13736604.3	-1480	TRA009
TRAX010	03/24/99	01:22 PM	5.936	41	2057595.1	13735121.4	42	2057480.3	13735505.2	-1293	TRA010
TRAX011	03/24/99	02:11 PM	5.497	51	2061607.6	13732395.0	52	2061706.0	13732536.1	-2375	TRA014
TRAX012	03/24/99	02:16 PM	5.463	55	2061154.9	13732755.9	56	2061213.9	13732969.2	-2342	TRA015
TRAX013	03/24/99	02:21 PM	5.431	59	2060131.2	13733093.8	60	2060183.7	13733280.8	-2076	TRA016
TRAX014	03/24/99	02:28 PM	5.387	63	2059373.4	13733713.9	64	2059484.9	13733845.1	-2131	TRA017
TRAX015	03/24/99	02:32 PM	5.362	67	2058326.8	13734501.3	68	2058418.6	13734622.7	-1961	TRA018
TRAX016	03/24/99	02:40 PM	5.311	71	2057874.0	13734803.1	72	2057916.7	13734950.8	-1632	TRA019
TRAX017	03/24/99	02:44 PM	5.286	75	2057519.7	13734872.0	76	2057647.6	13734996.7	-1902	TRA020
TRAX018	03/24/99	02:57 PM	5.204	79	2057381.9	13735150.9	80	2057641.1	13735157.5	-1391	TRA021
TRAX019	03/24/99	03:03 PM	5.166	81	2059291.3	13733927.2	82	2058038.1	13740469.2	-222	

Signs on discharge values are positive for flows that cross from left to right when looking from the start of the transect line toward the finish of the transect line. Signs are negative when flows cross from right to left beneath the transect line.

Frame 001 : 19 Jul 1999 : TRA BOTTOM PROFILE




TRA Transects - Dots Indicate Start of Transect (Dist=0)
2057000
2058000
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13735000
Northing, ft
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Intake Boom
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Hammer Island
unnamed island
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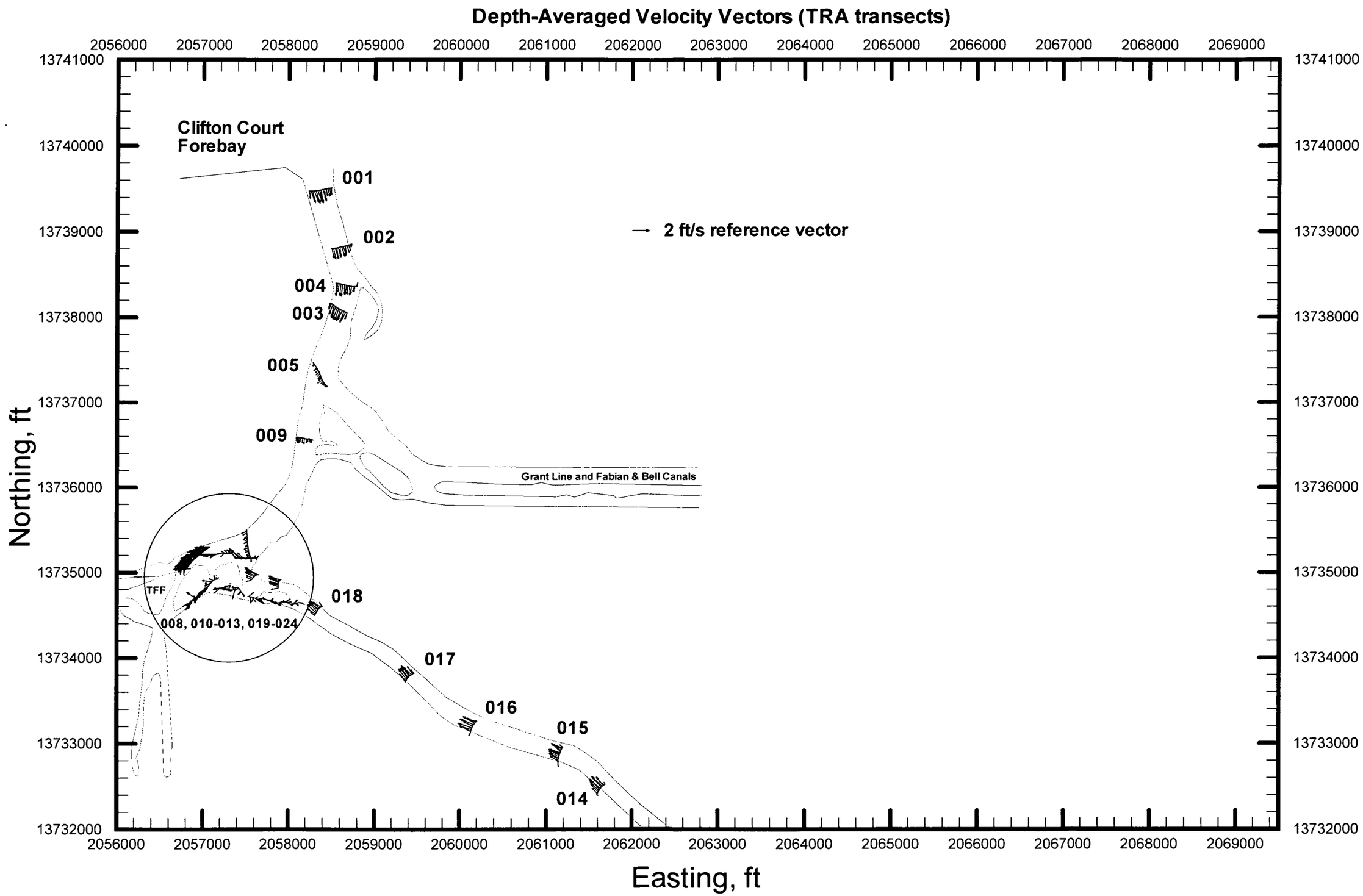

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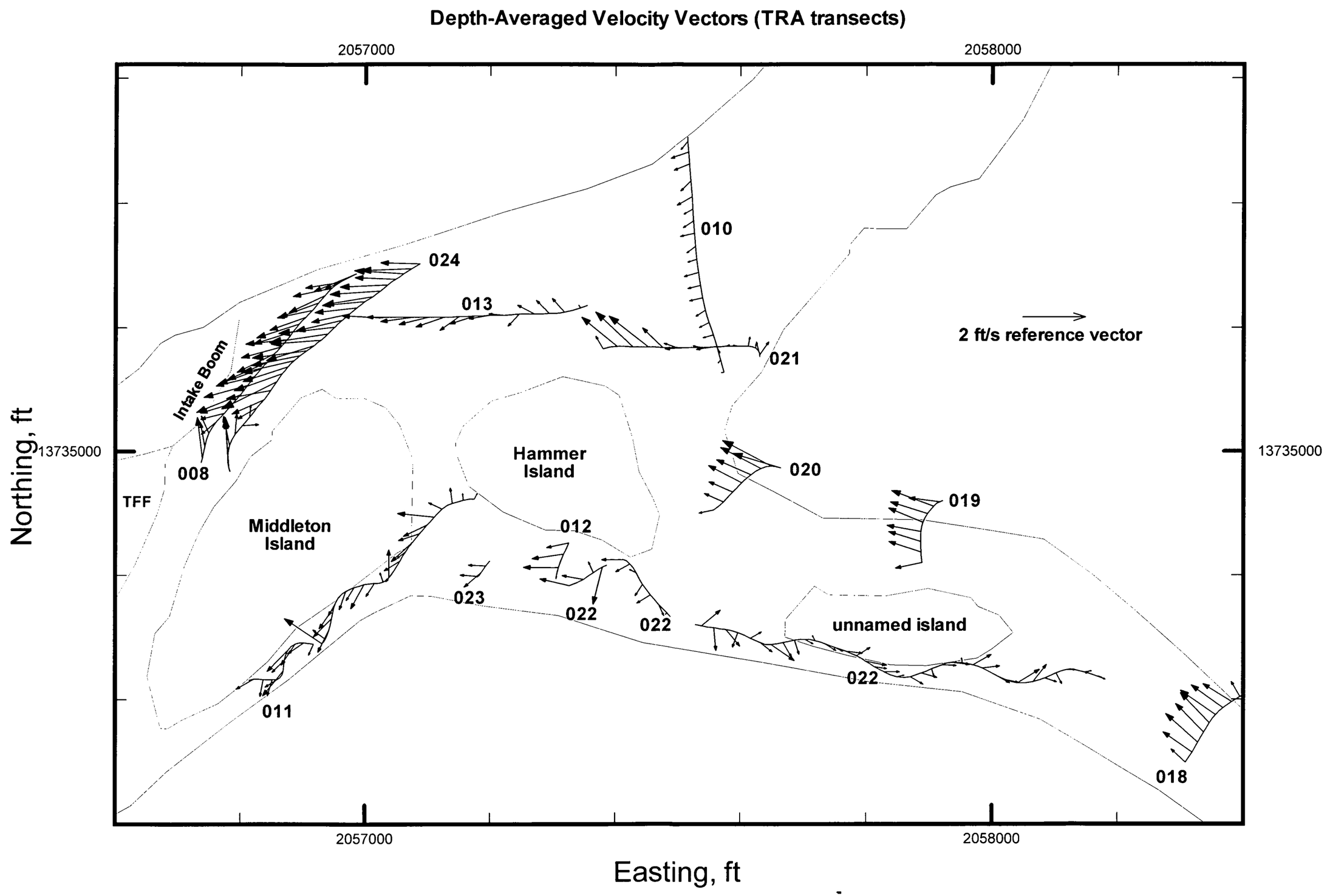

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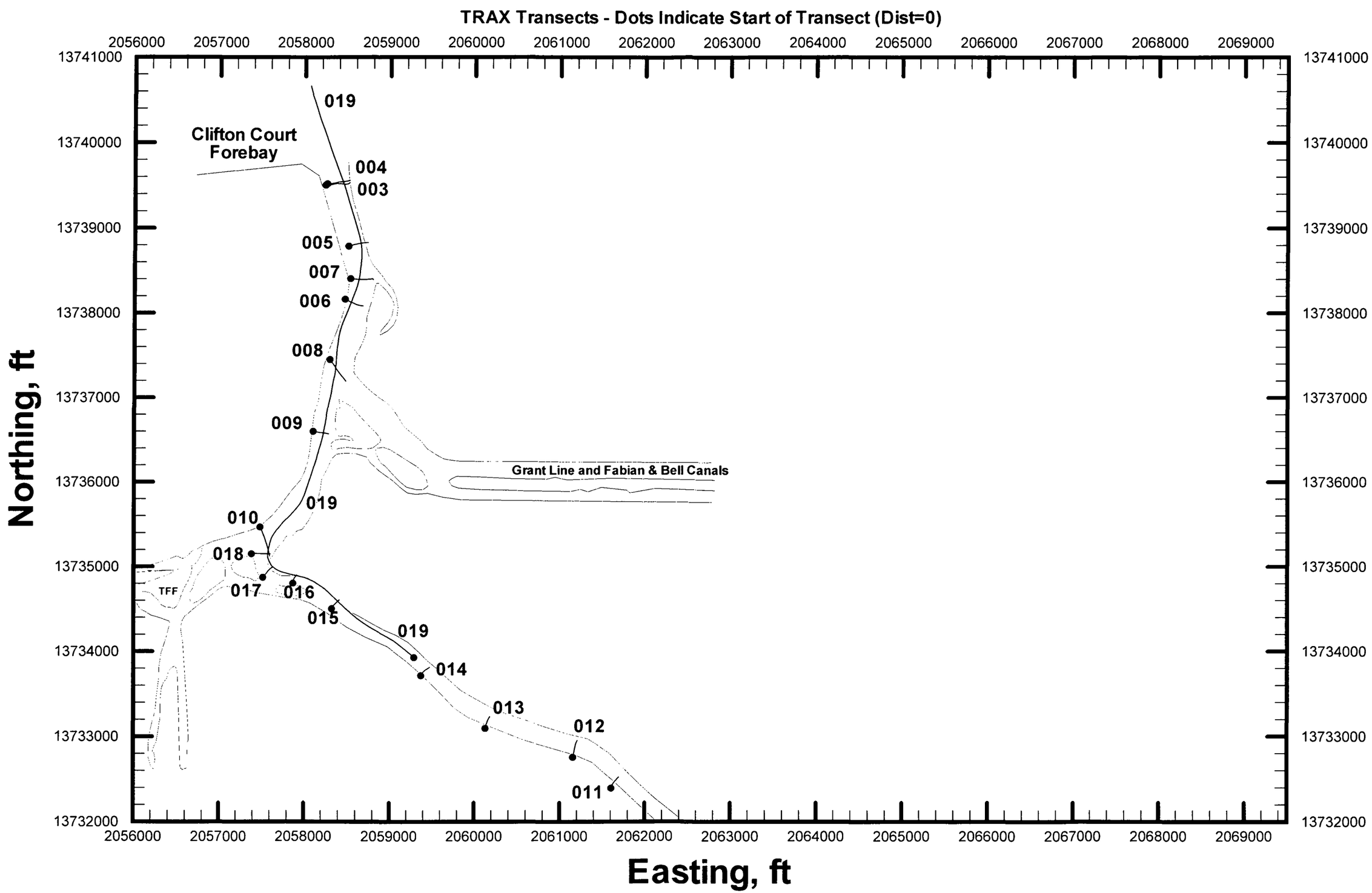

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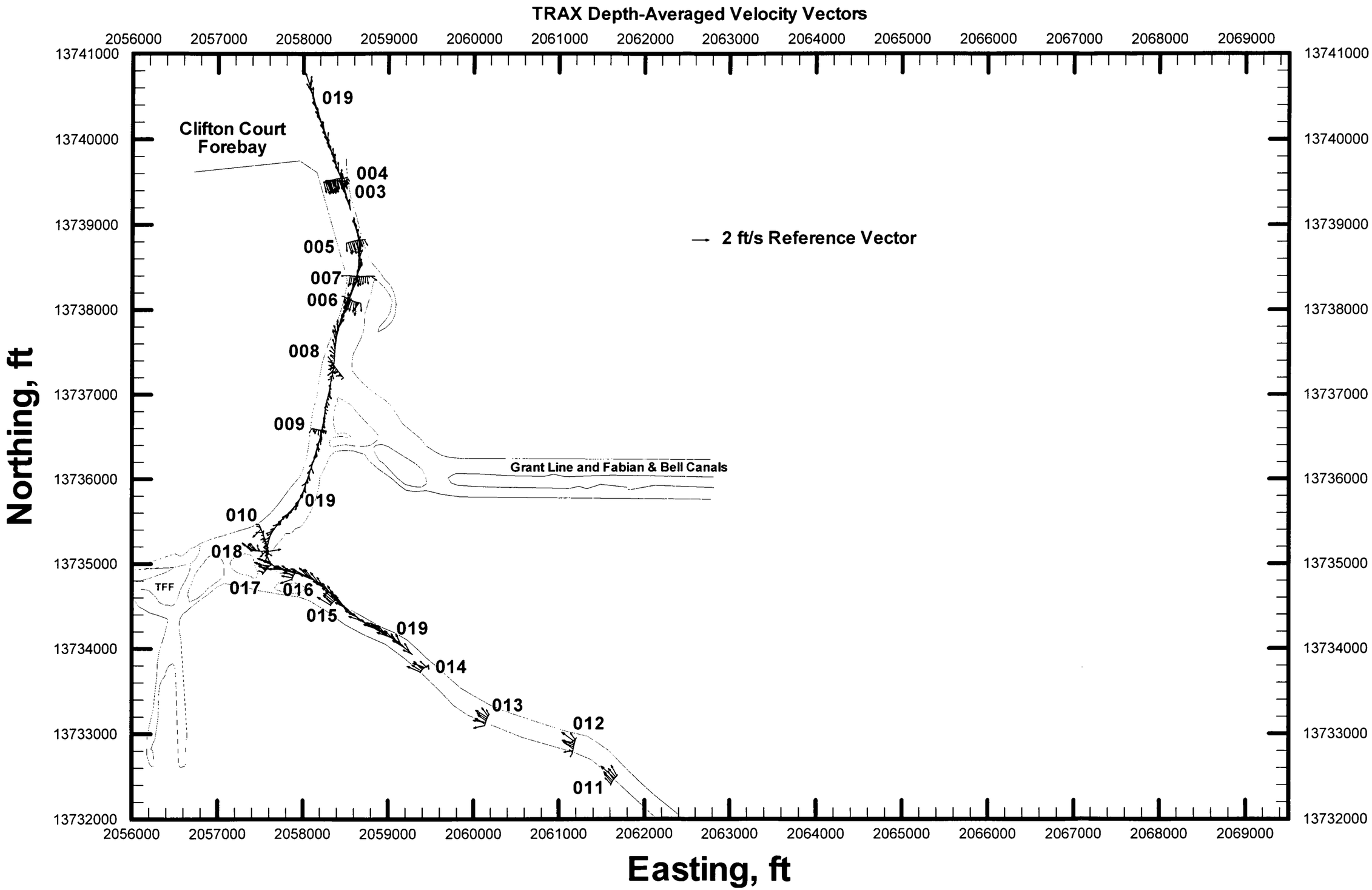

APPENDIX B

CROSS-SECTION PLOTS

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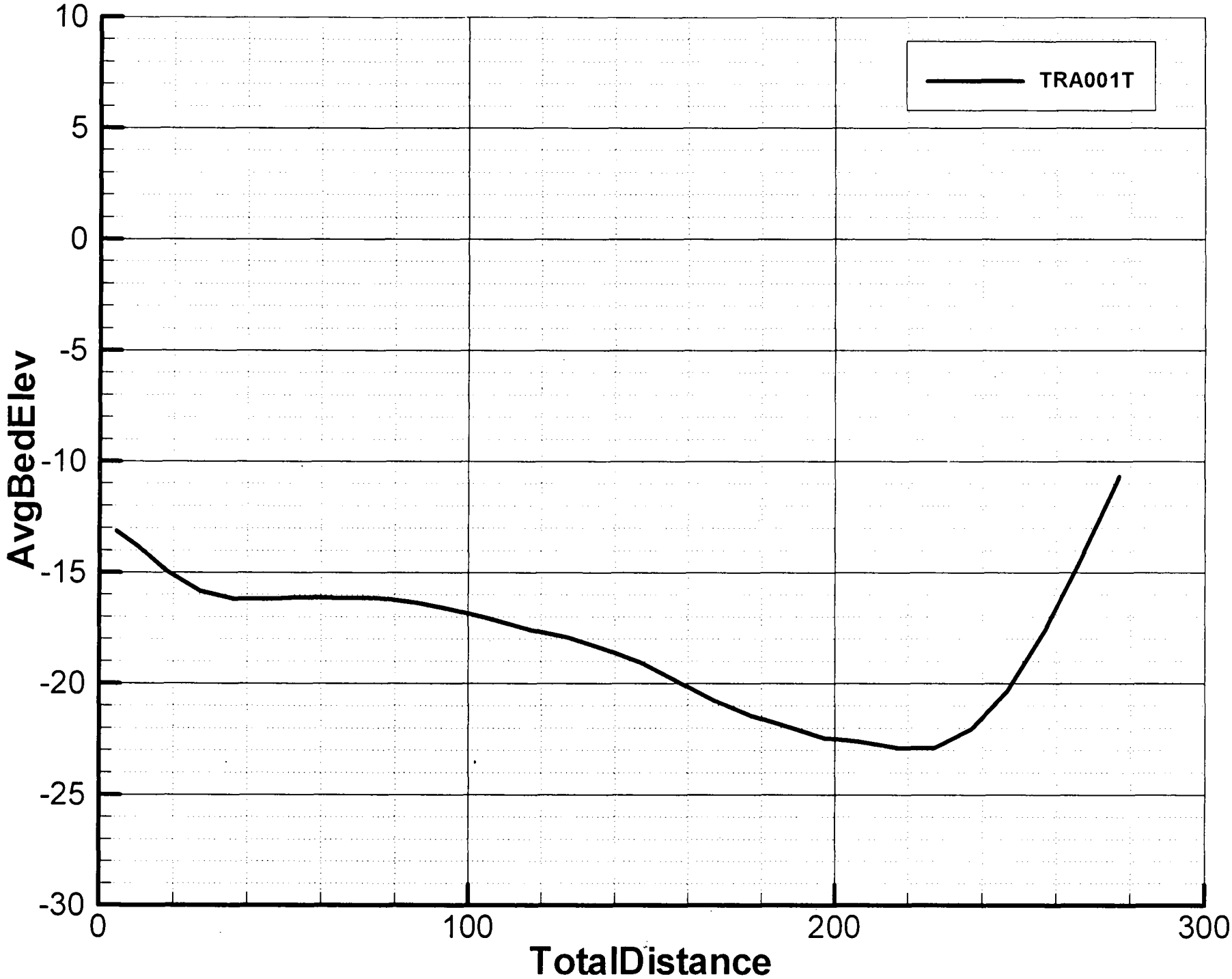

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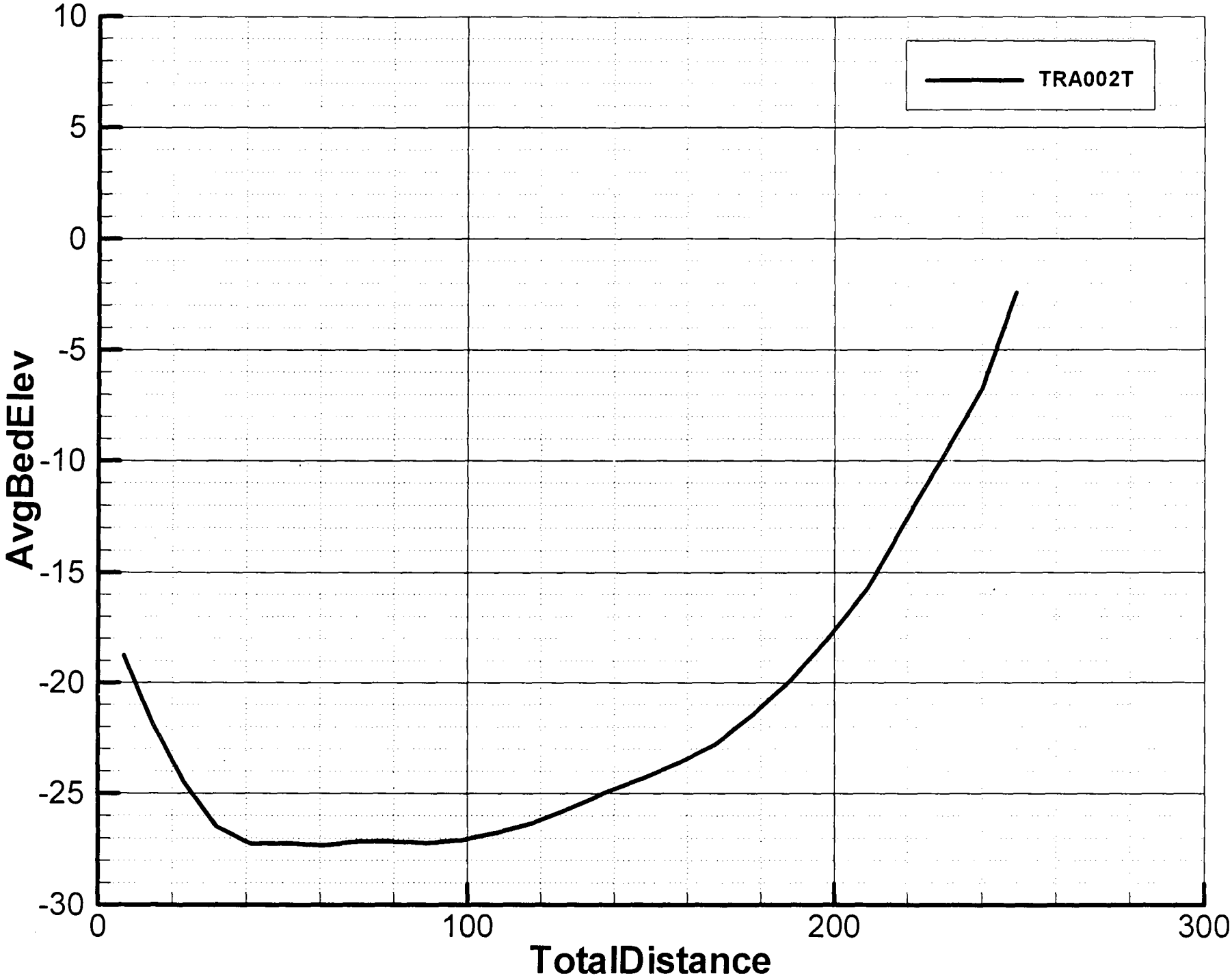

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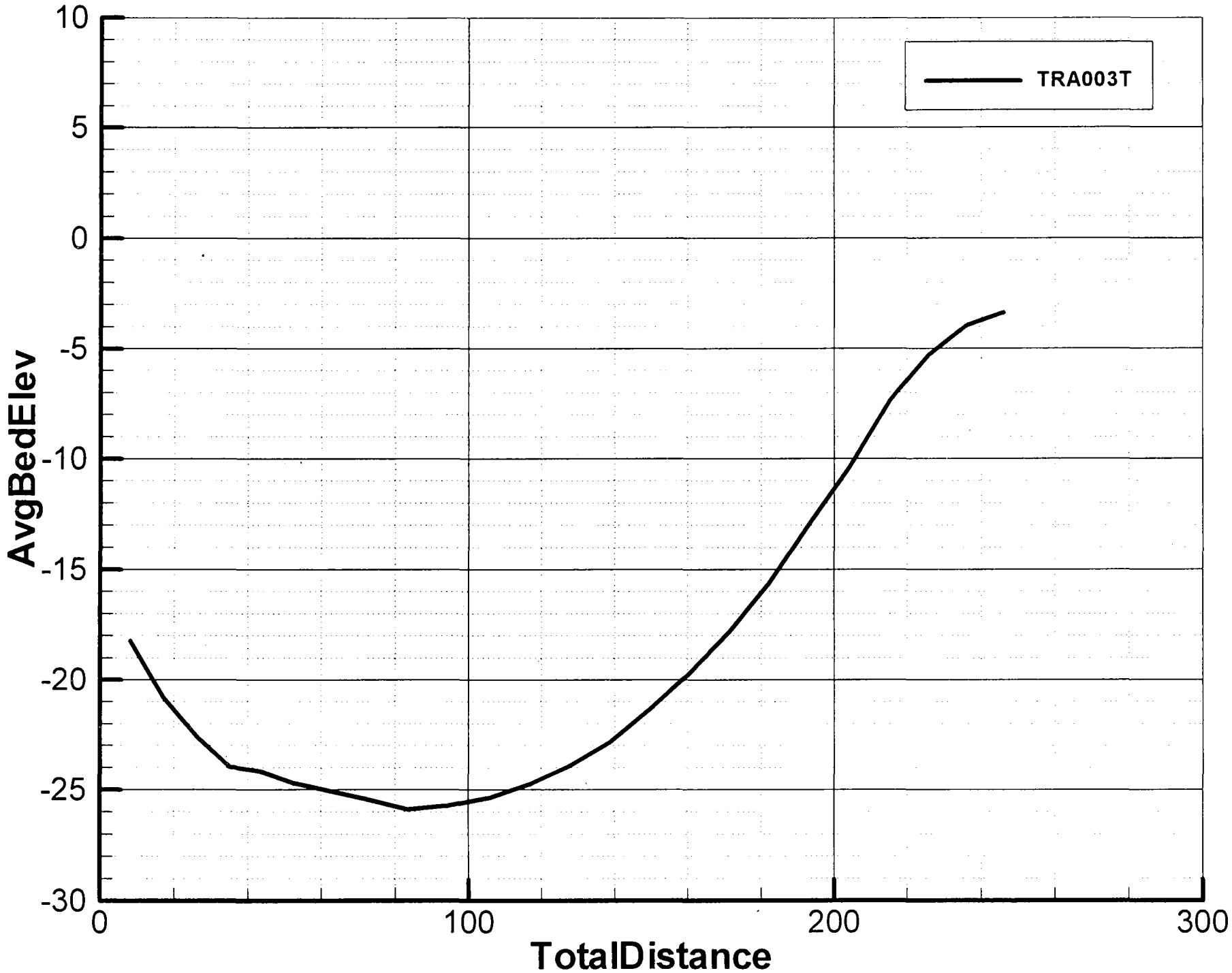

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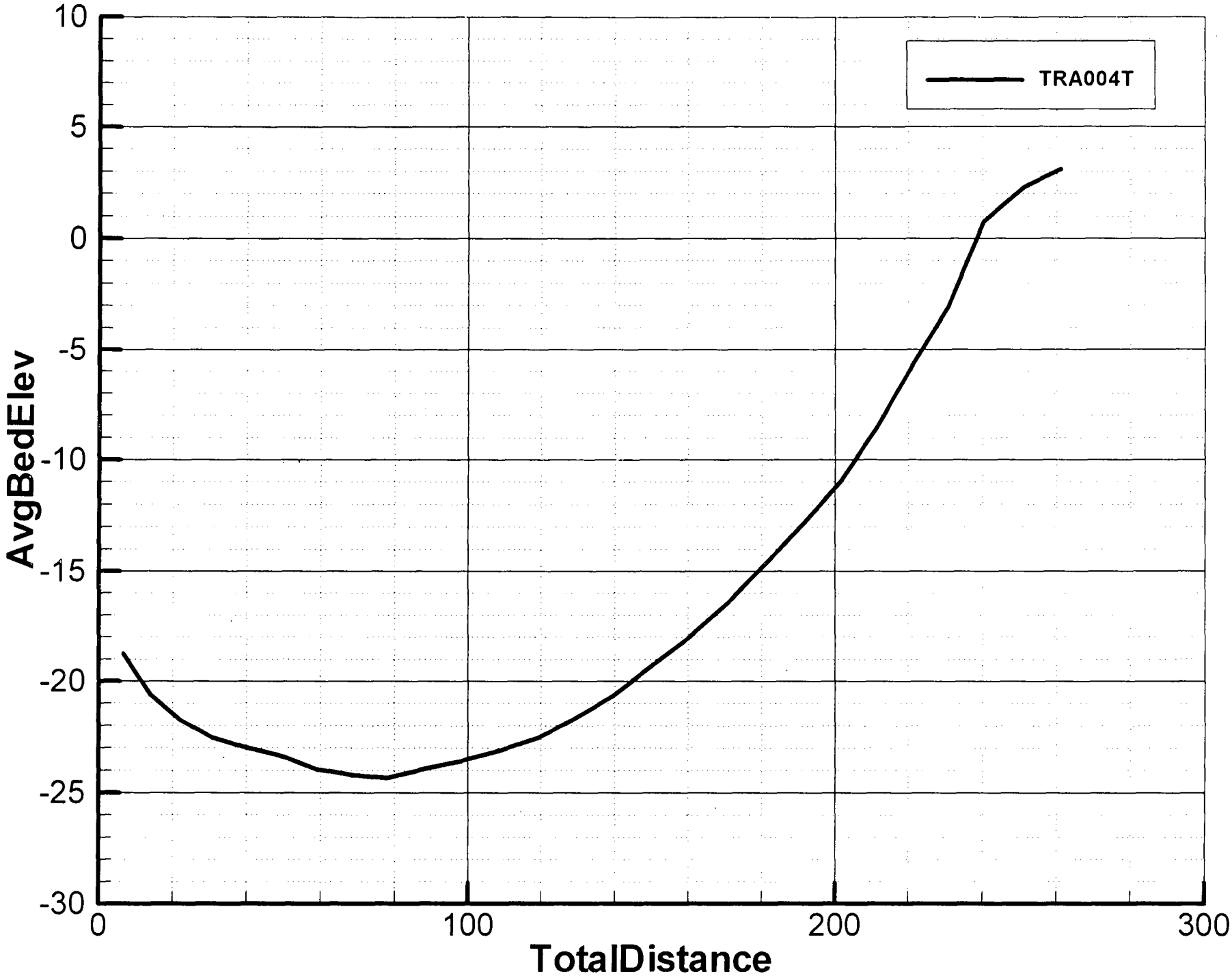

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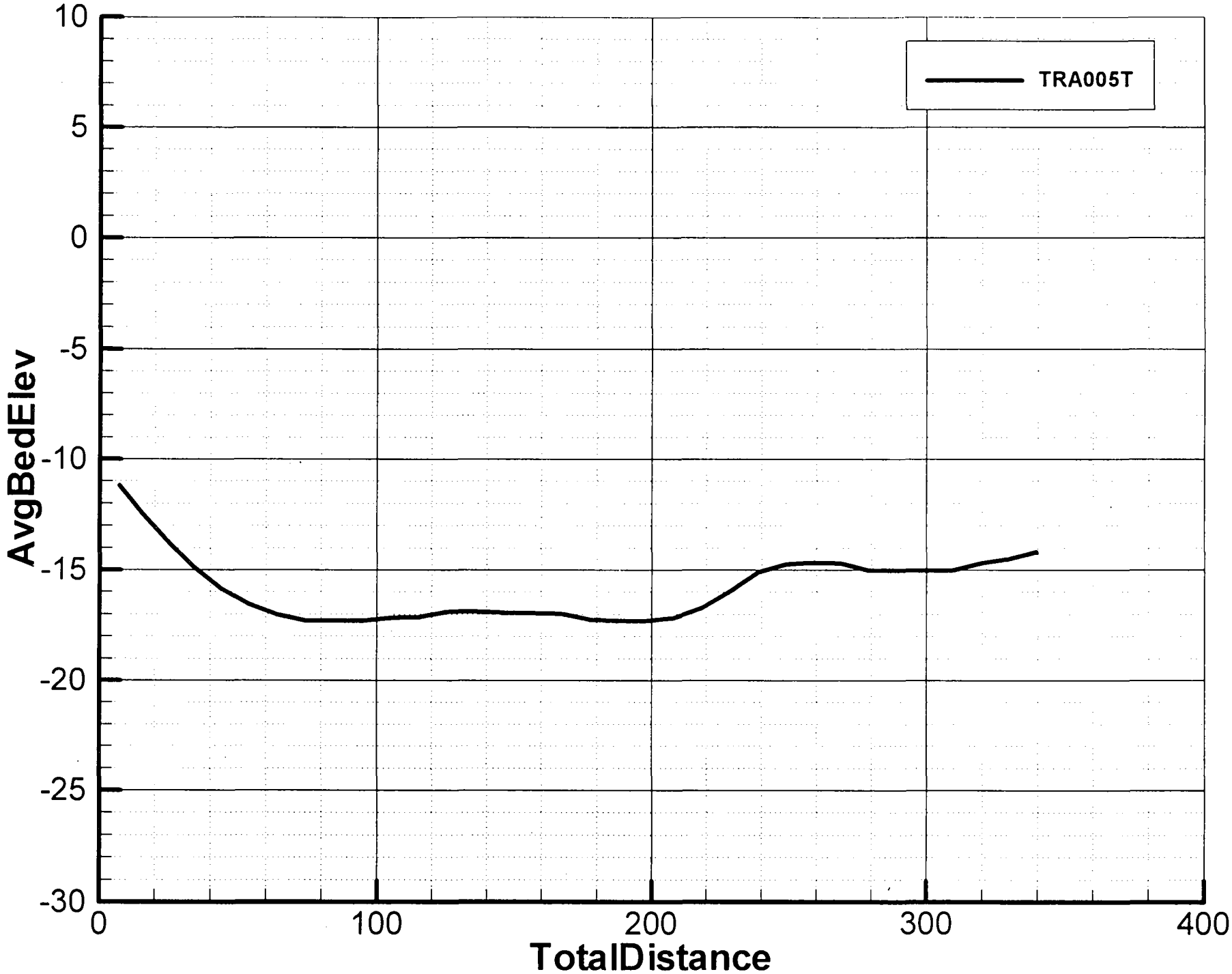

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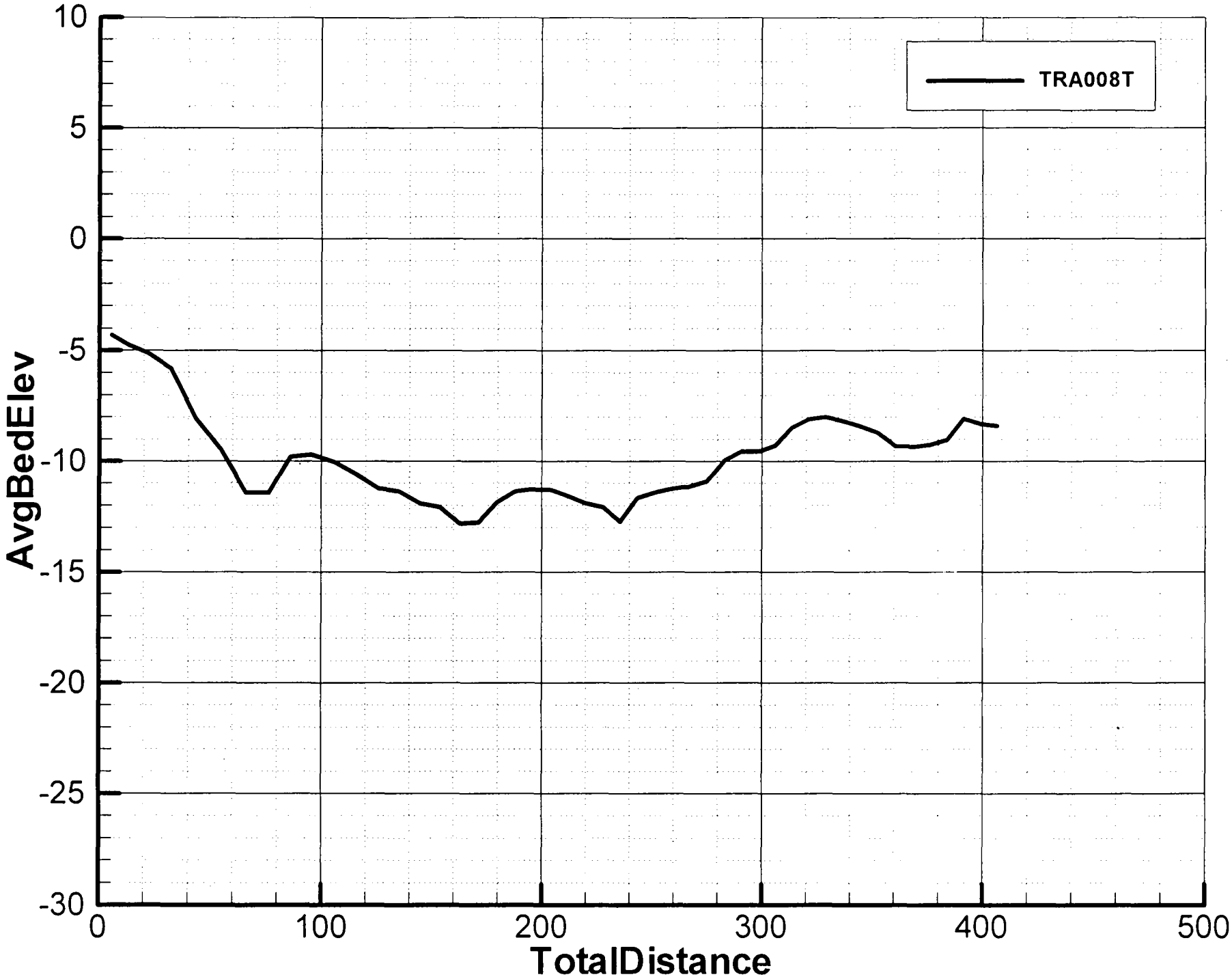

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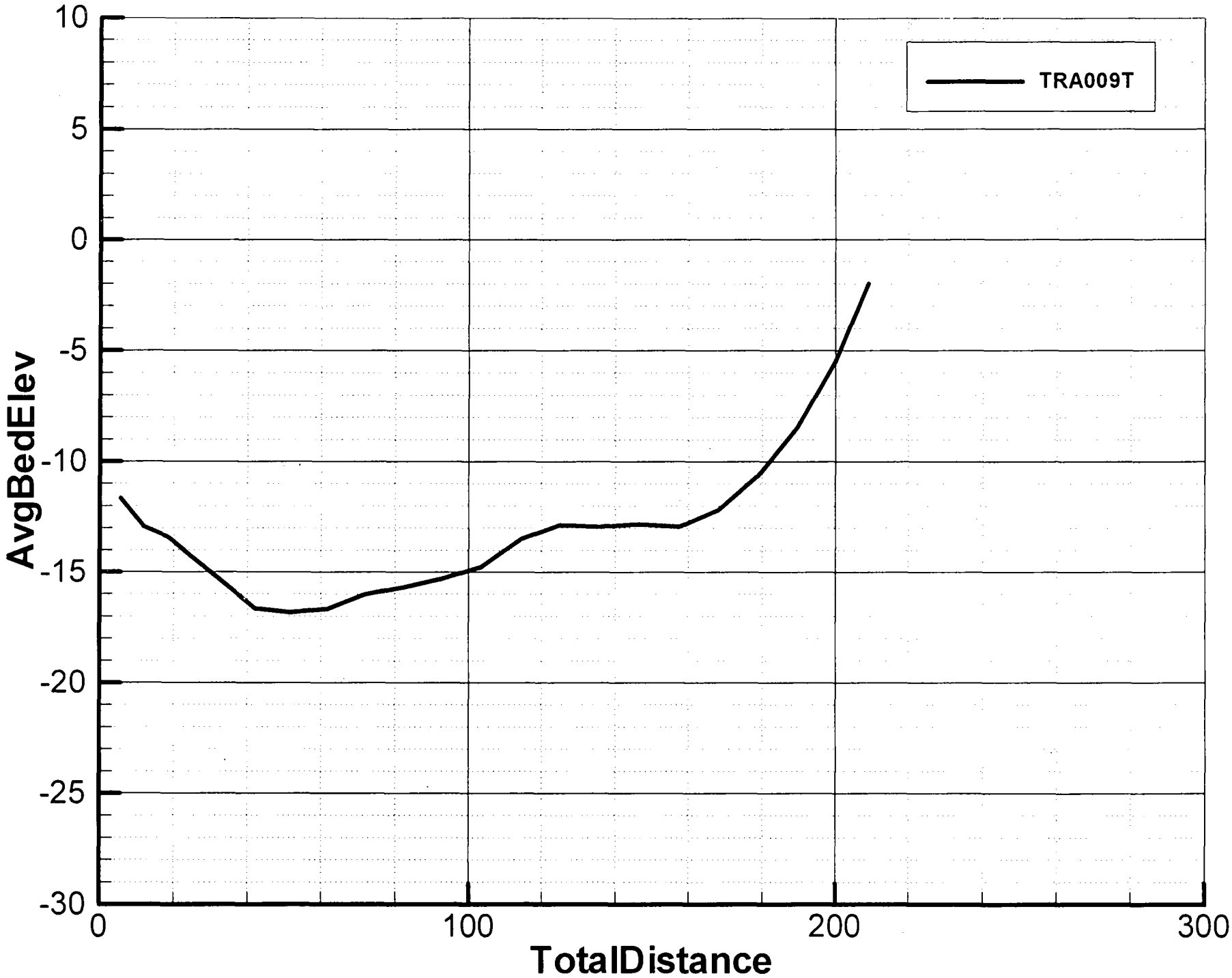

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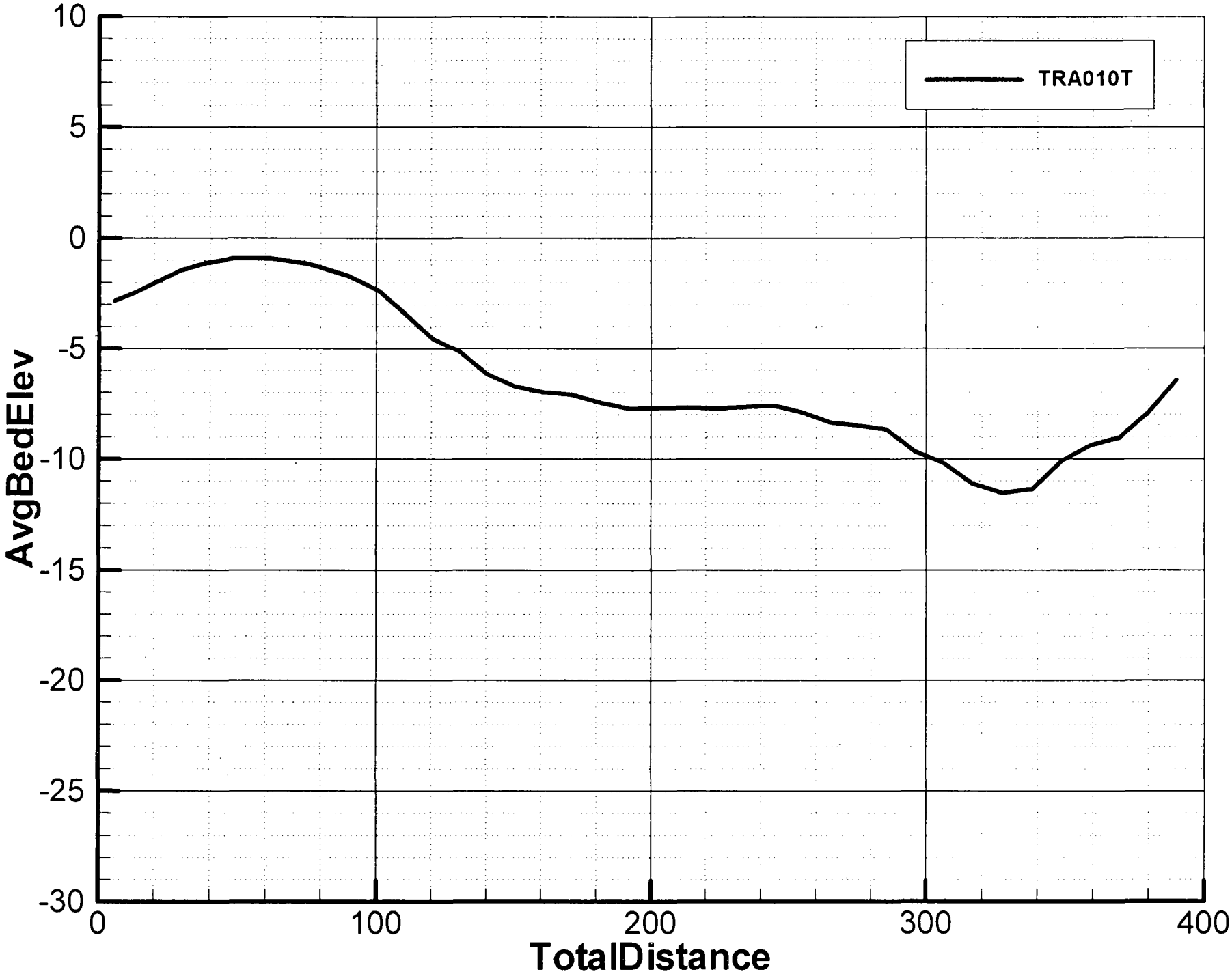

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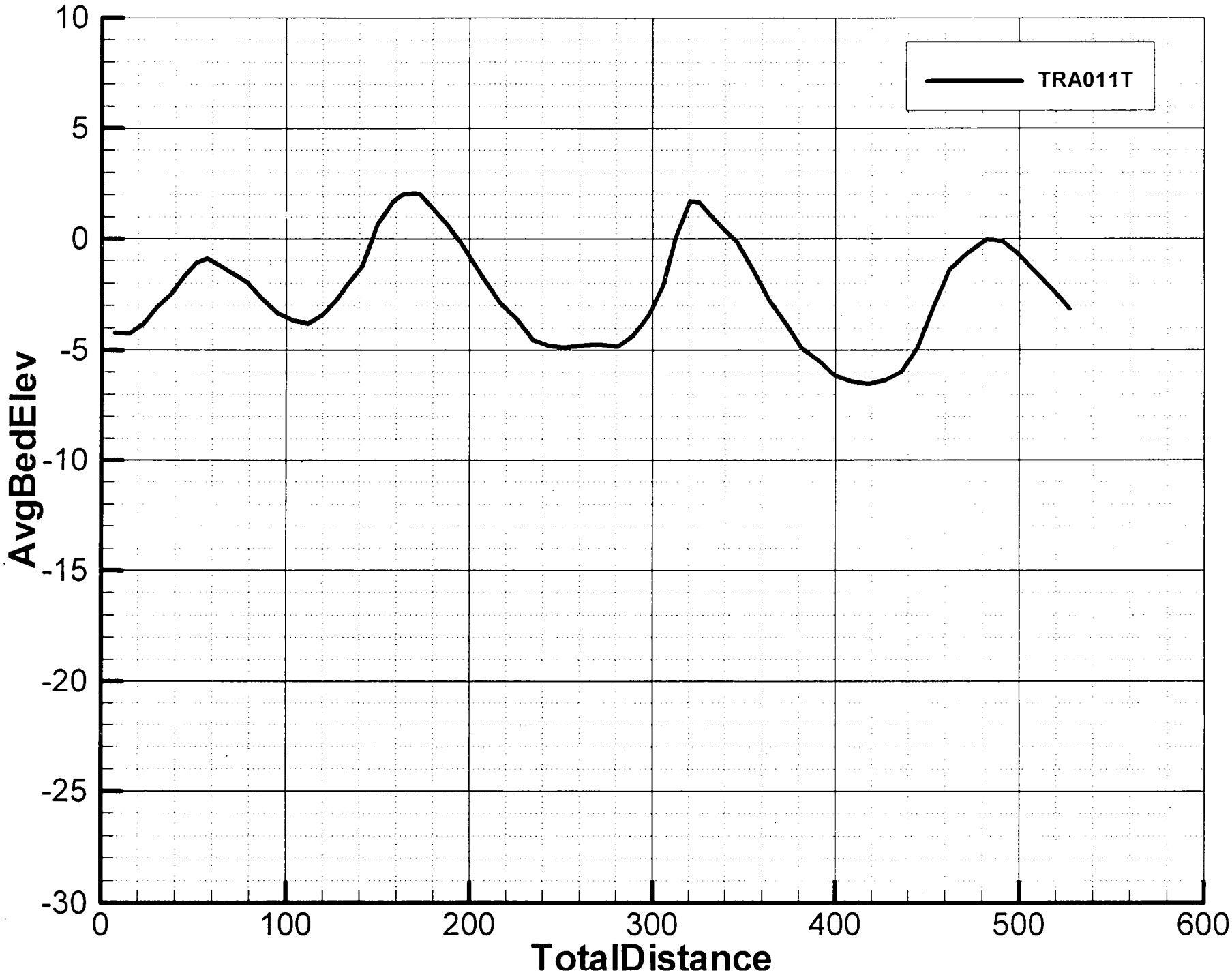

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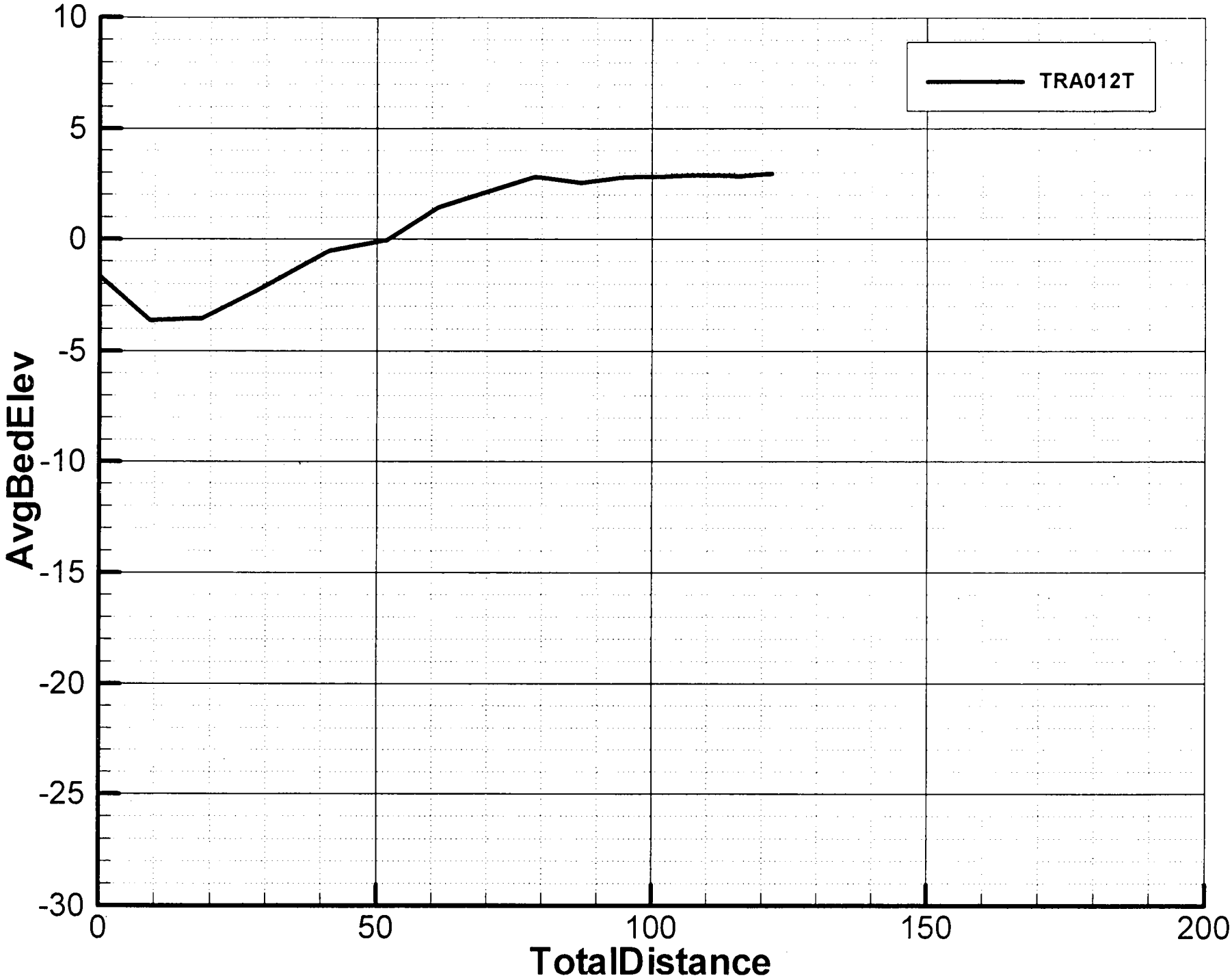

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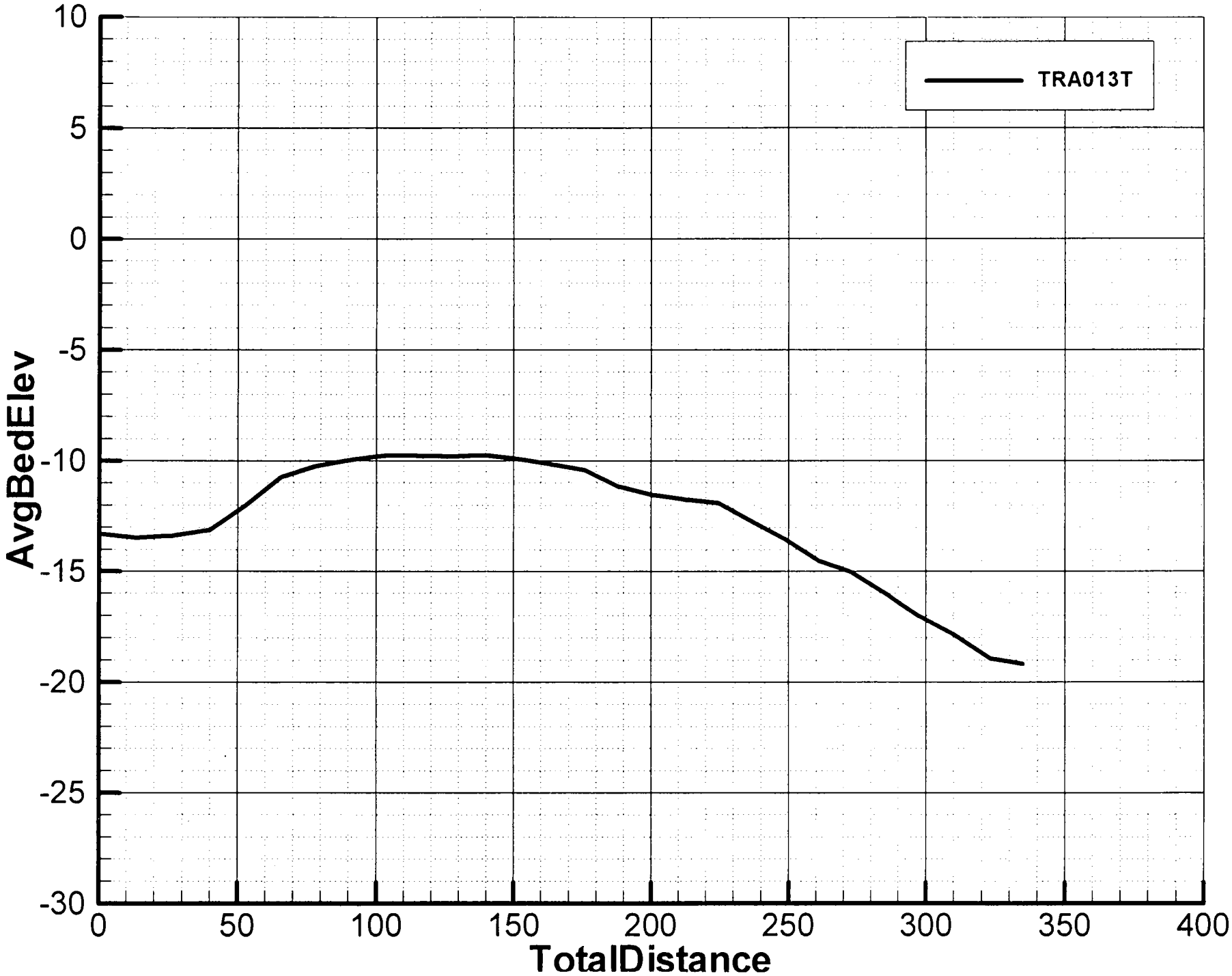

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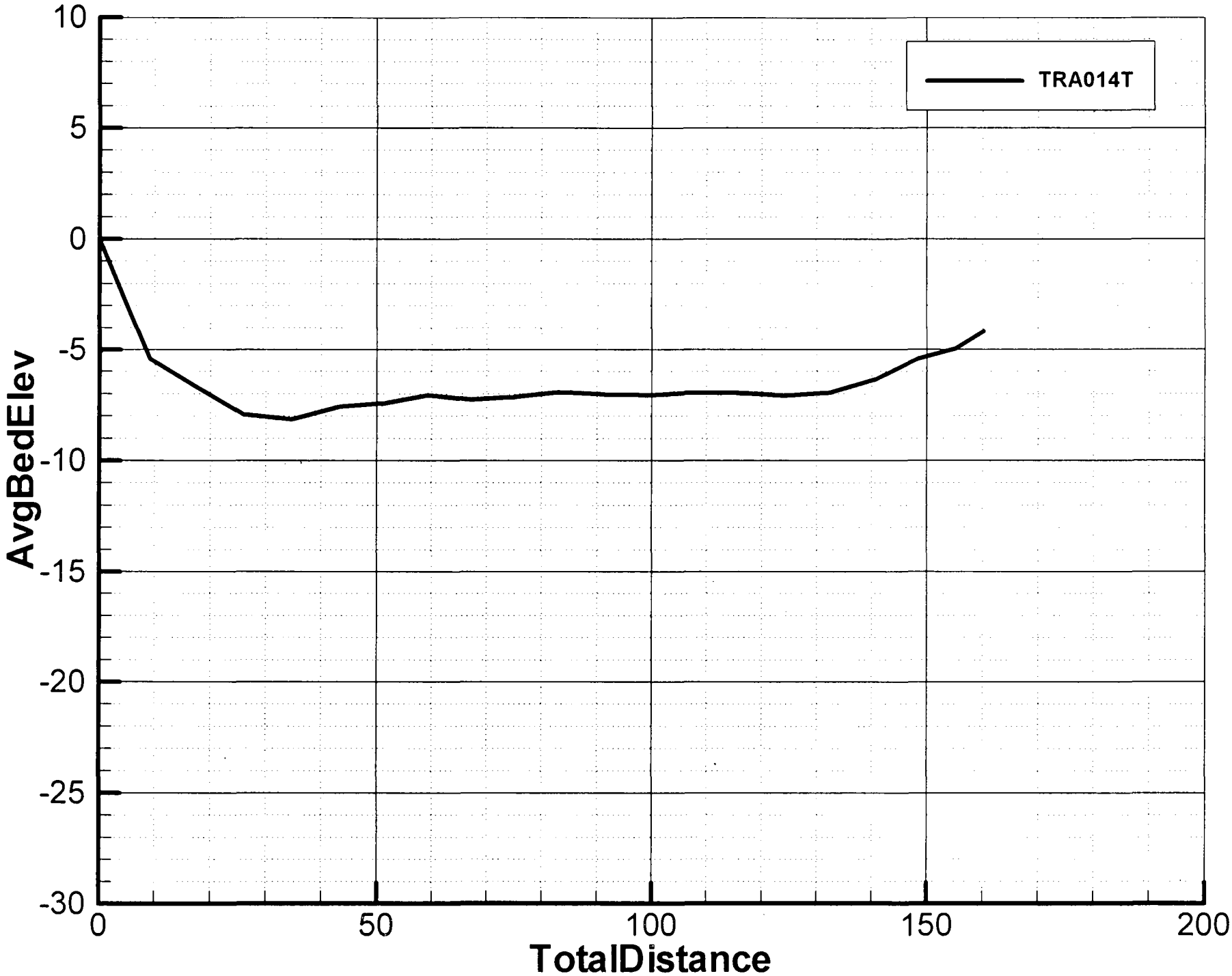

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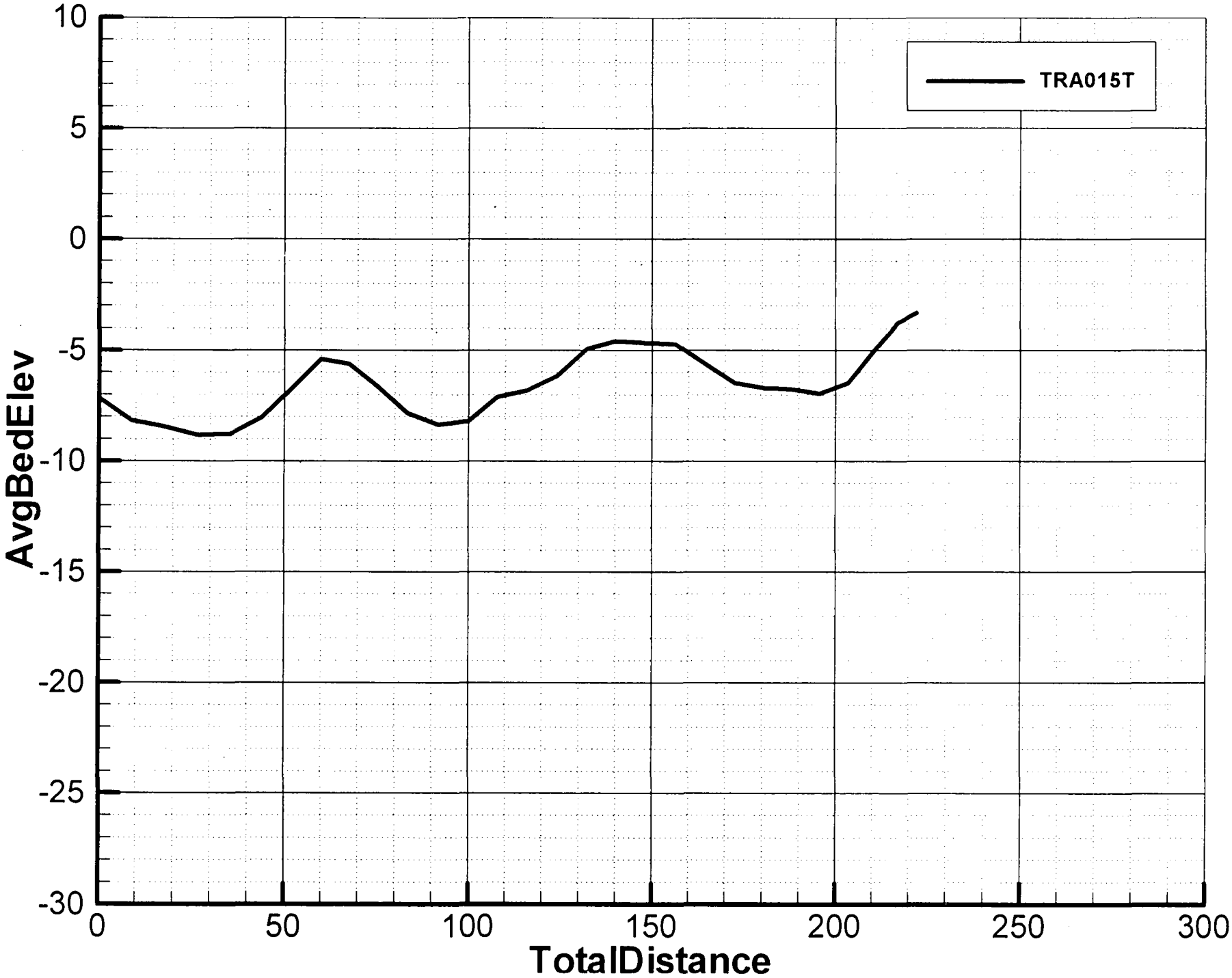
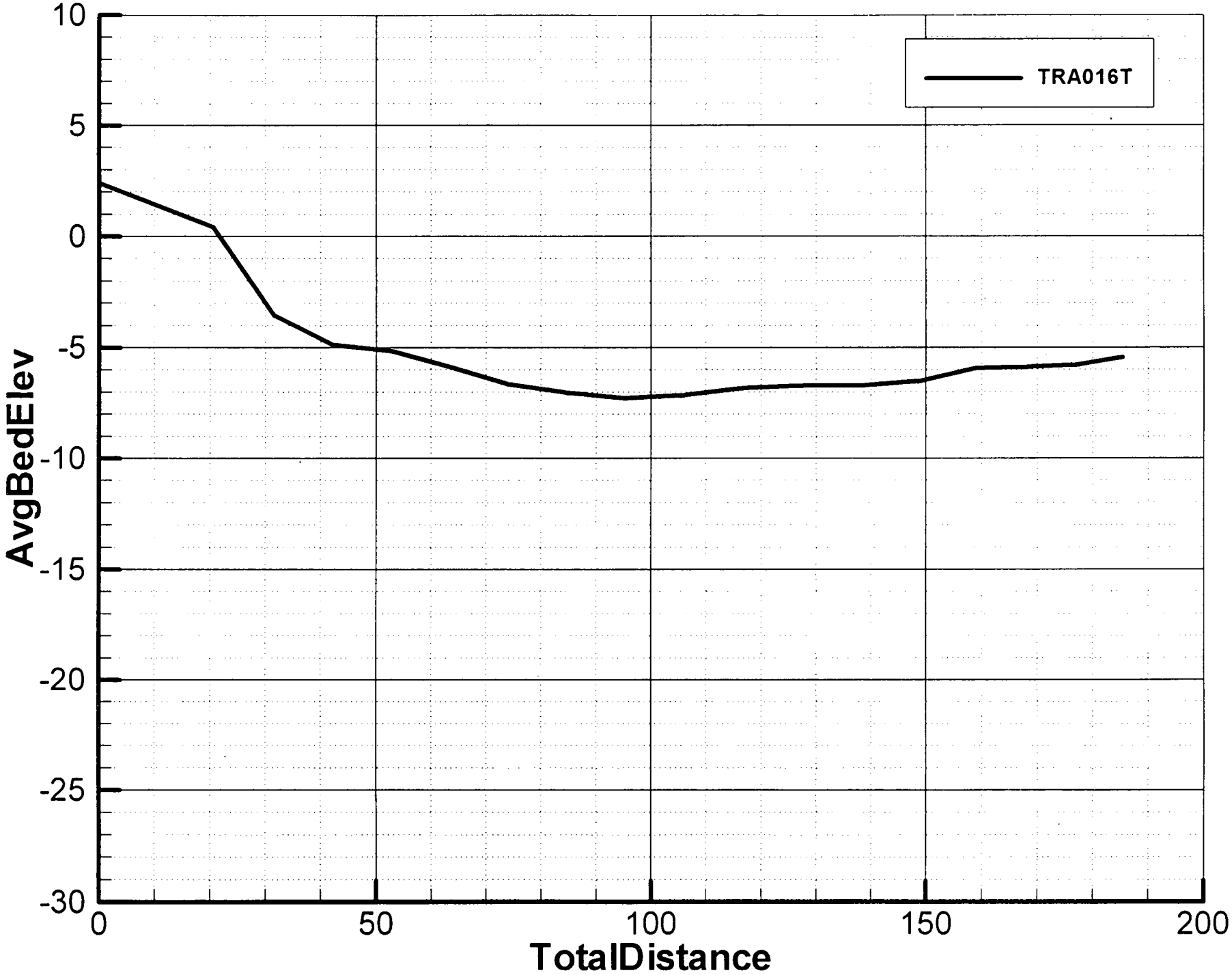
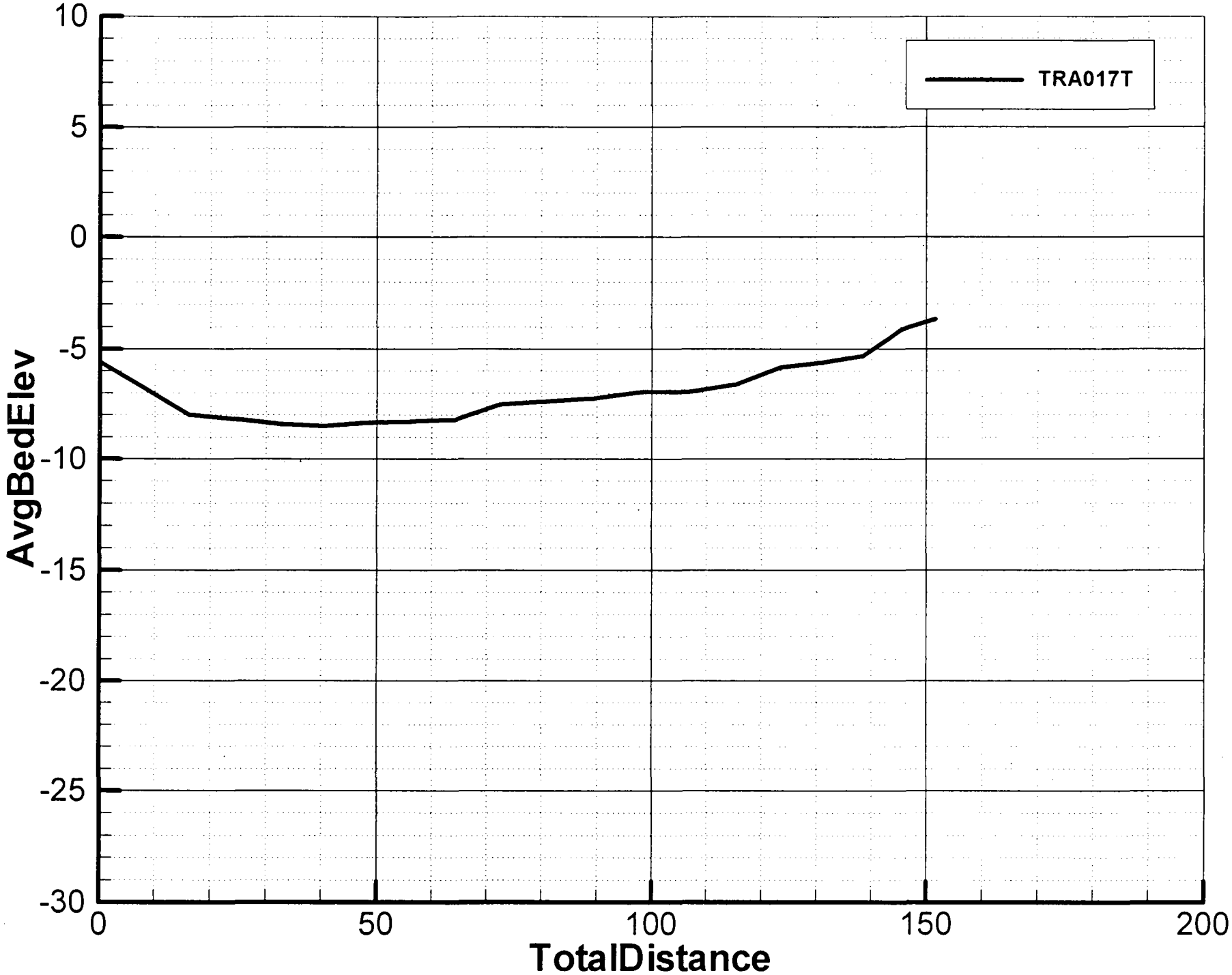


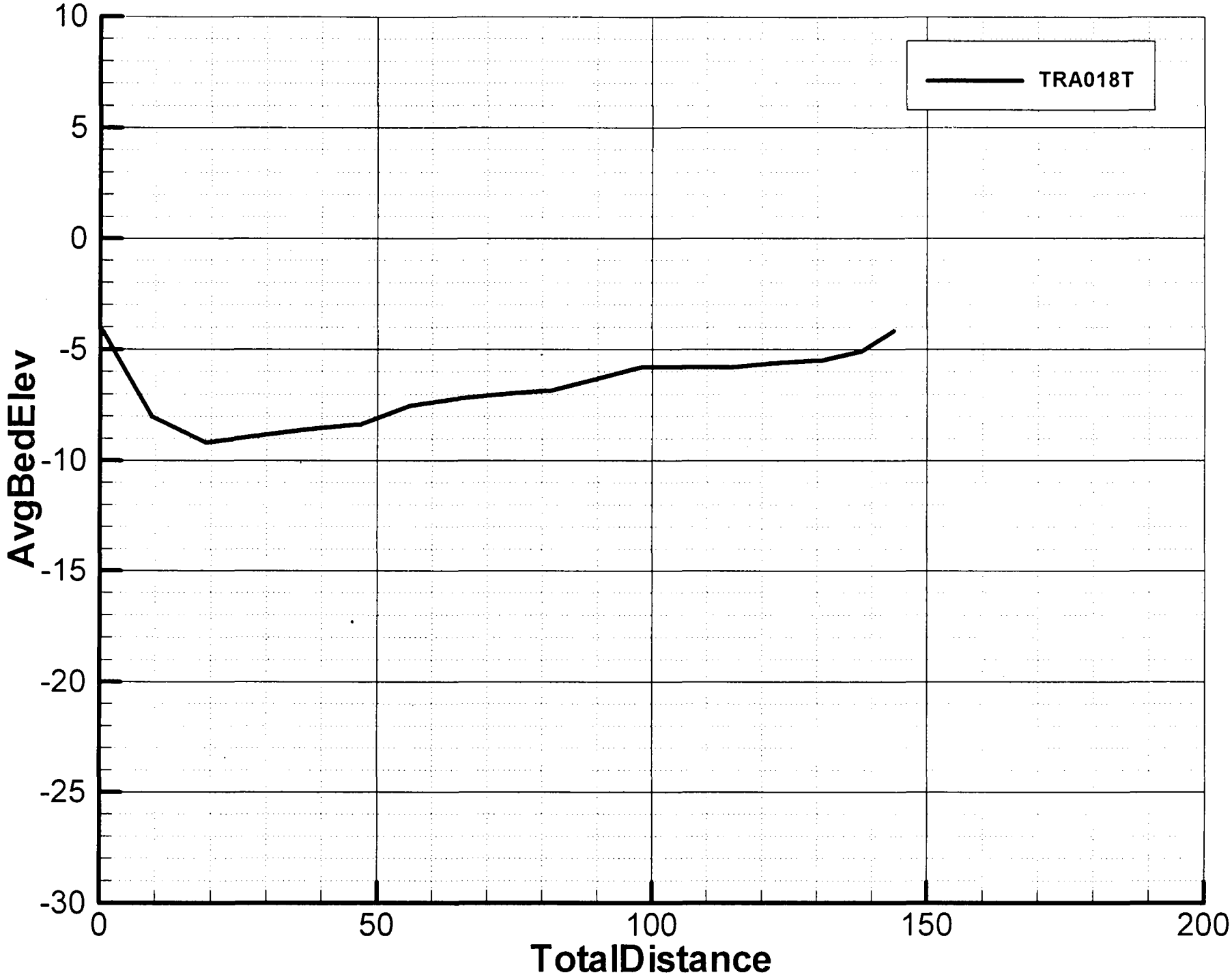
Frame 001 | 12 Jul 1999 | TRA BOTTOM PROFILE



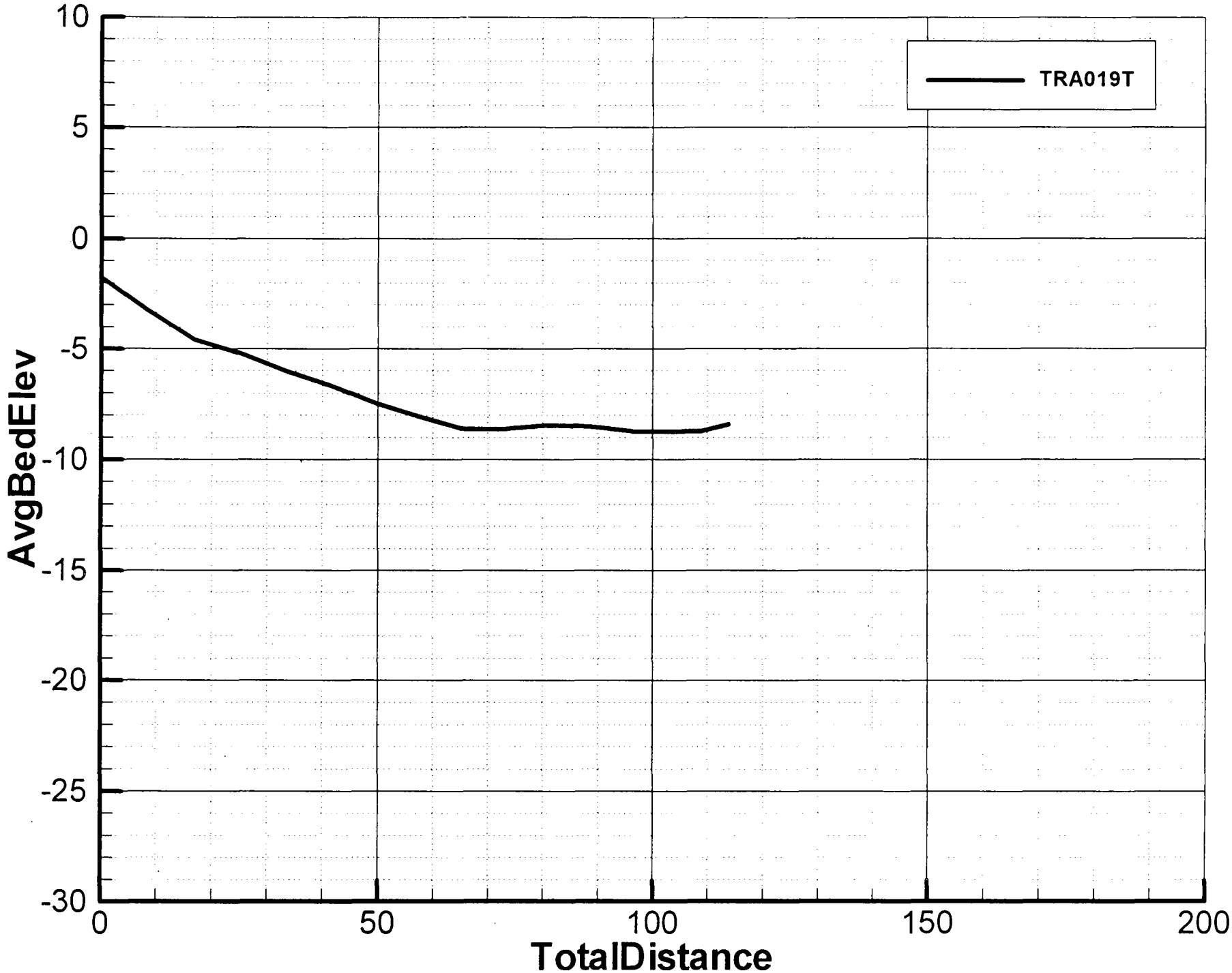
Frame 001 | 12 Jul 1999 | TRA BOTTOM PROFILE



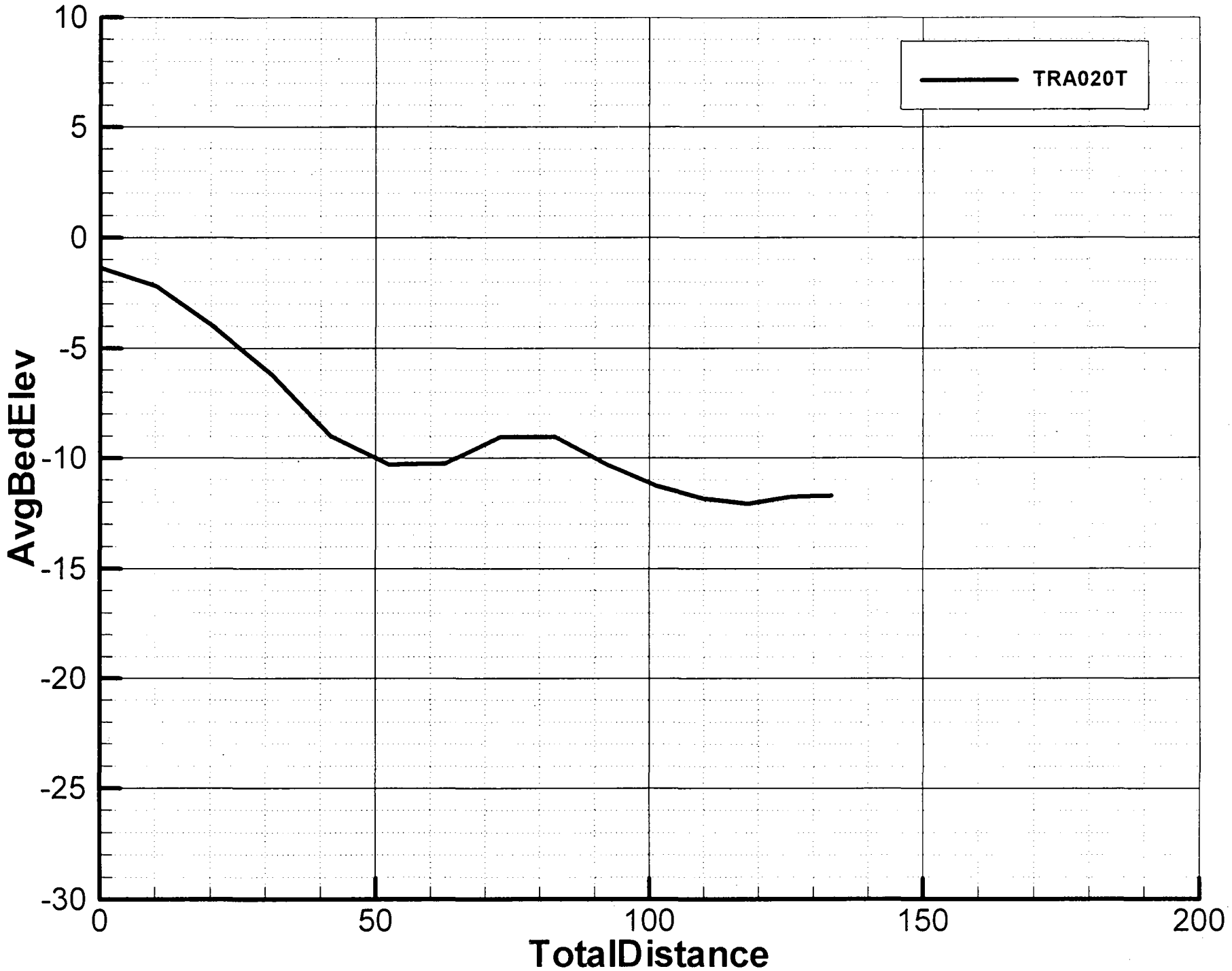
Frame 001 | 12 Jul 1999 | TRA BOTTOM PROFILE



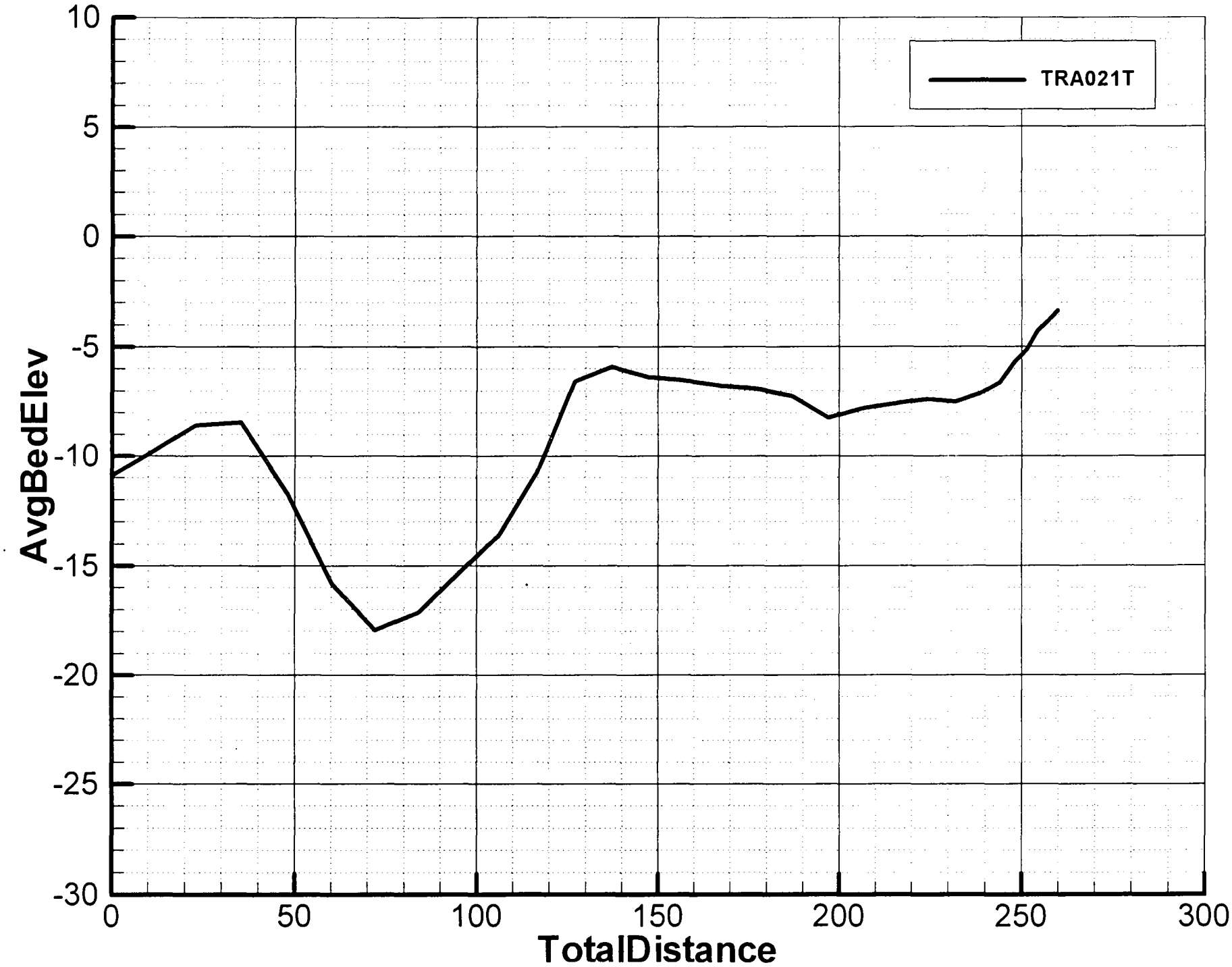
Frame 001 | 12 Jul 1999 | TRA BOTTOM PROFILE



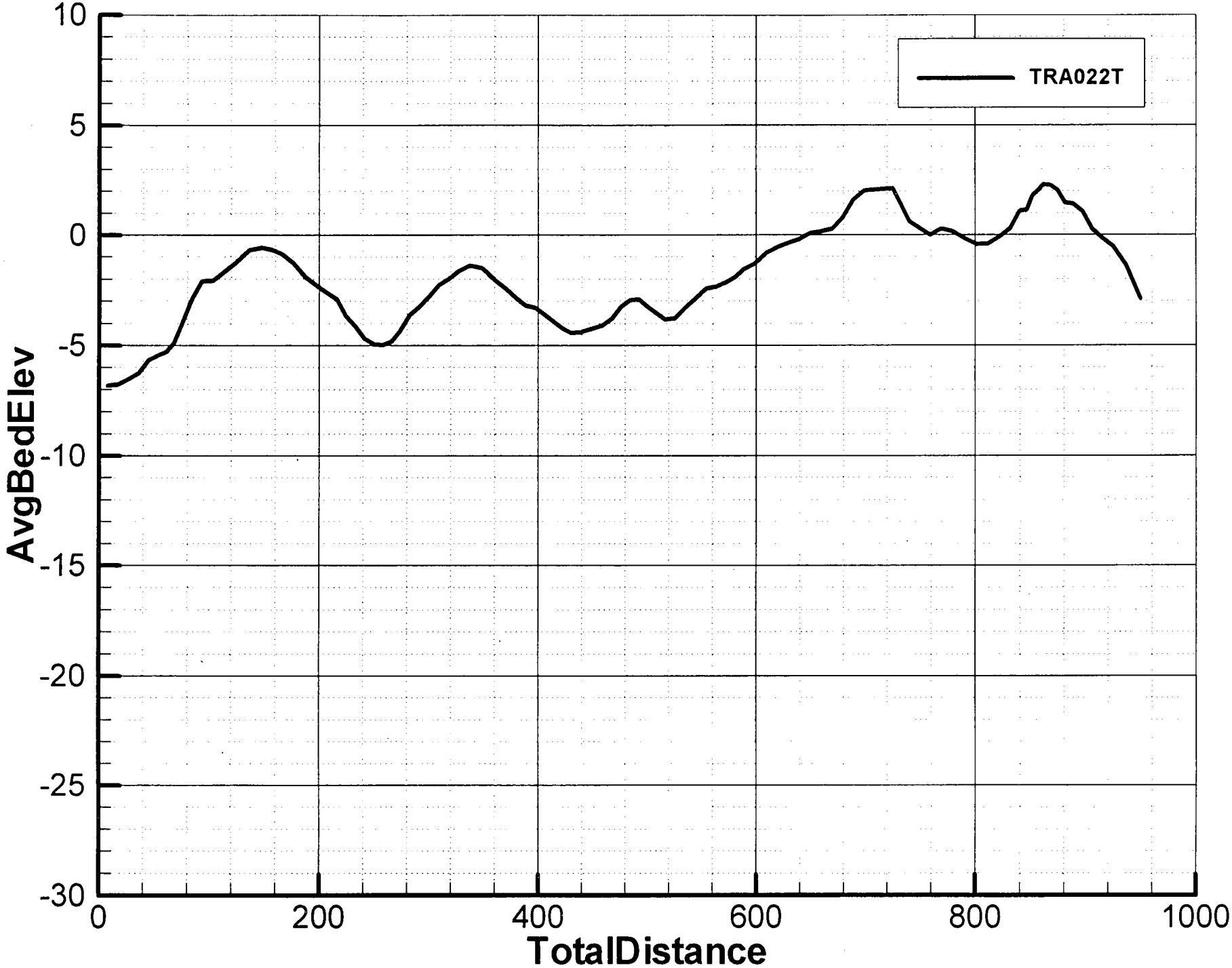
Frame 001 | 12 Jul 1999 | TRA BOTTOM PROFILE



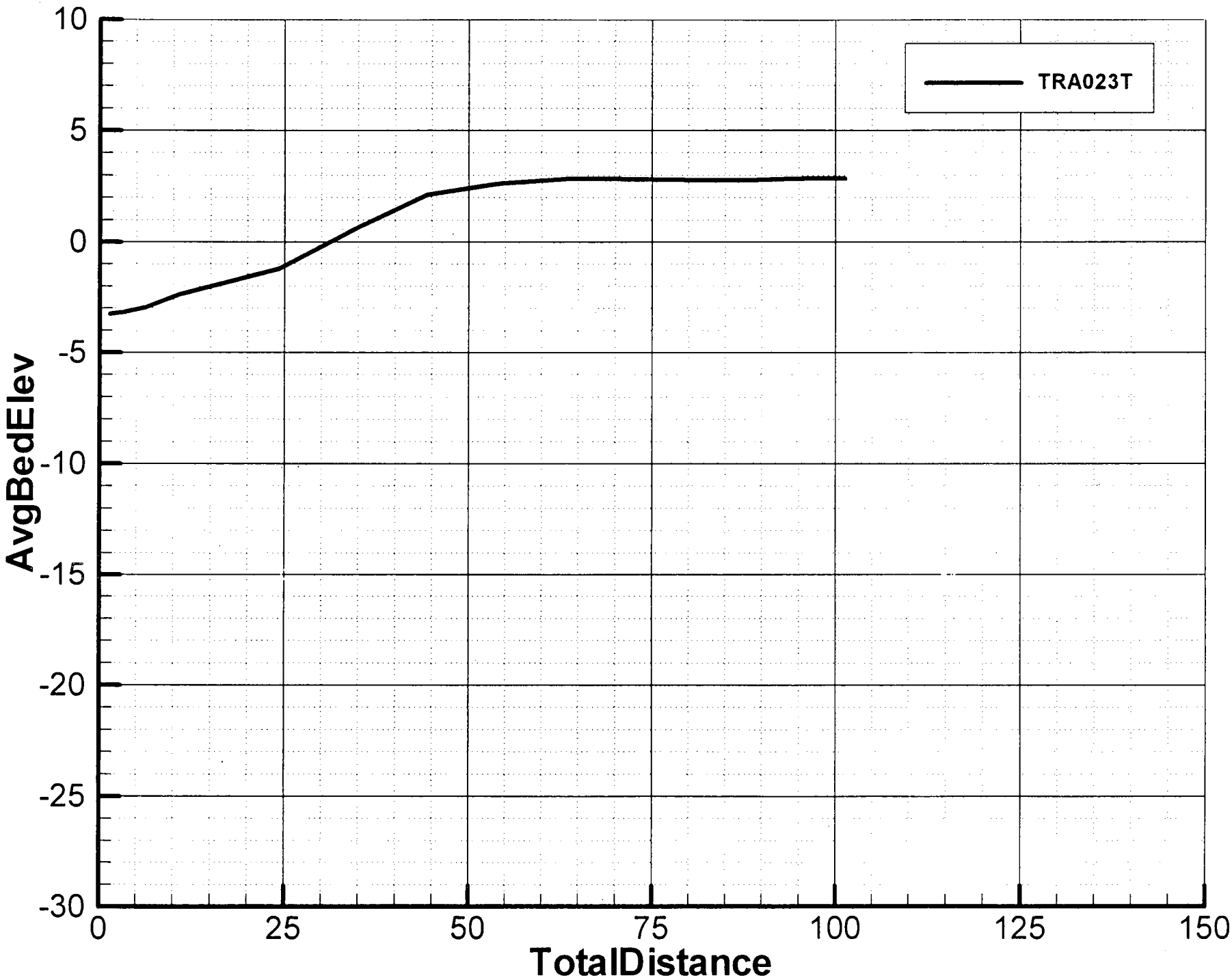
Frame 001 | 12 Jul 1999 : TRA BOTTOM PROFILE



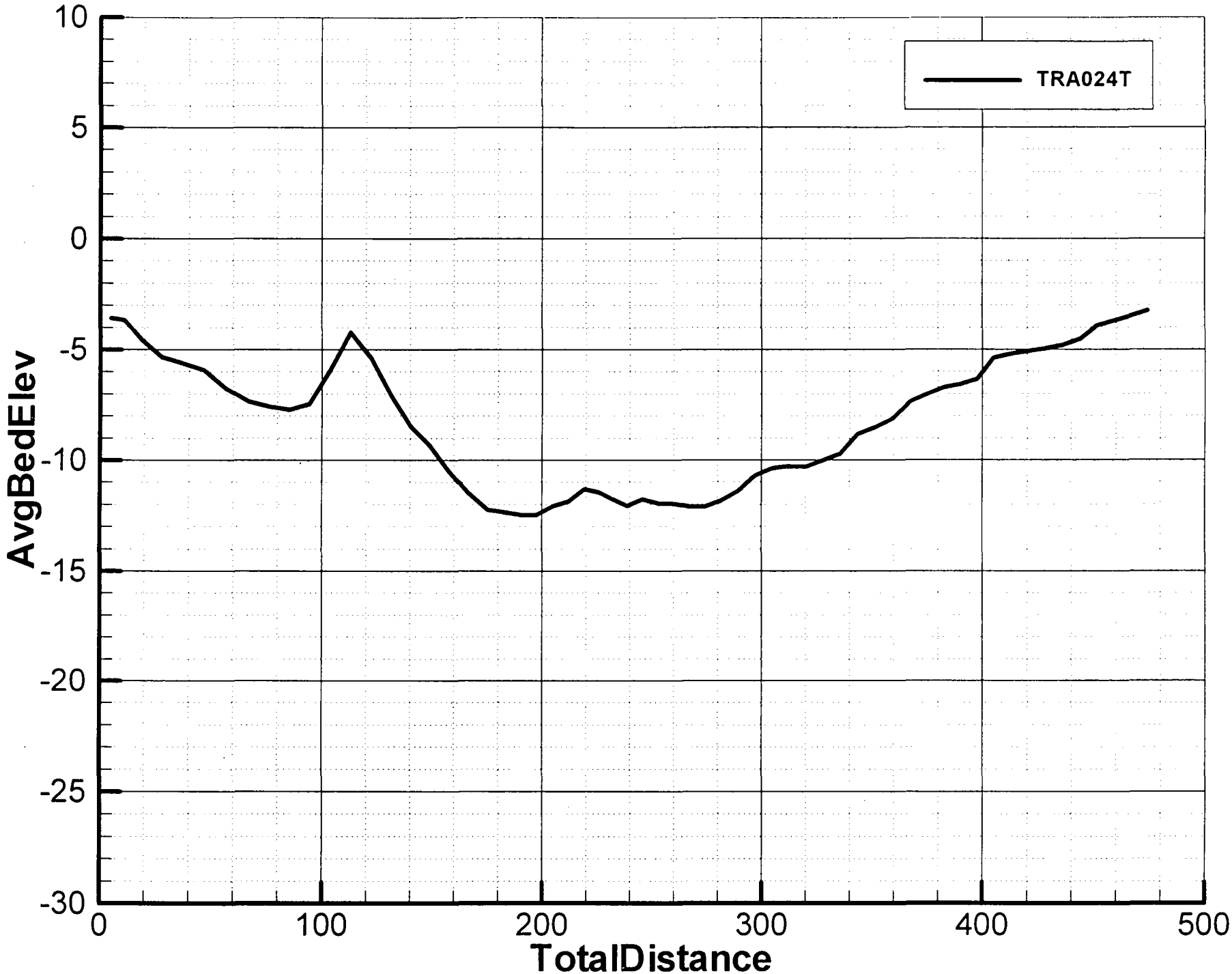
Frame 001 | 12 Jul 1999 | TRA BOTTOM PROFILE



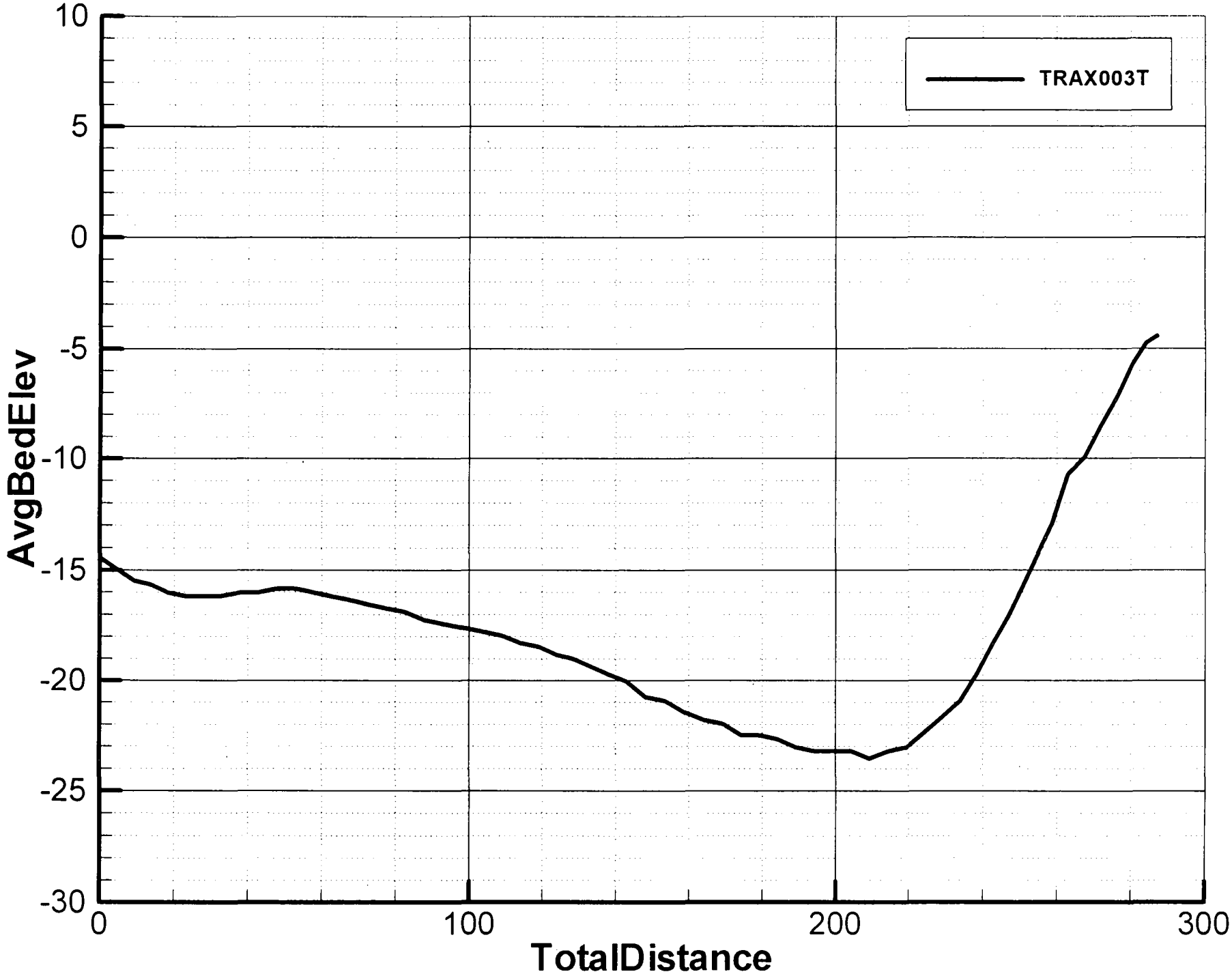
Frame 001 | 12 Jul 1999 | TRA BOTTOM PROFILE



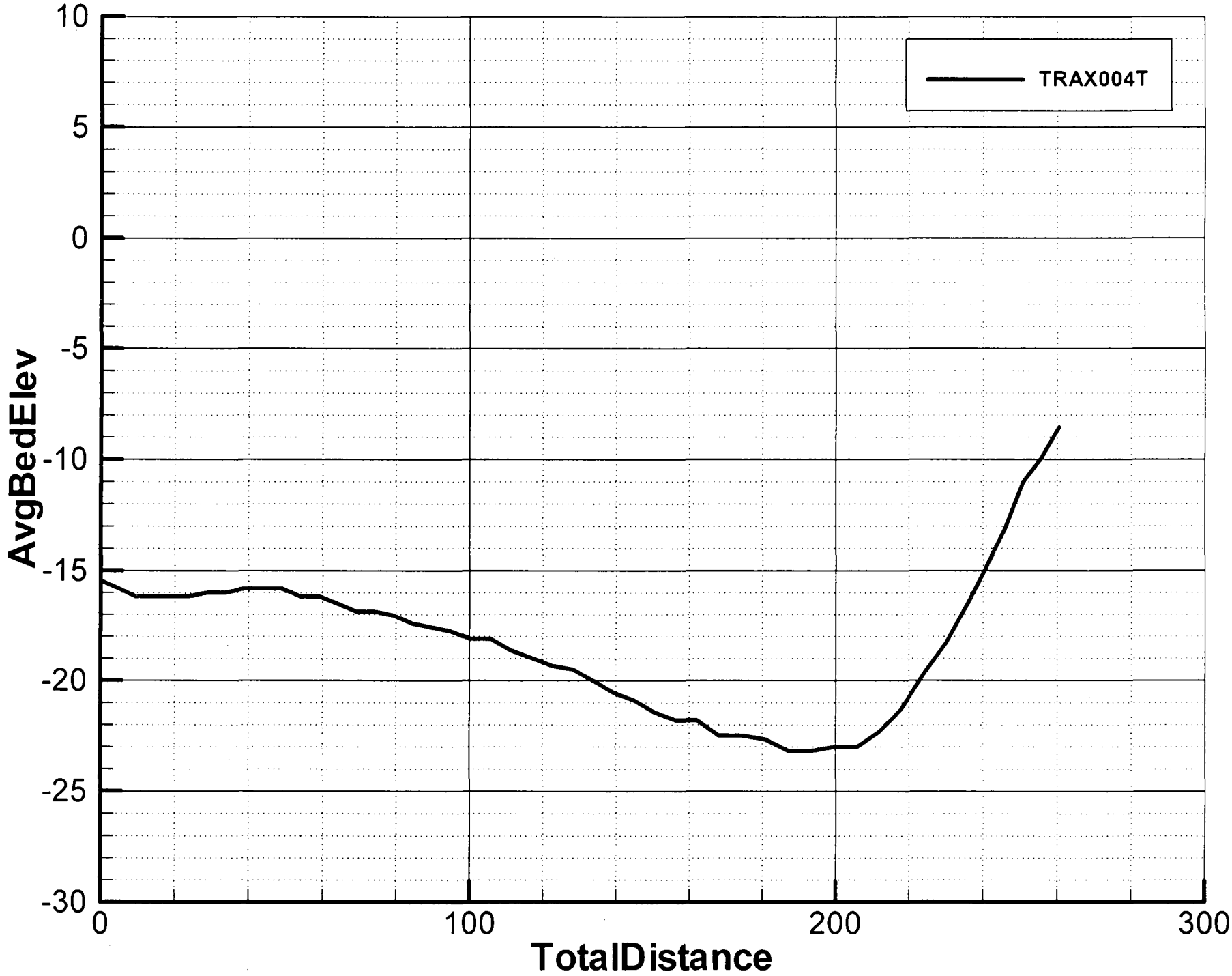
Frame 001 | 12 Jul 1999 | TRA BOTTOM PROFILE



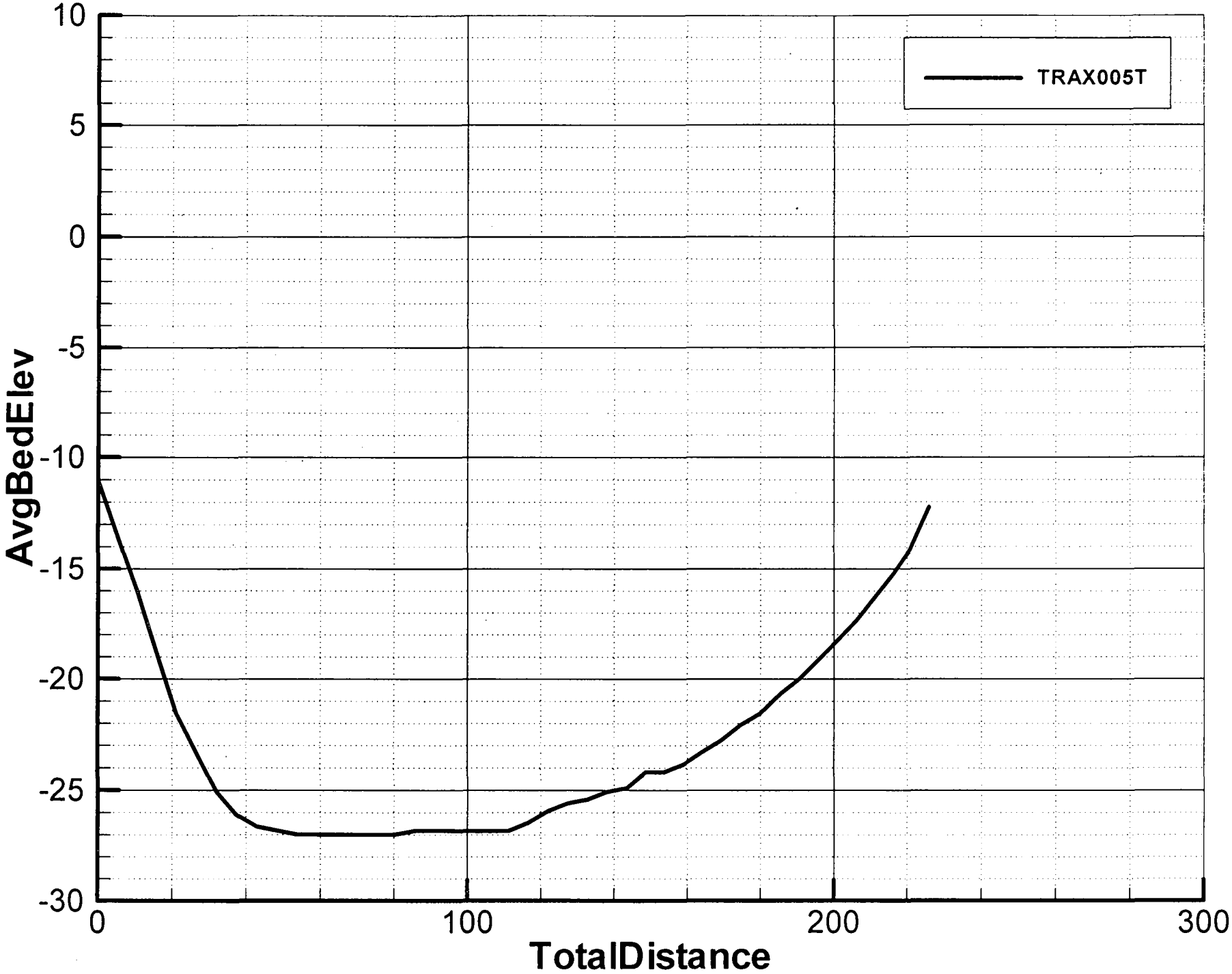
Frame 001 | 12 Jul 1999 : TRAX BOTTOM PROFILE



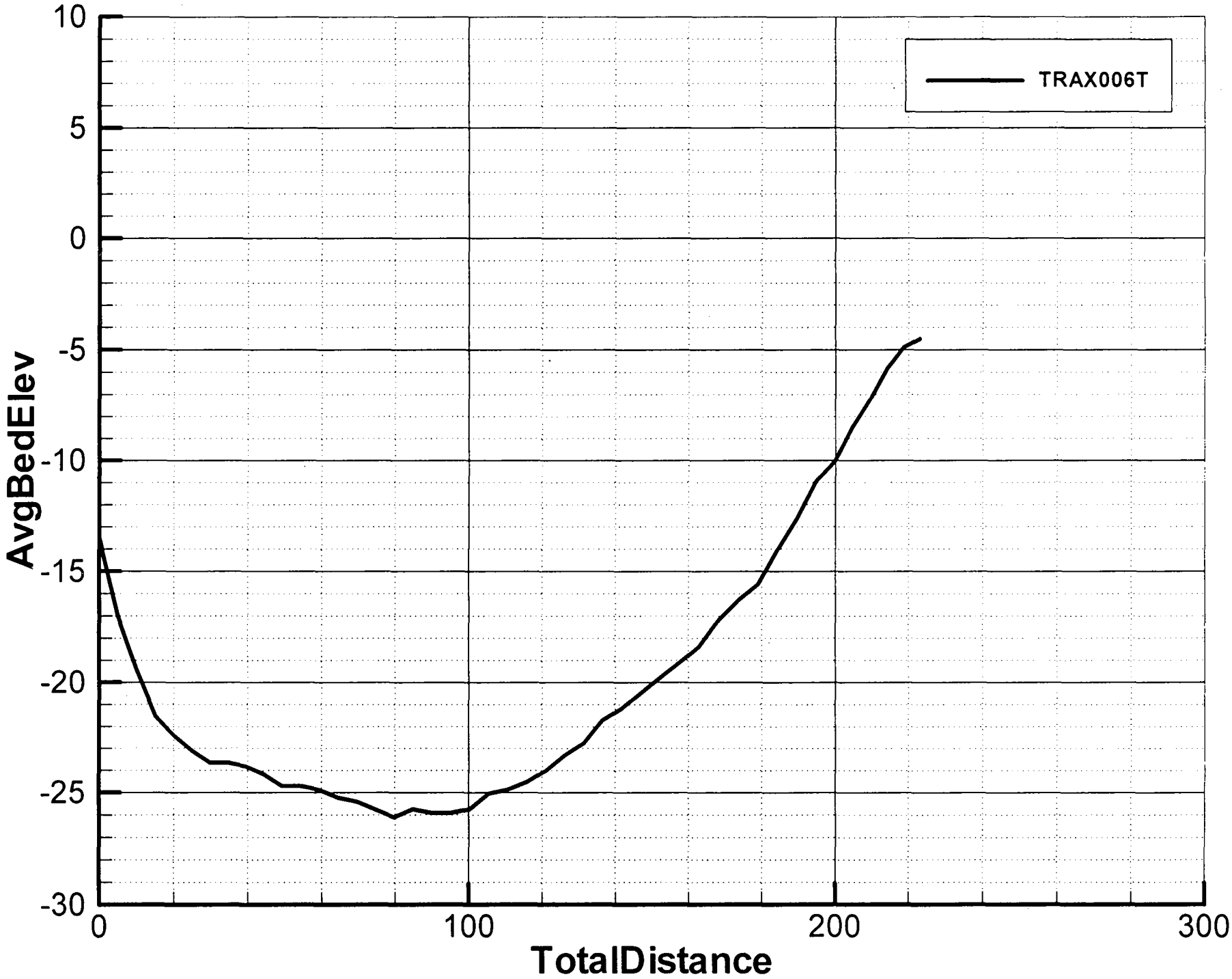
Frame 001 | 12 Jul 1999 | TRAX BOTTOM PROFILE



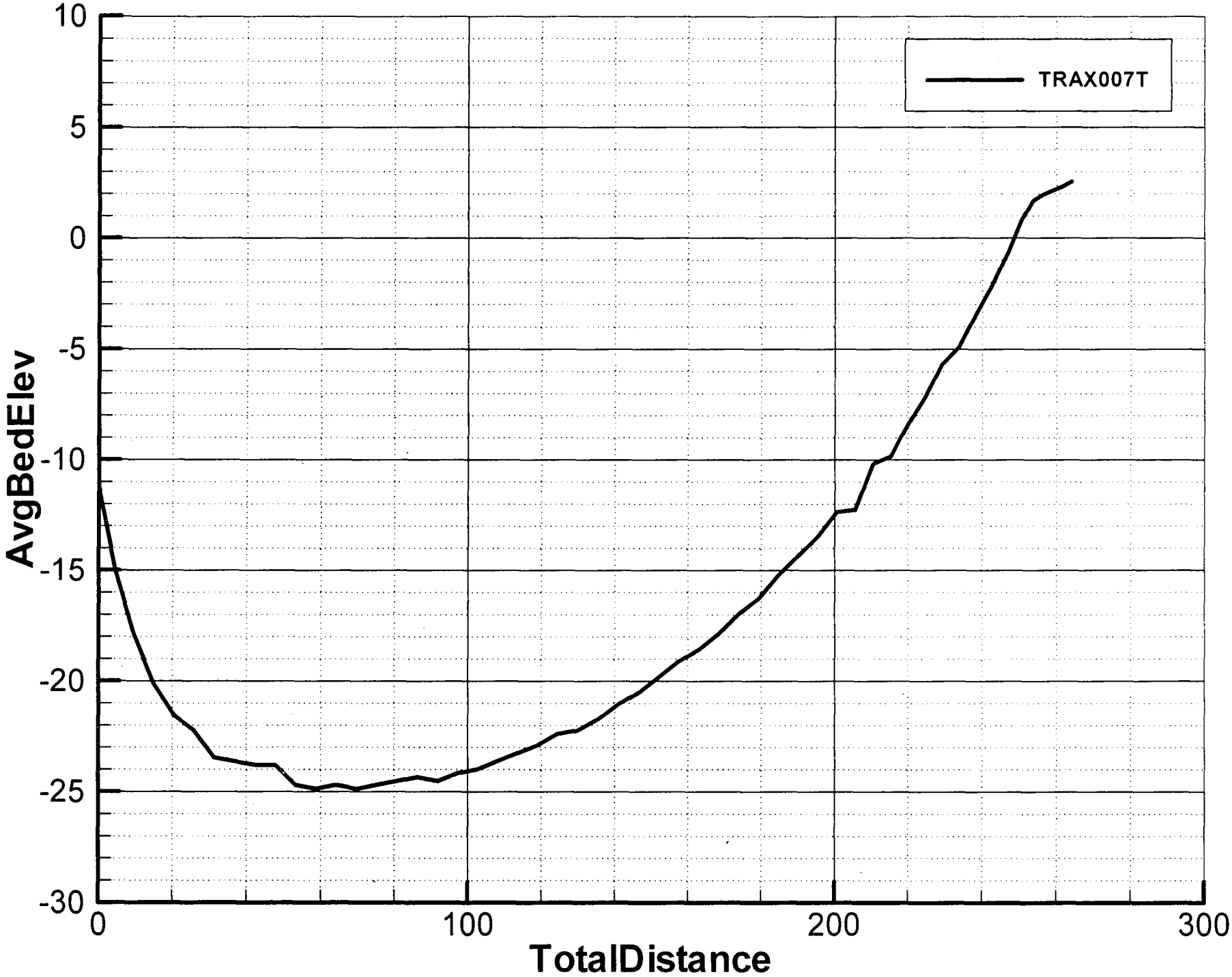
Frame 001 | 12 Jul 1999 | TRAX BOTTOM PROFILE



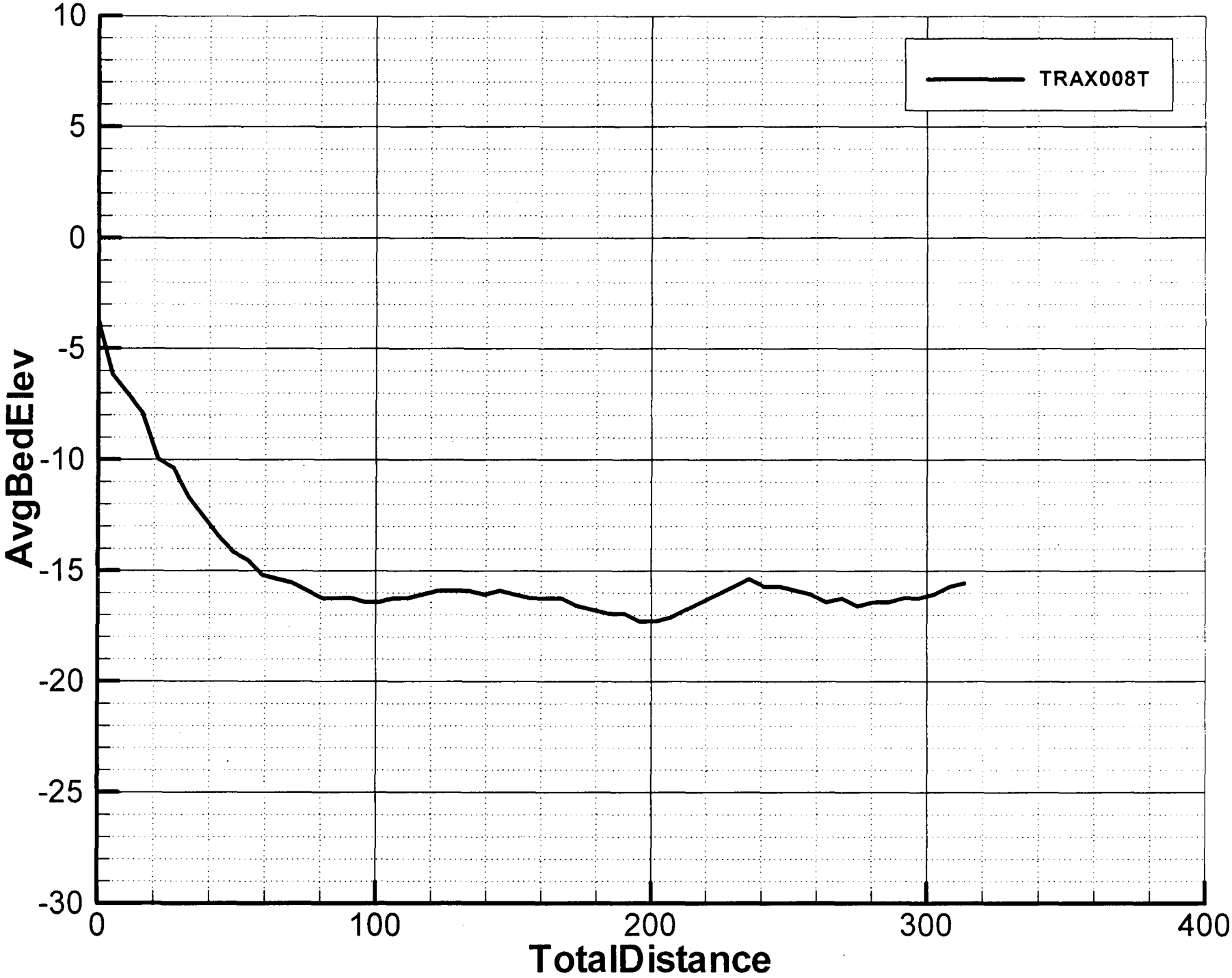
Frame 001 | 12 Jul 1999 TRAX BOTTOM PROFILE



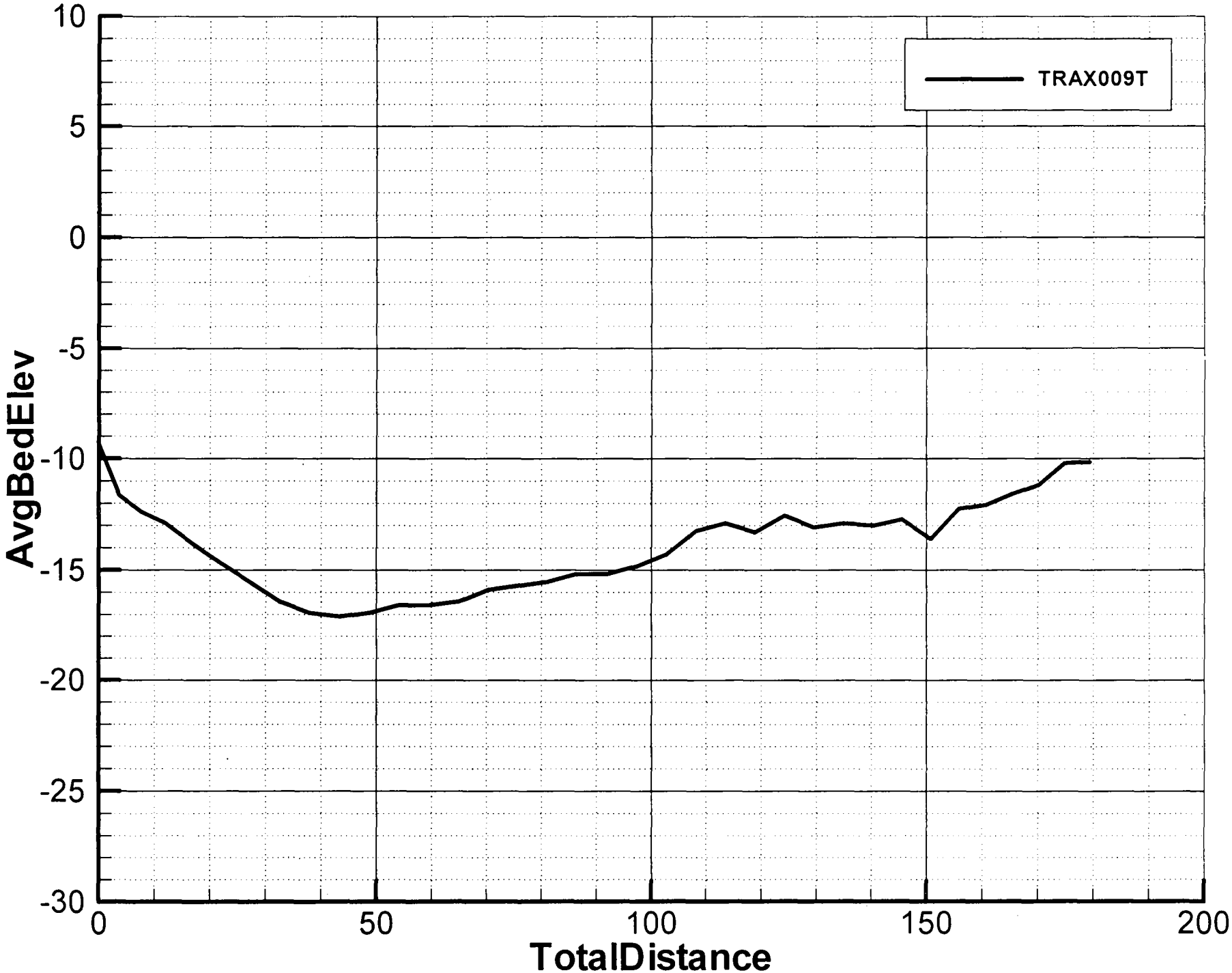
Frame 001 | 12 Jul 1999 | TRAX BOTTOM PROFILE



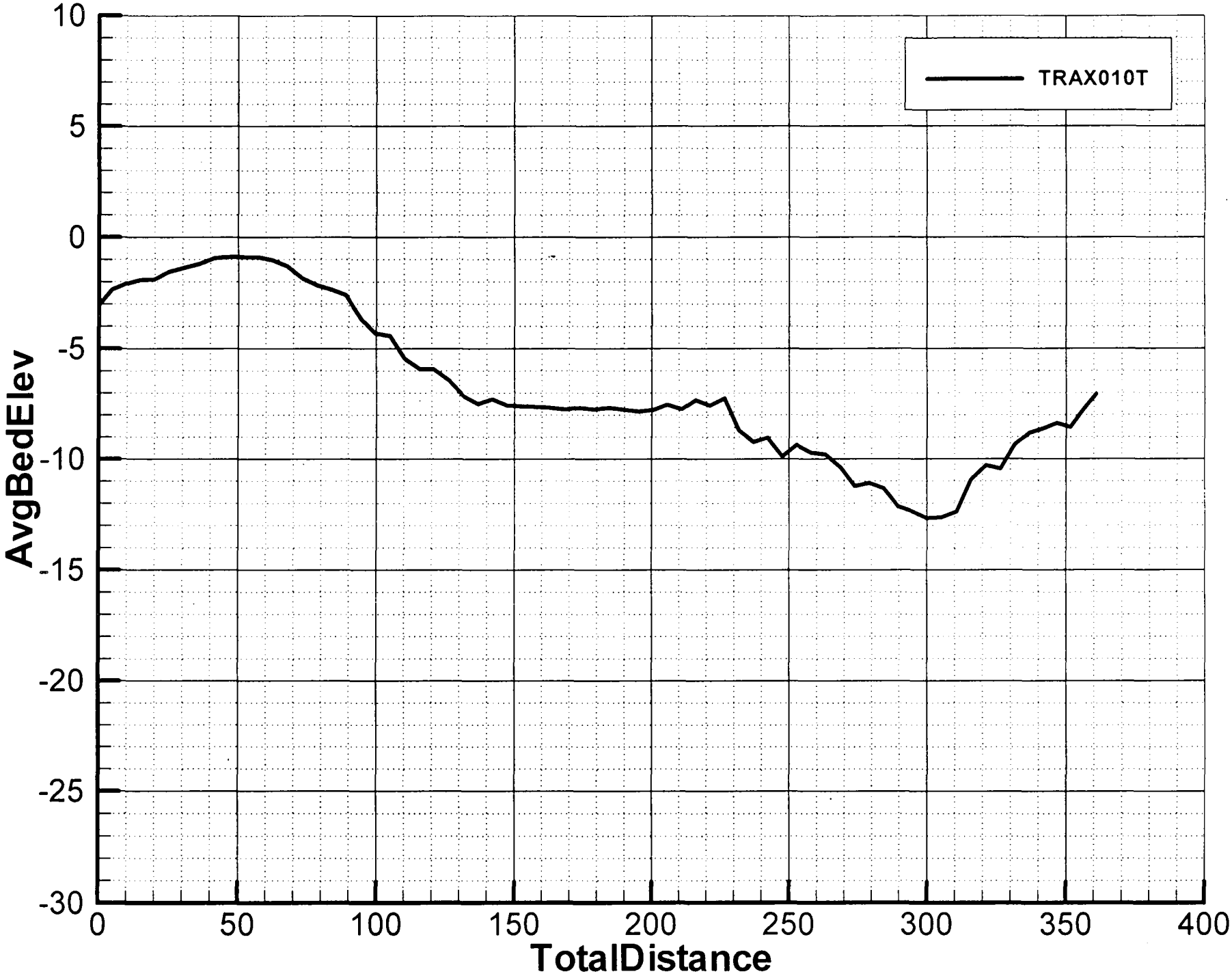
Frame 001 | 12 Jul 1999 | TRAX BOTTOM PROFILE



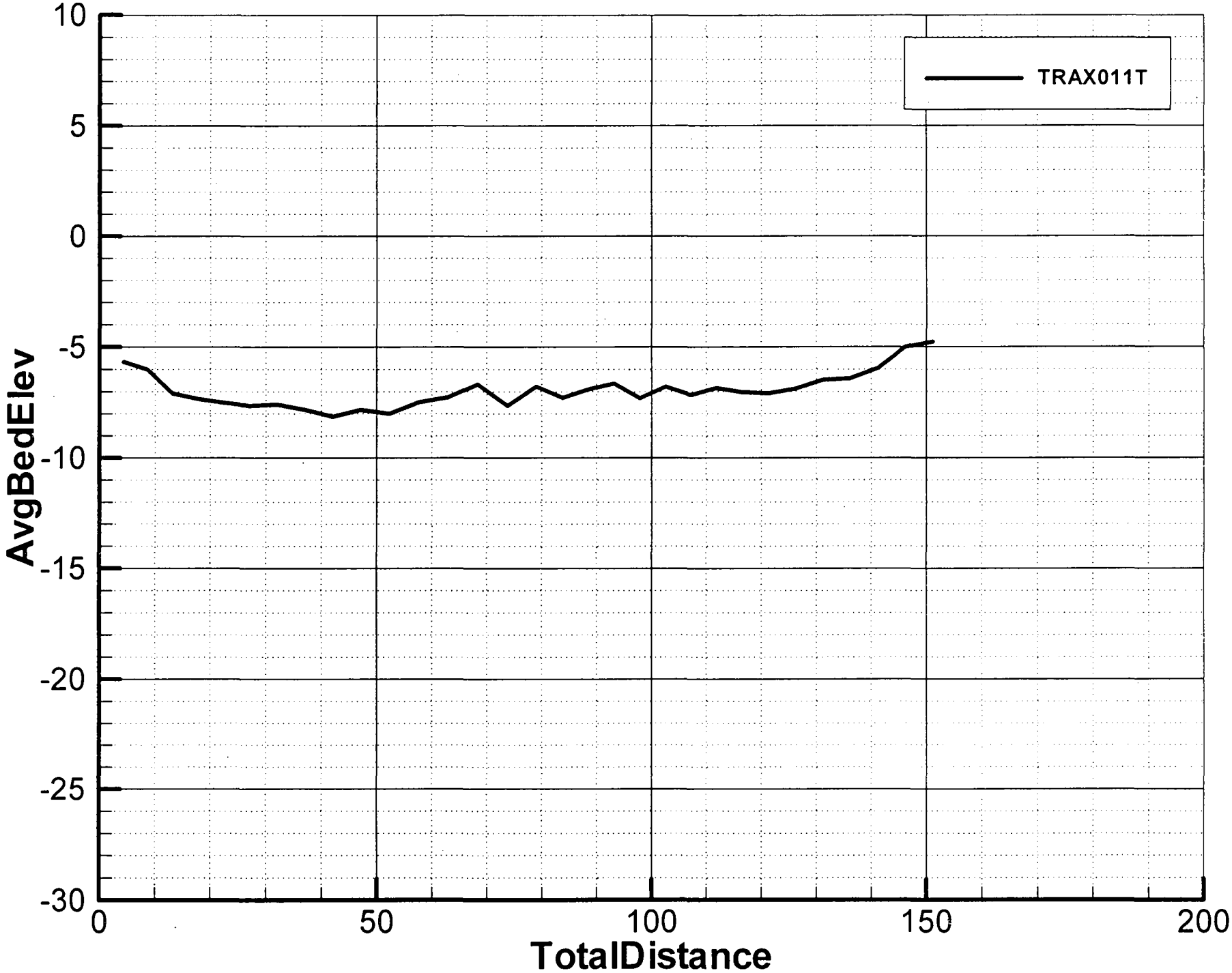
Frame 001 : 12 Jul 1999 : TRAX BOTTOM PROFILE



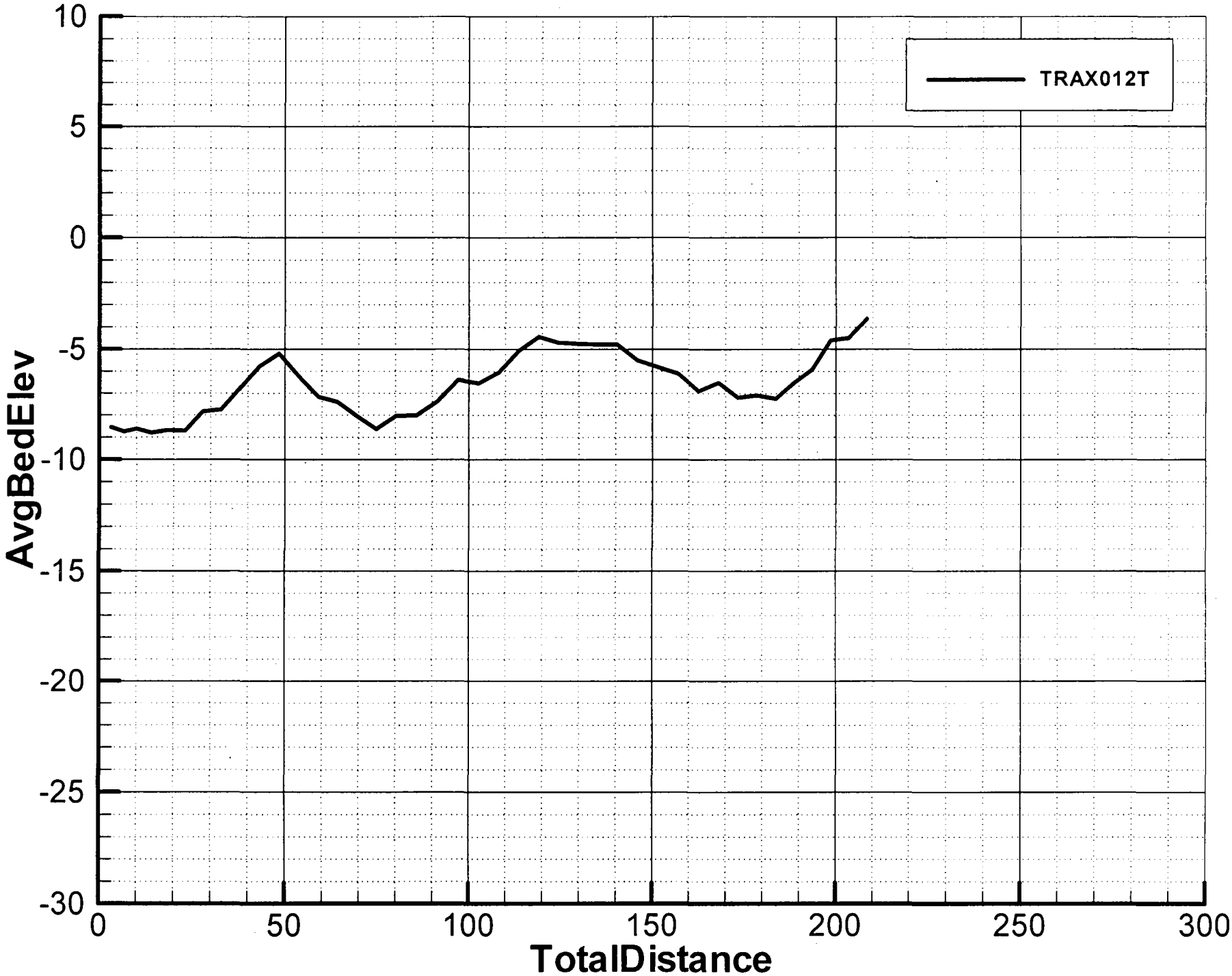
Frame 001 | 12 Jul 1999 : TRAX BOTTOM PROFILE



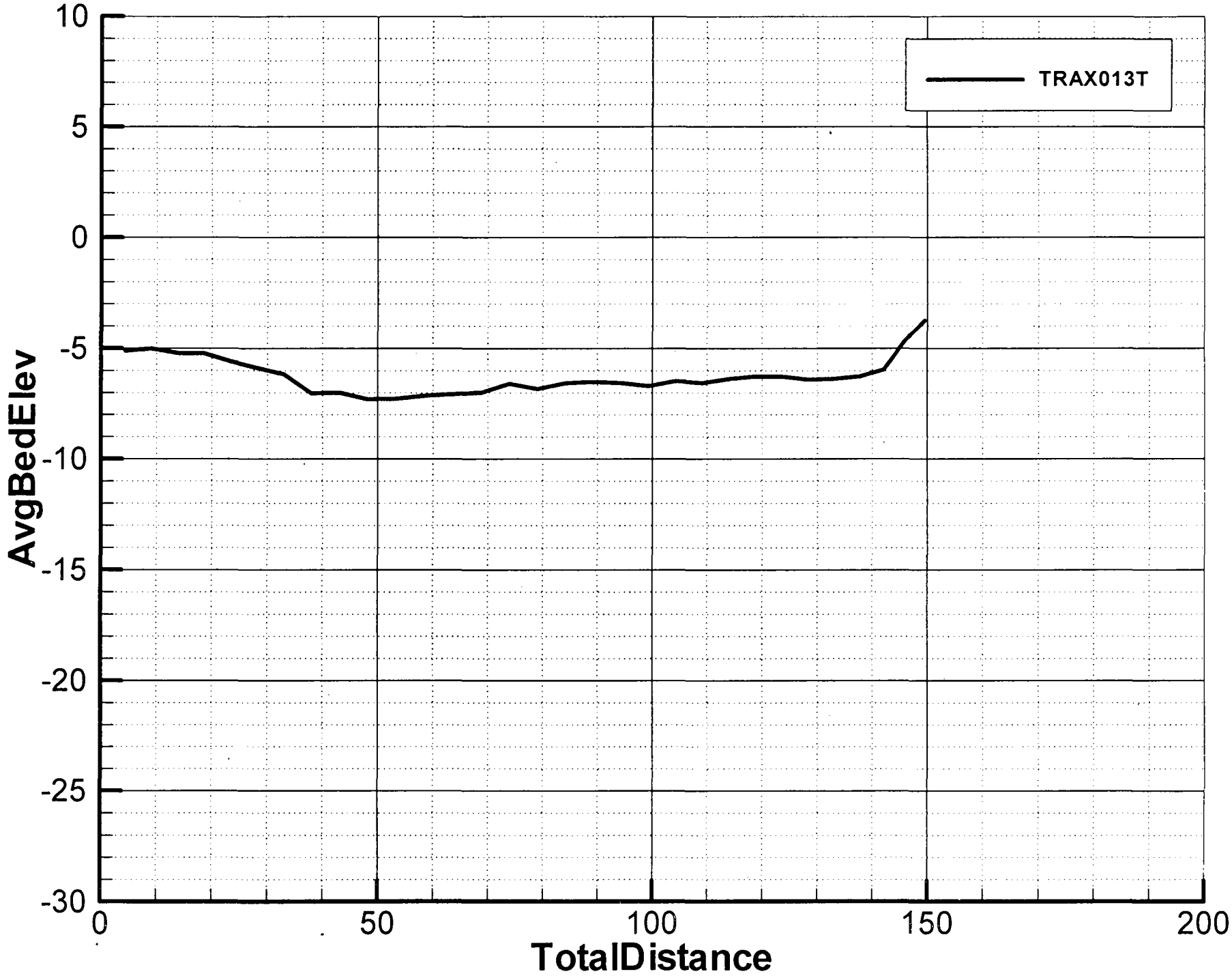
Frame 001 | 12 Jul 1999 | TRAX BOTTOM PROFILE



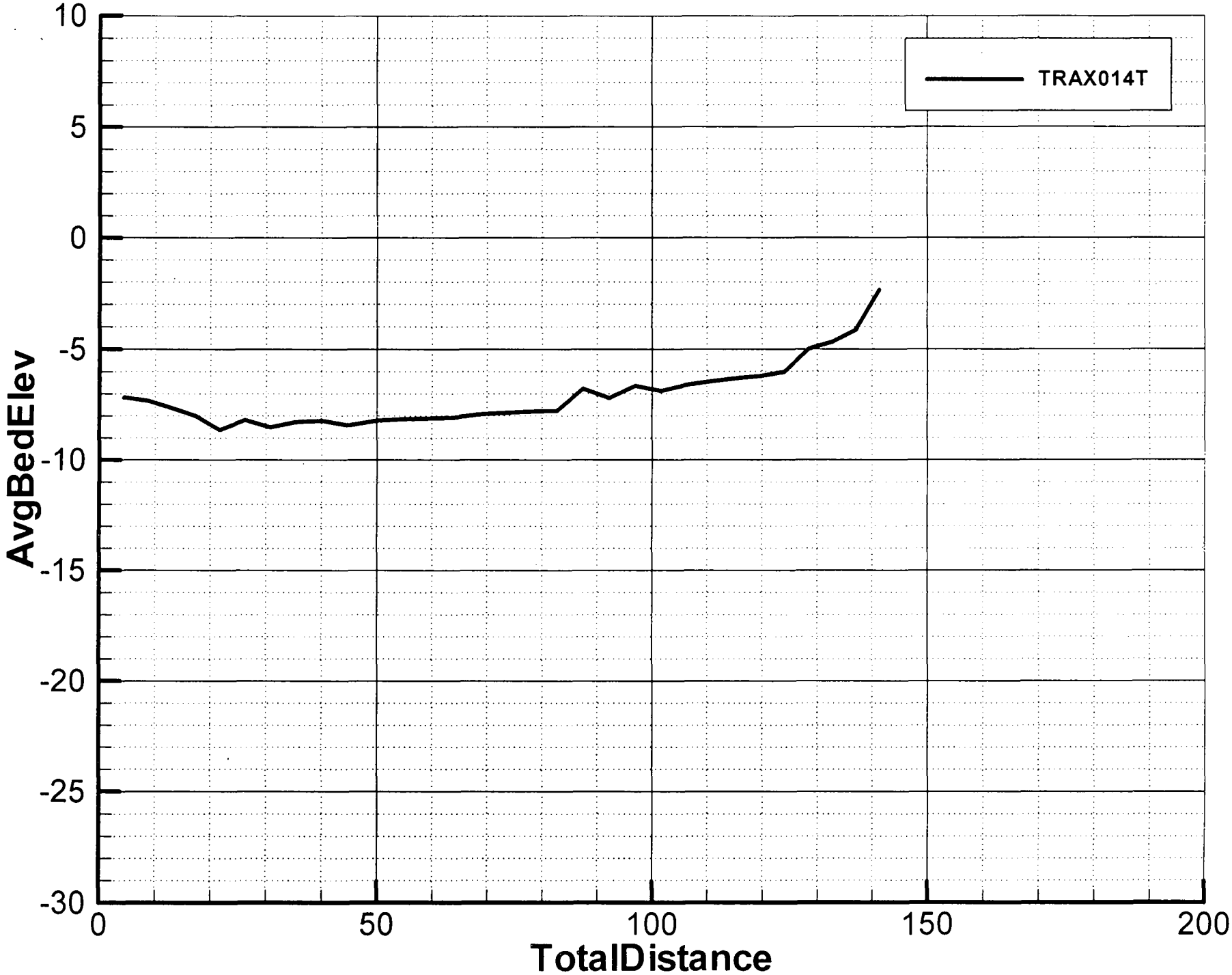
Frame 001 | 12 Jul 1999 | TRAX BOTTOM PROFILE



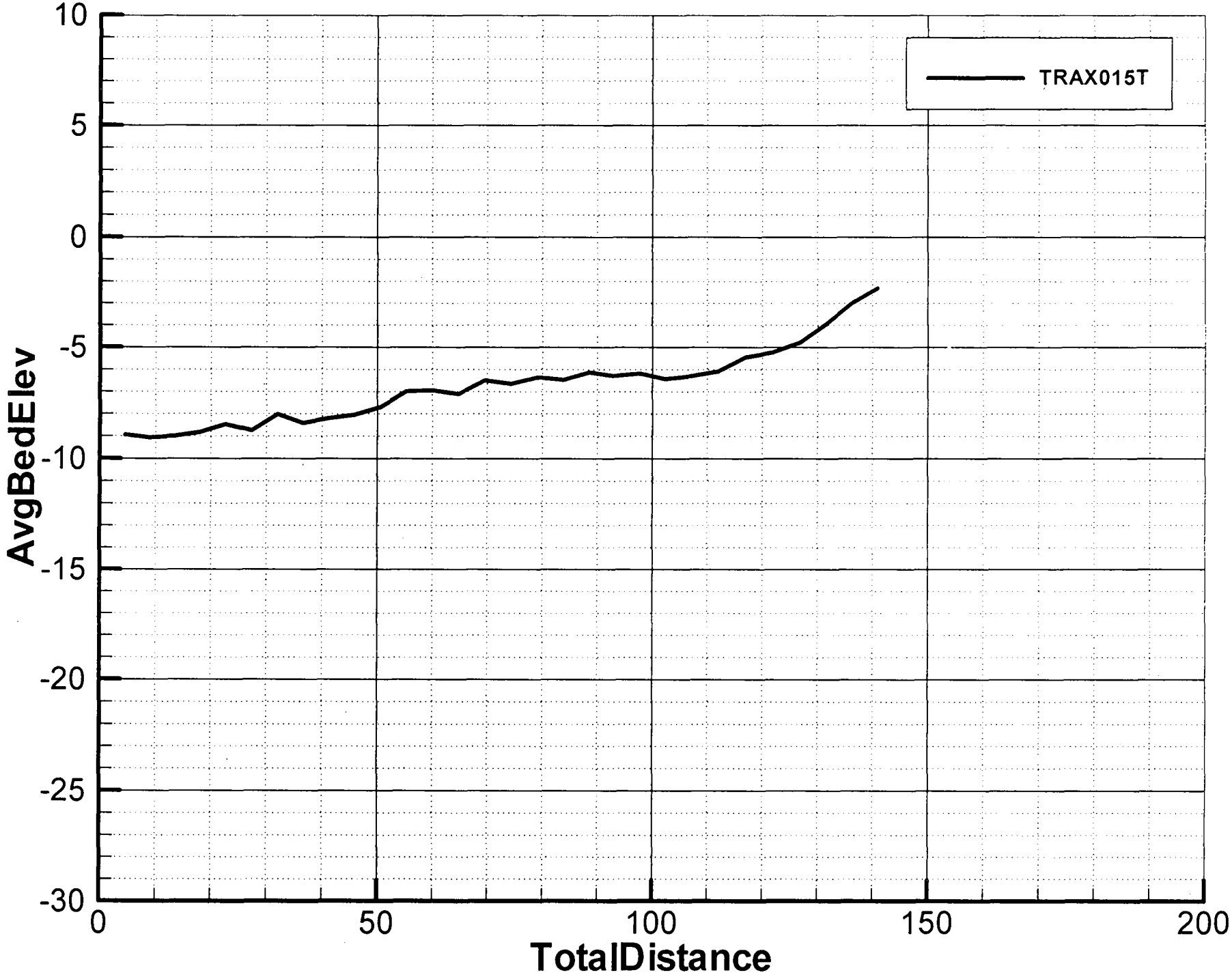
Frame 001 : 12 Jul 1999 | TRAX BOTTOM PROFILE



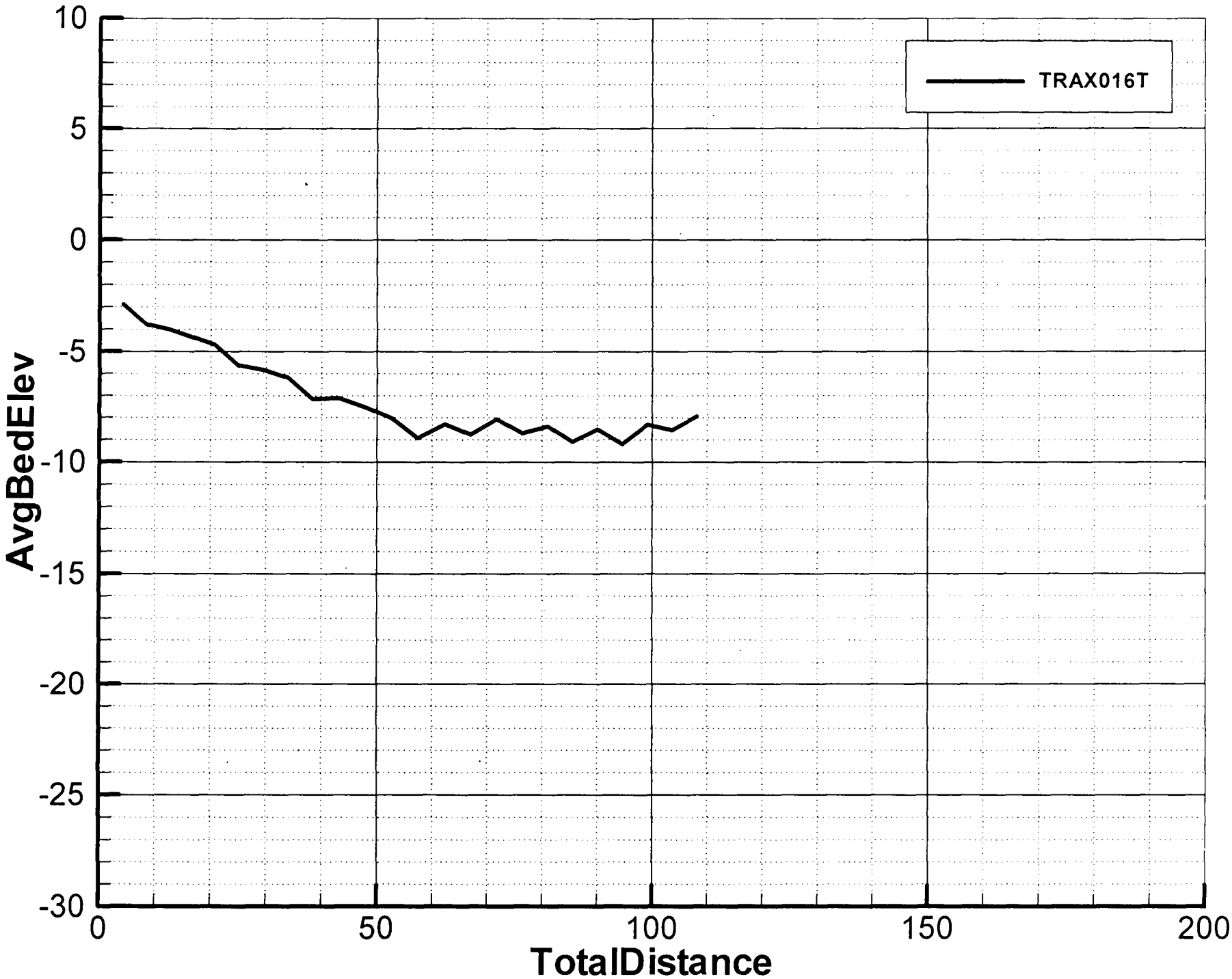
Frame 001 | 12 Jul 1999 | TRAX BOTTOM PROFILE



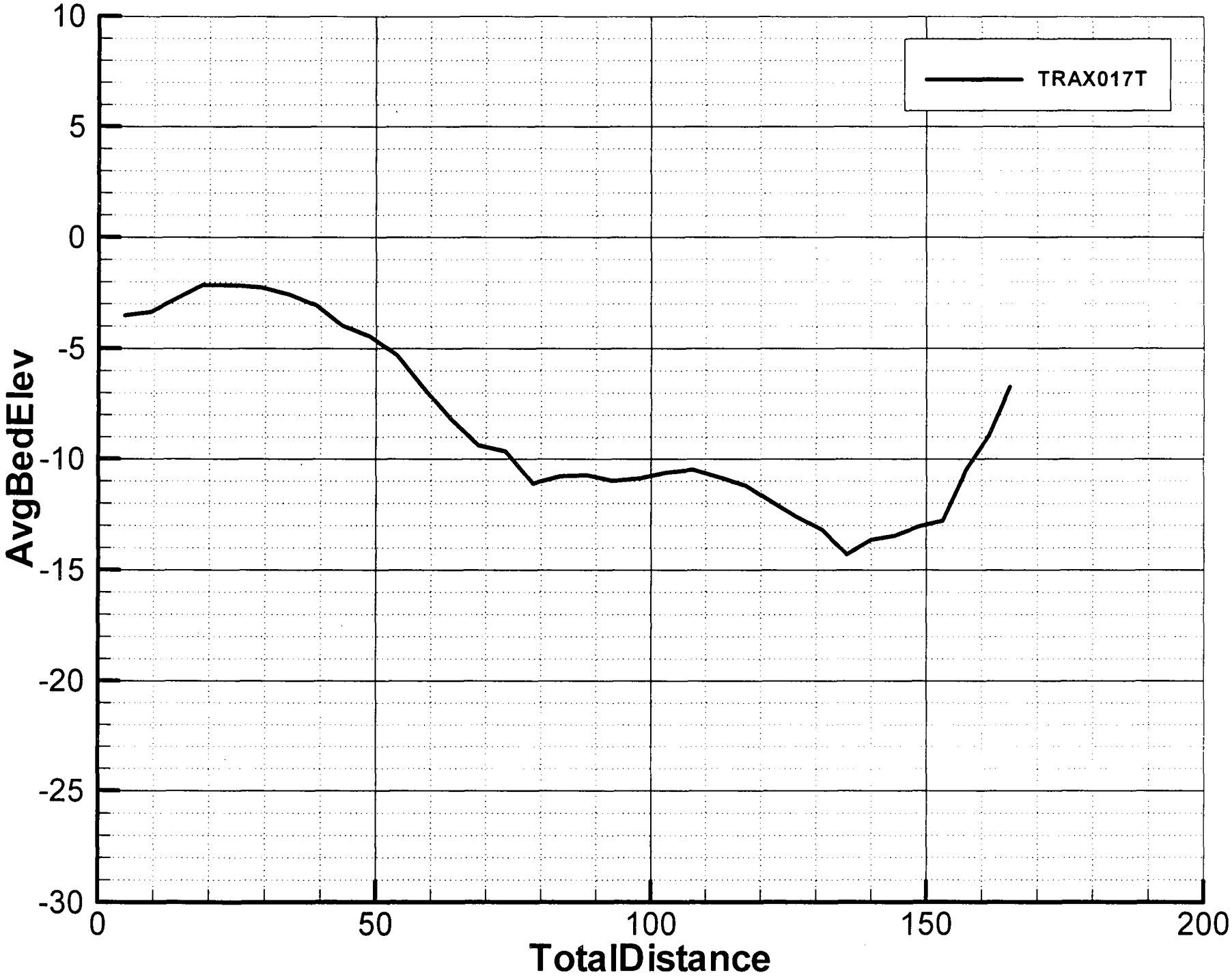
Frame 001 | 12 Jul 1999 | TRAX BOTTOM PROFILE



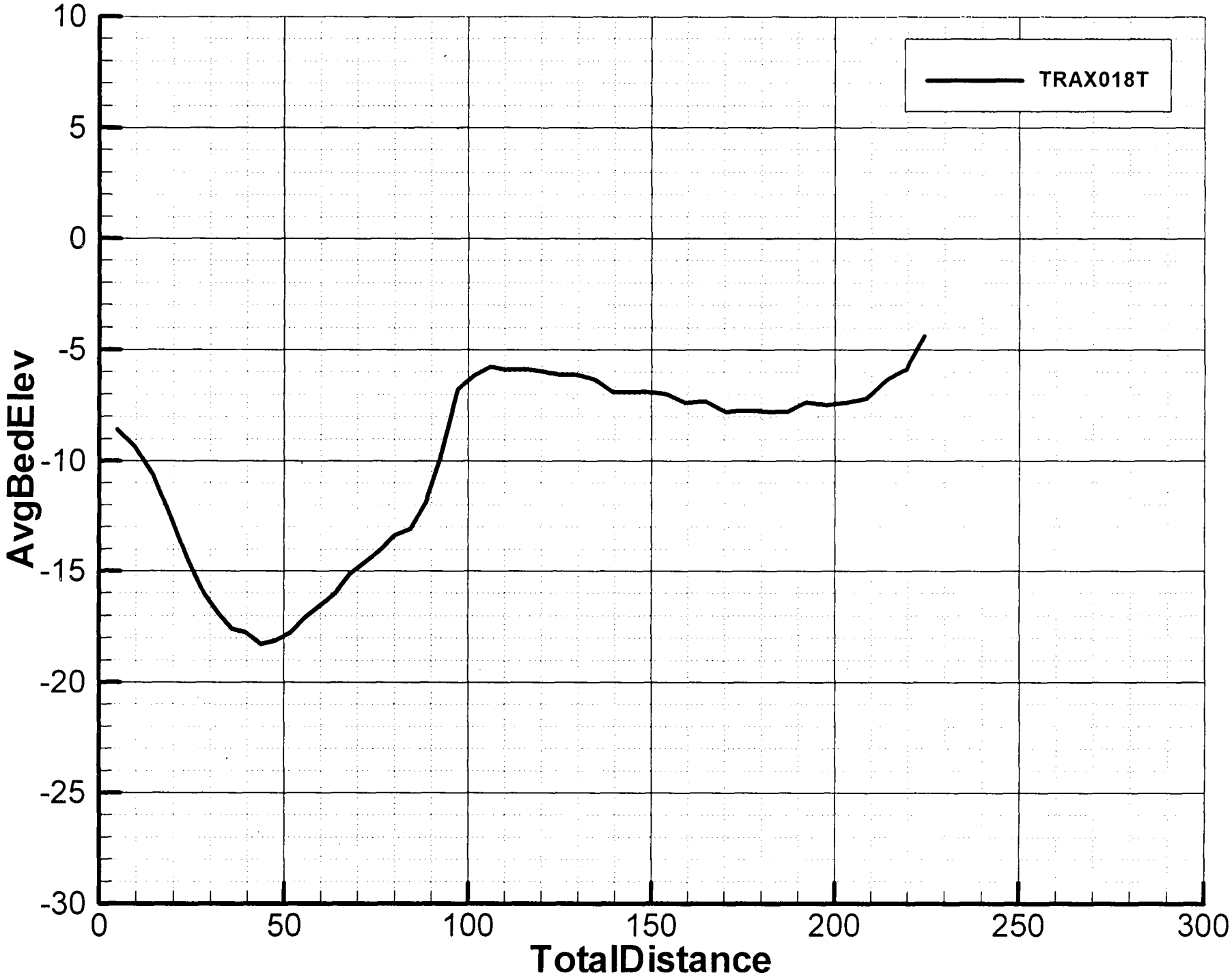
Frame 001 | 12 Jul 1999 | TRAX BOTTOM PROFILE

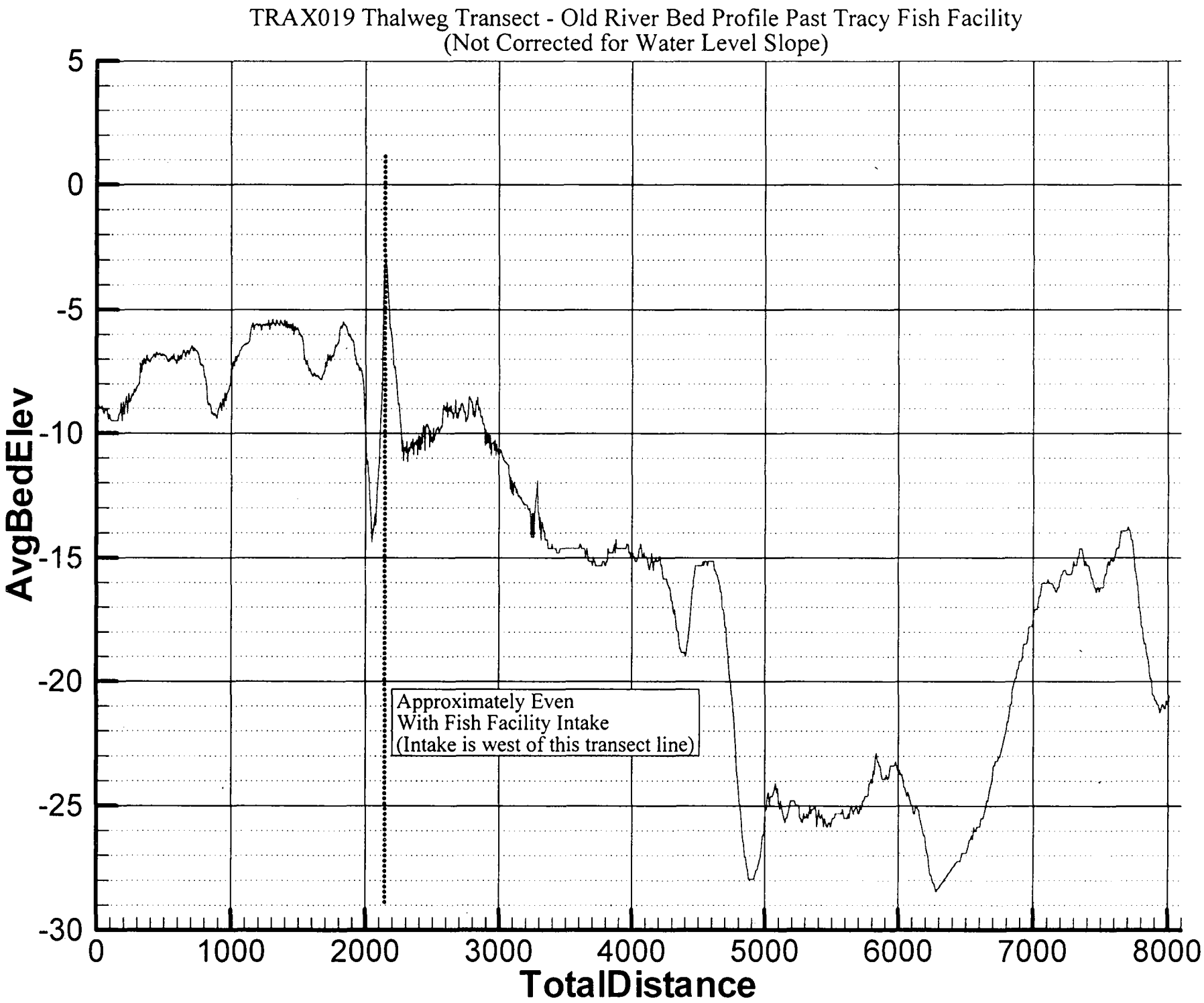


Frame 001 | 12 Jul 1999 | TRAX BOTTOM PROFILE



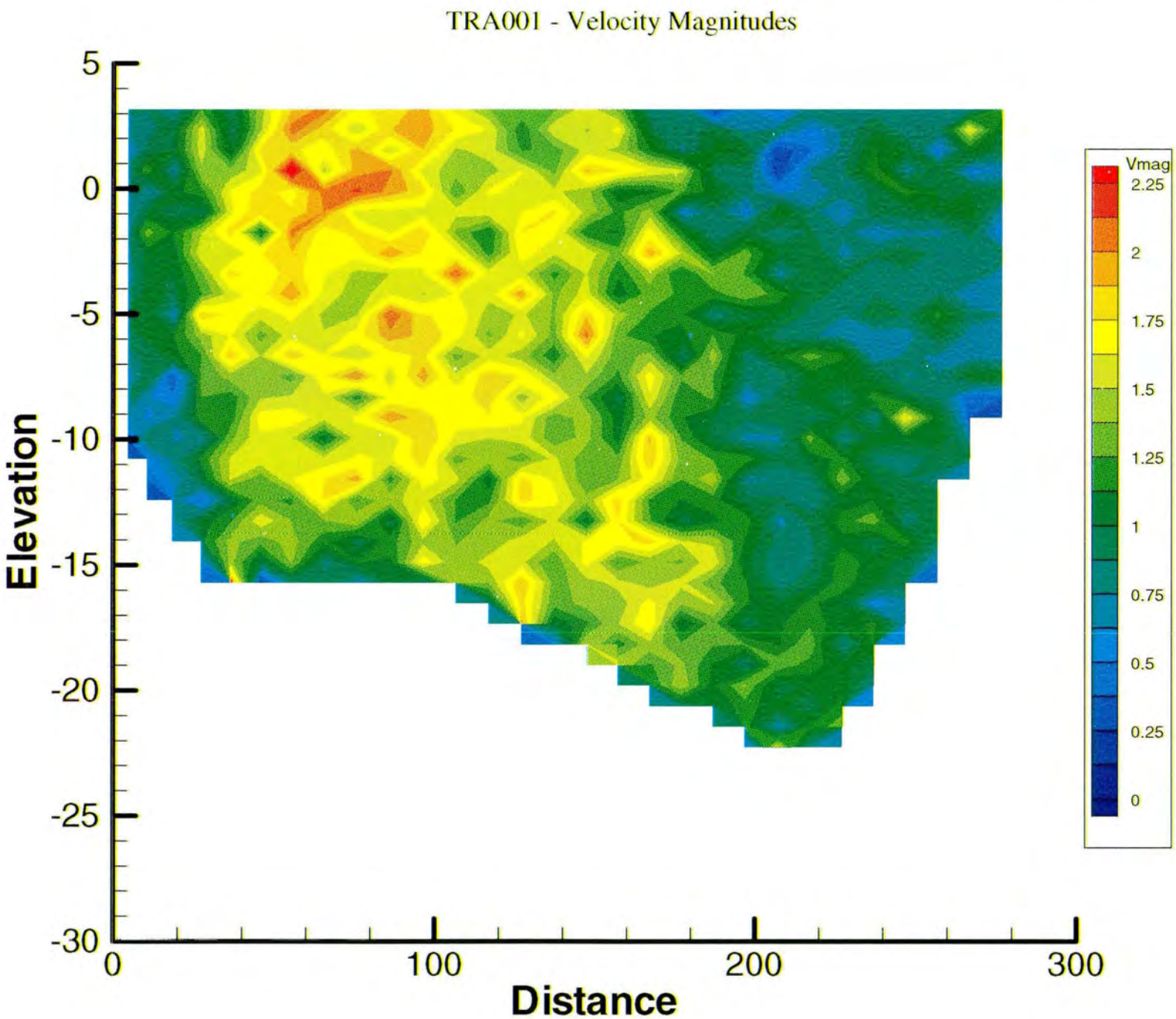
Frame 001 : 12 Jul 1999 | TRAX BOTTOM PROFILE



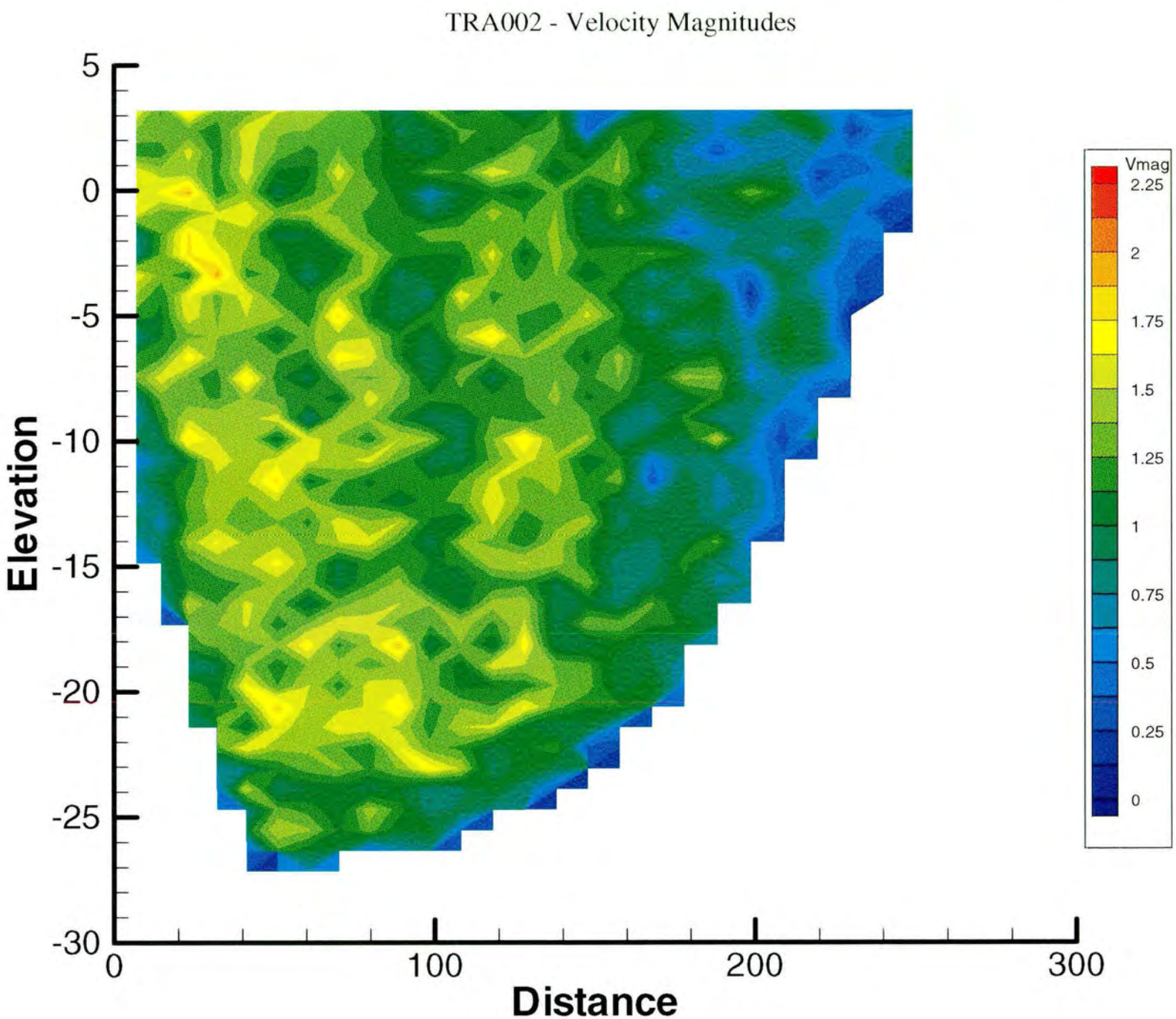

TRAX019 Thalweg Transect - Old River Bed Profile Past Tracy Fish Facility
(Not Corrected for Water Level Slope)
AvgBedElev
5
0
-5
-10
-15
-20
-25
-30
0
1000
2000
3000
4000
5000
6000
7000
8000
TotalDistance
Approximately Even
With Fish Facility Intake
(Intake is west of this transect line)

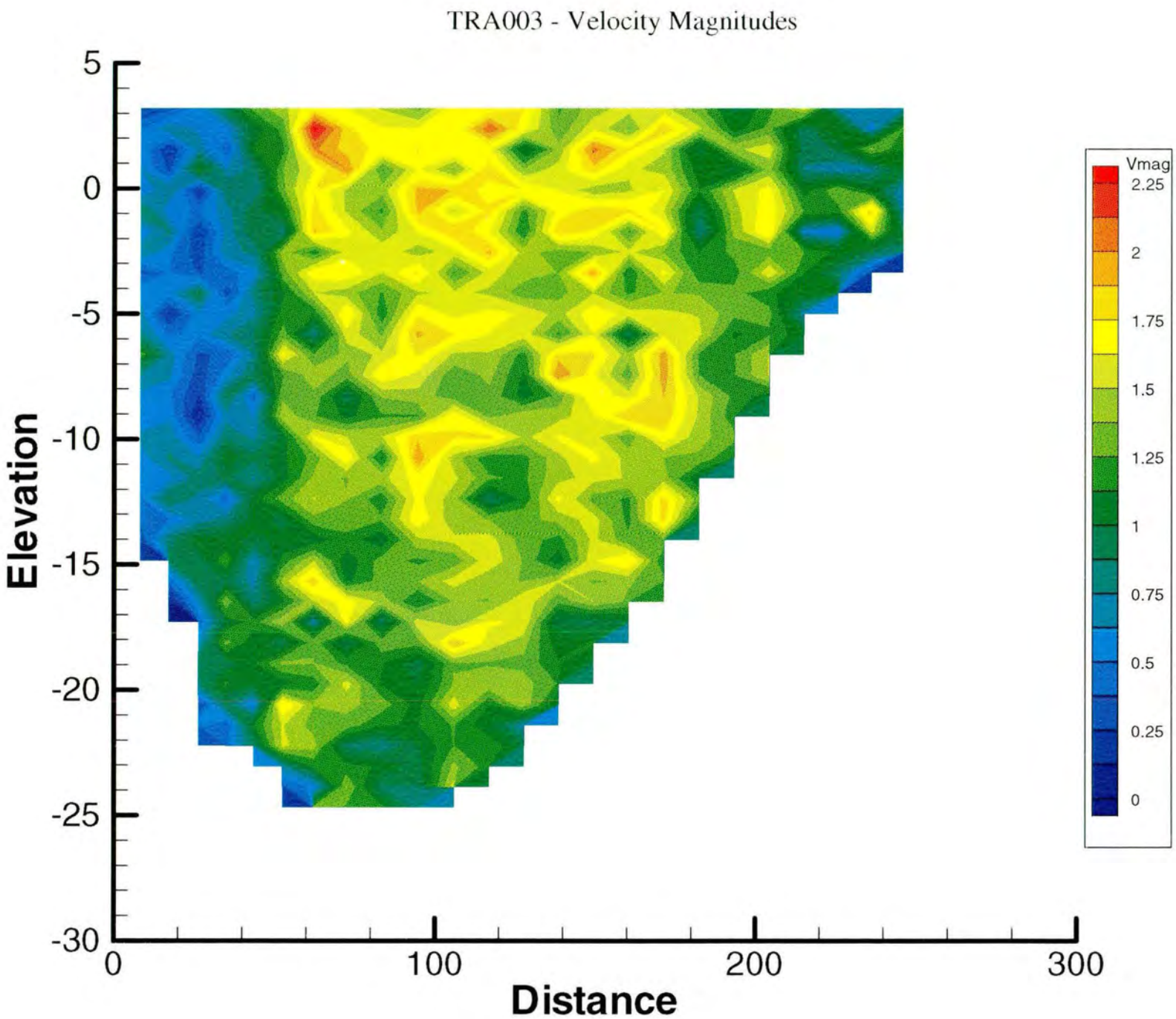
APPENDIX C

VELOCITY PROFILE PLOTS

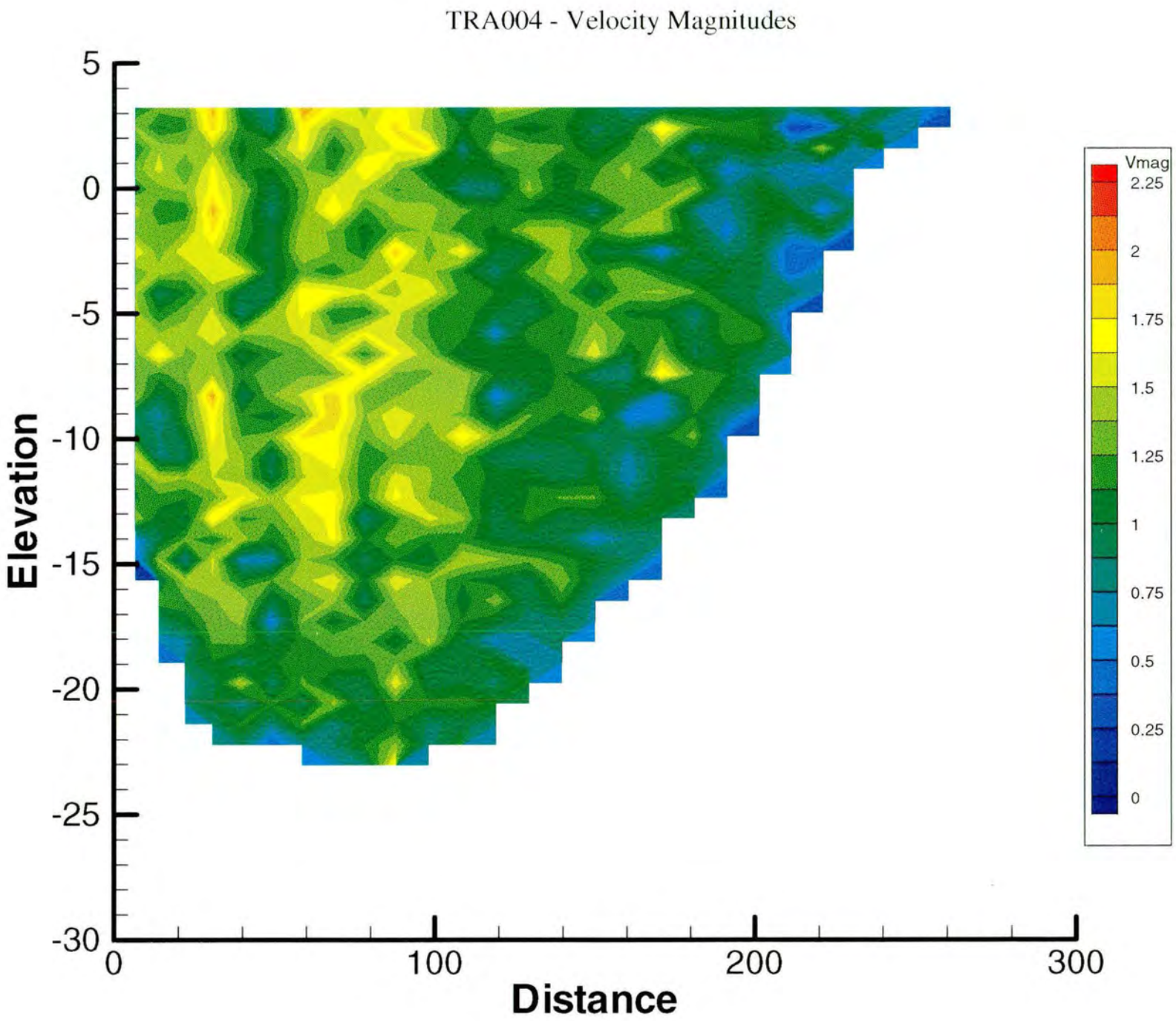

TRA001 - Velocity Magnitudes
Elevation
5
0
-5
-10
-15
-20
-25
-30
0
100
200
300
Distance
Vmag
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0

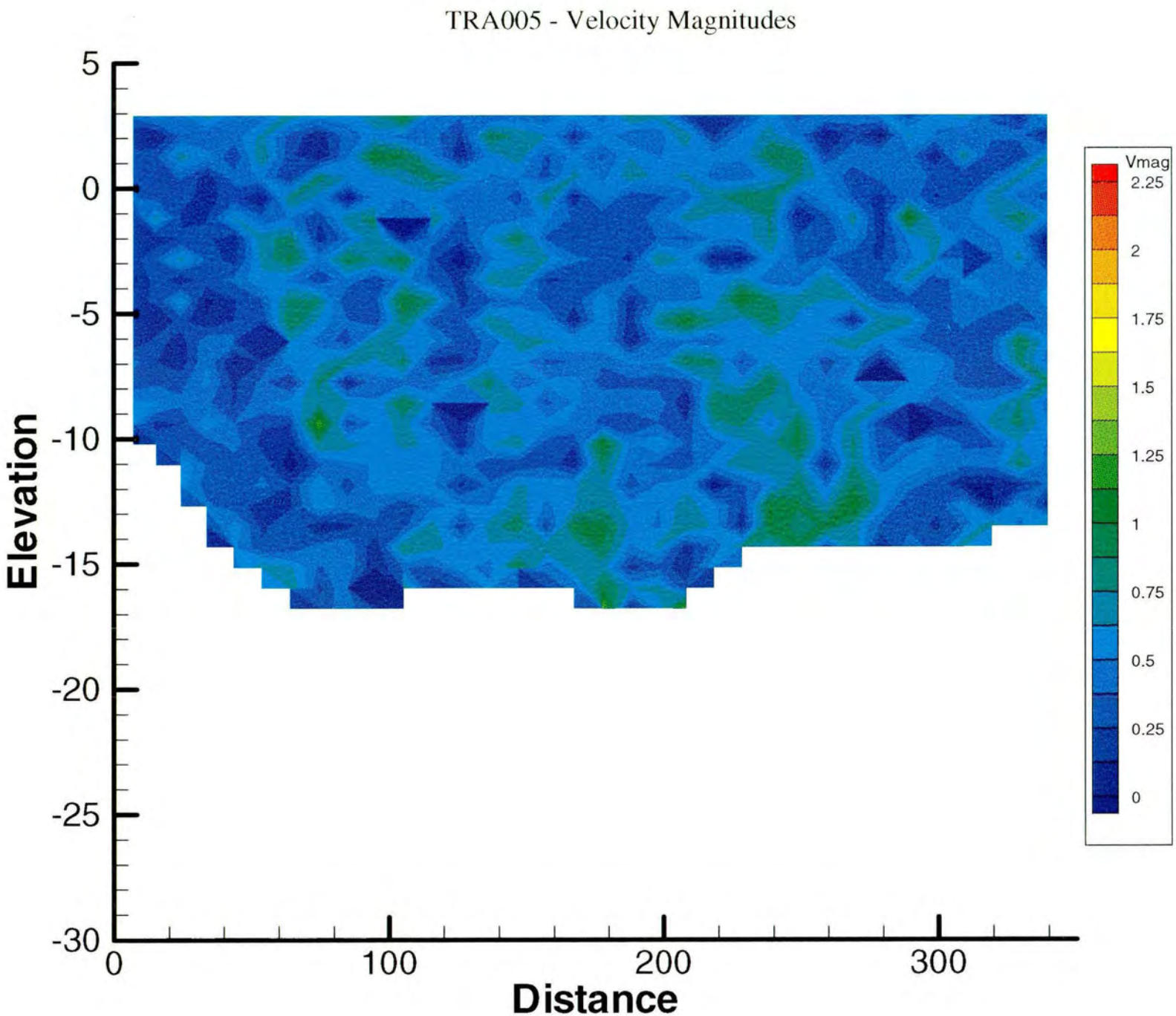
Frame 001 | 15 Jul 1999 | TRA TRANSECT DATA

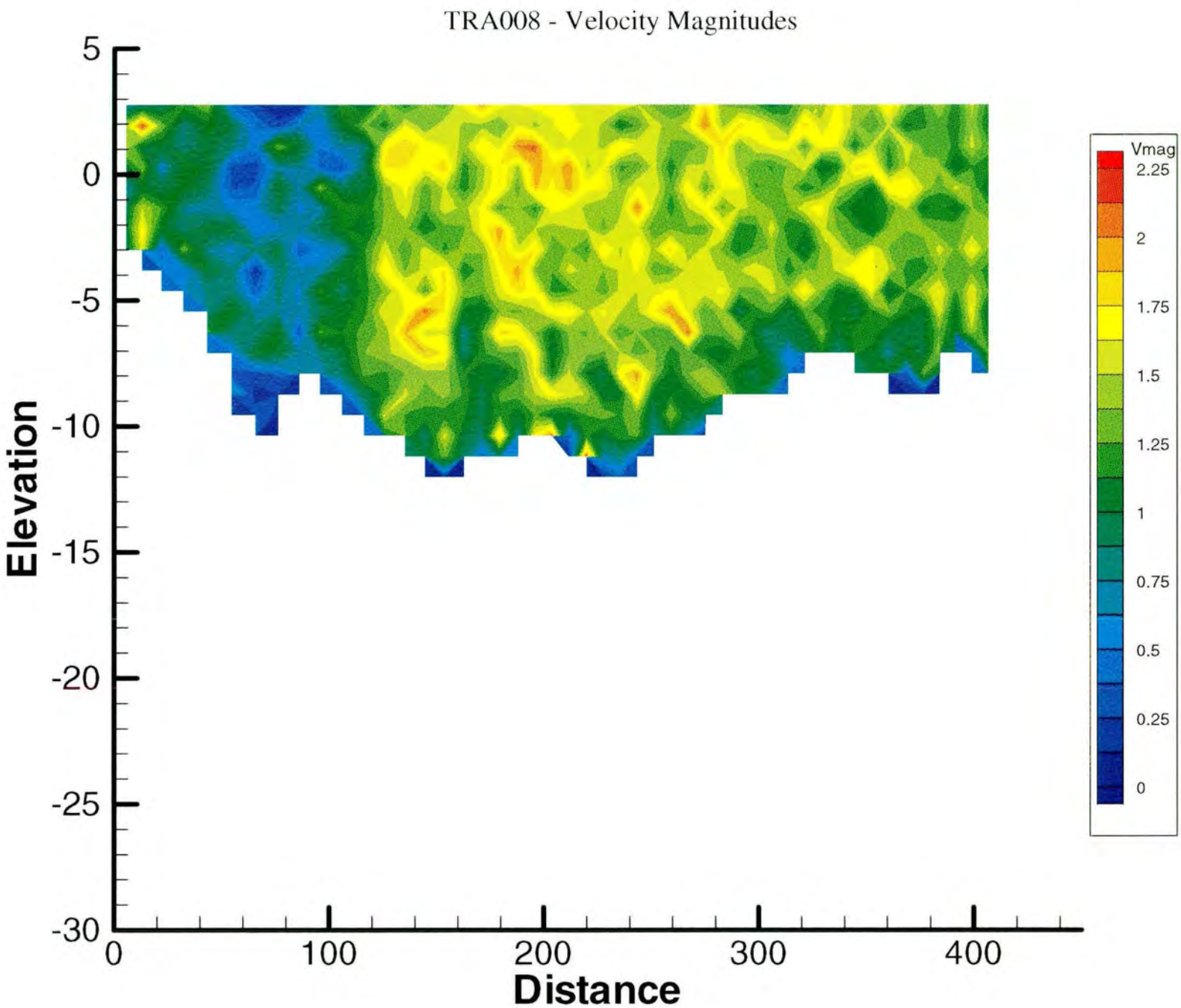


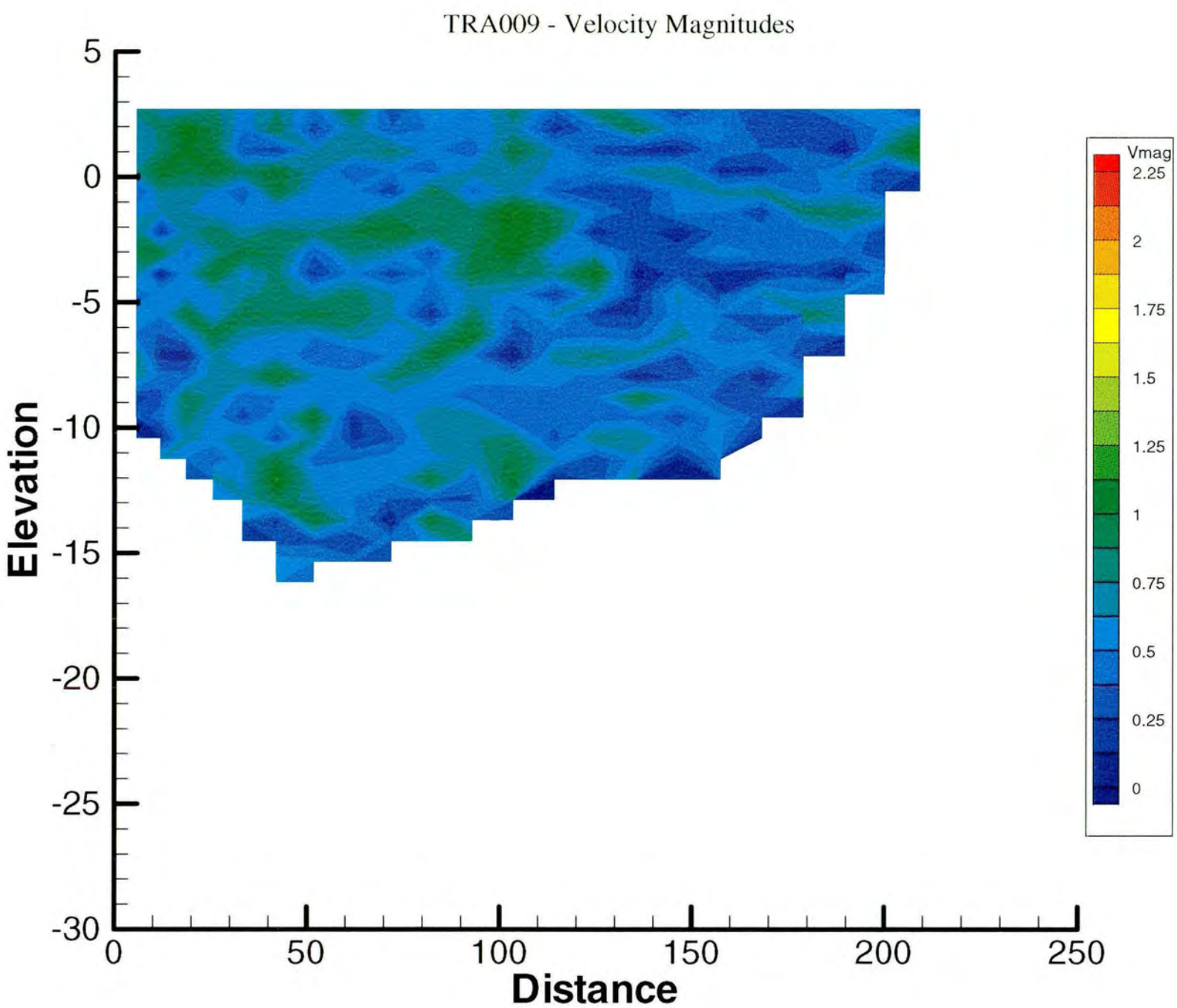

TRA003 - Velocity Magnitudes
Elevation
5
0
-5
-10
-15
-20
-25
-30
0
100
200
300
Distance
Vmag
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0

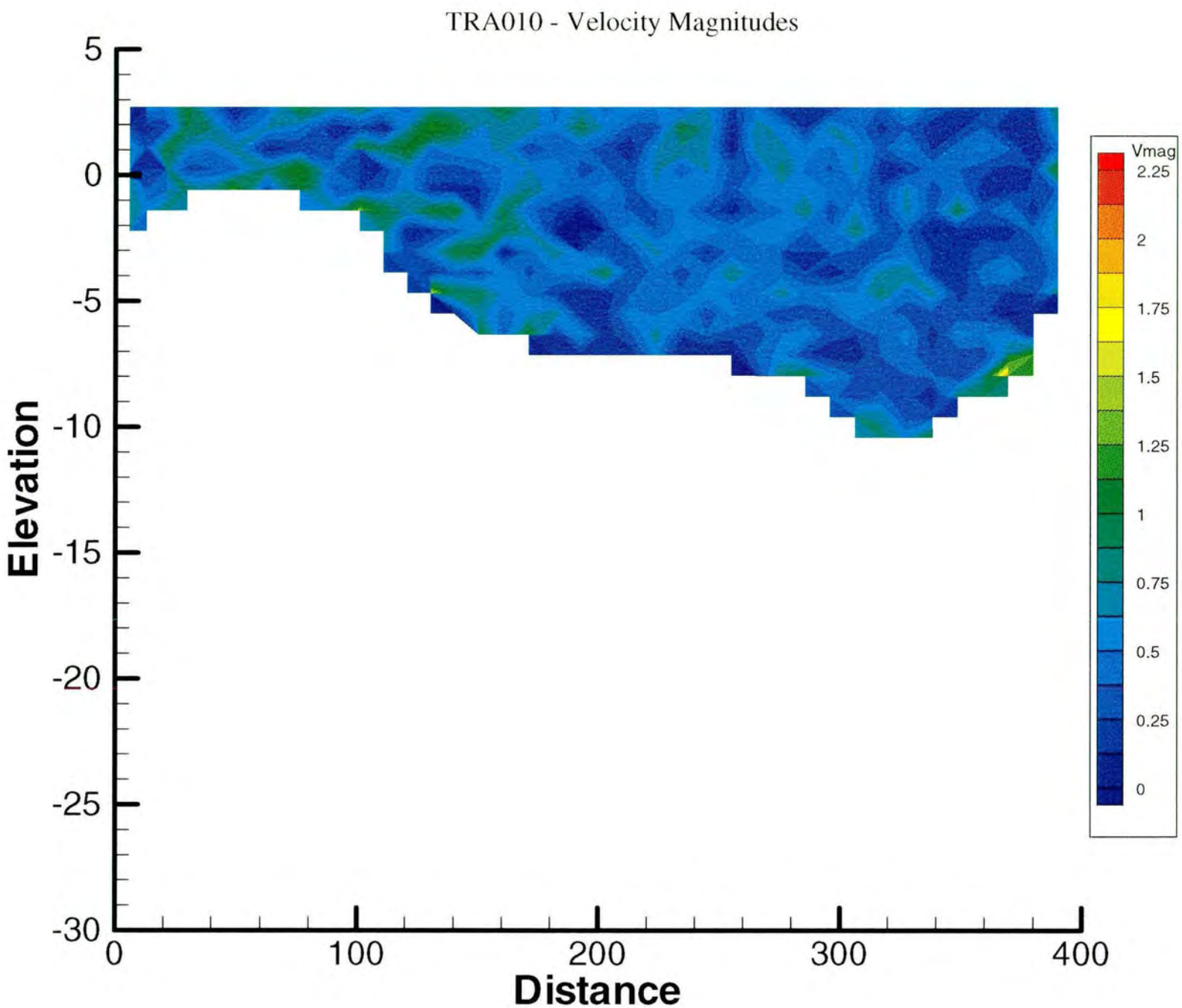
Frame 001 | 15 Jul 1999 | TRA TRANSECT DATA

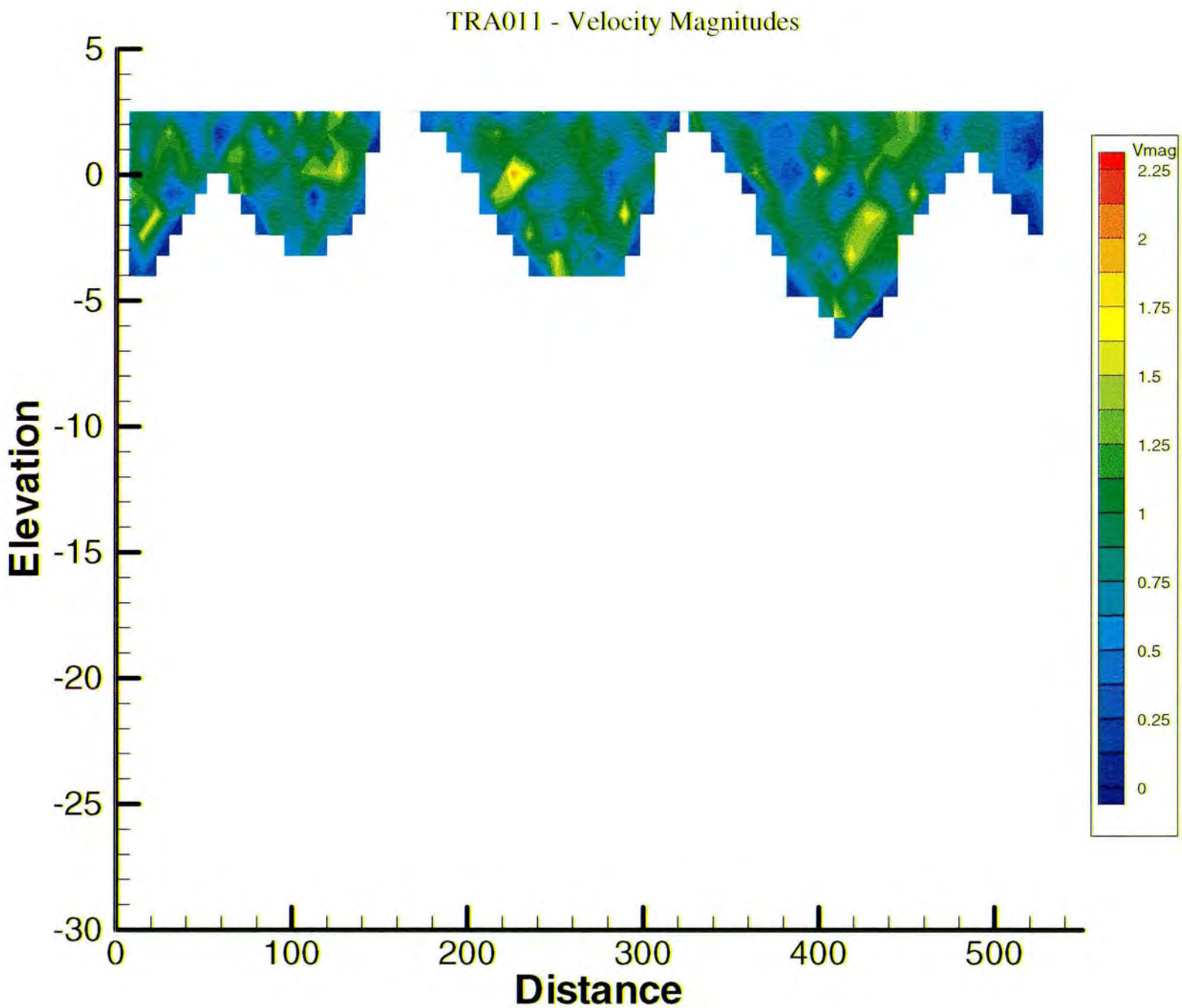



TRA005 - Velocity Magnitudes
Elevation
5
0
-5
-10
-15
-20
-25
-30
0
100
200
300
Distance
Vmag
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0

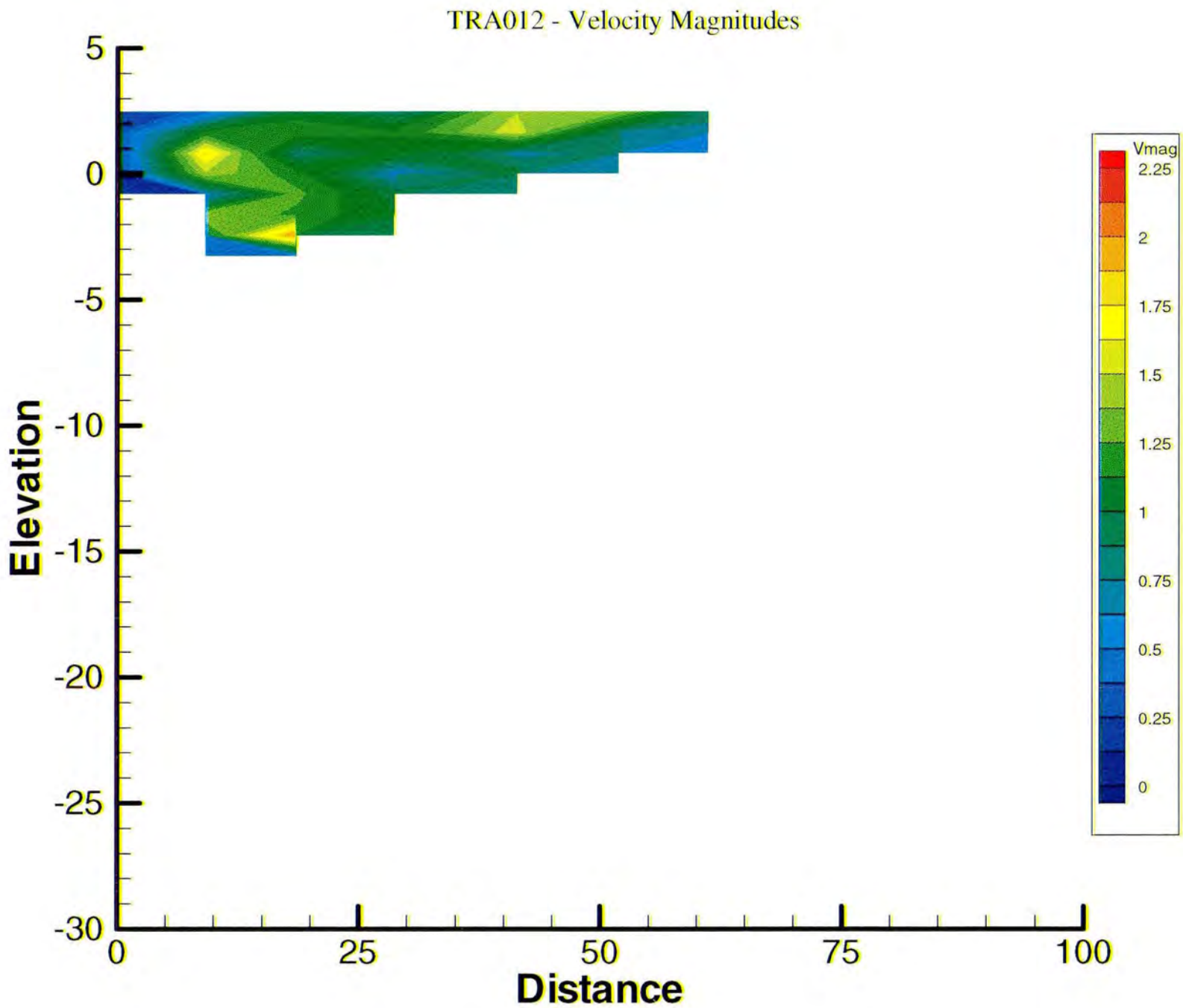

TRA008 - Velocity Magnitudes
Elevation
5
0
-5
-10
-15
-20
-25
-30
0
100
200
300
400
Distance
Vmag
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0

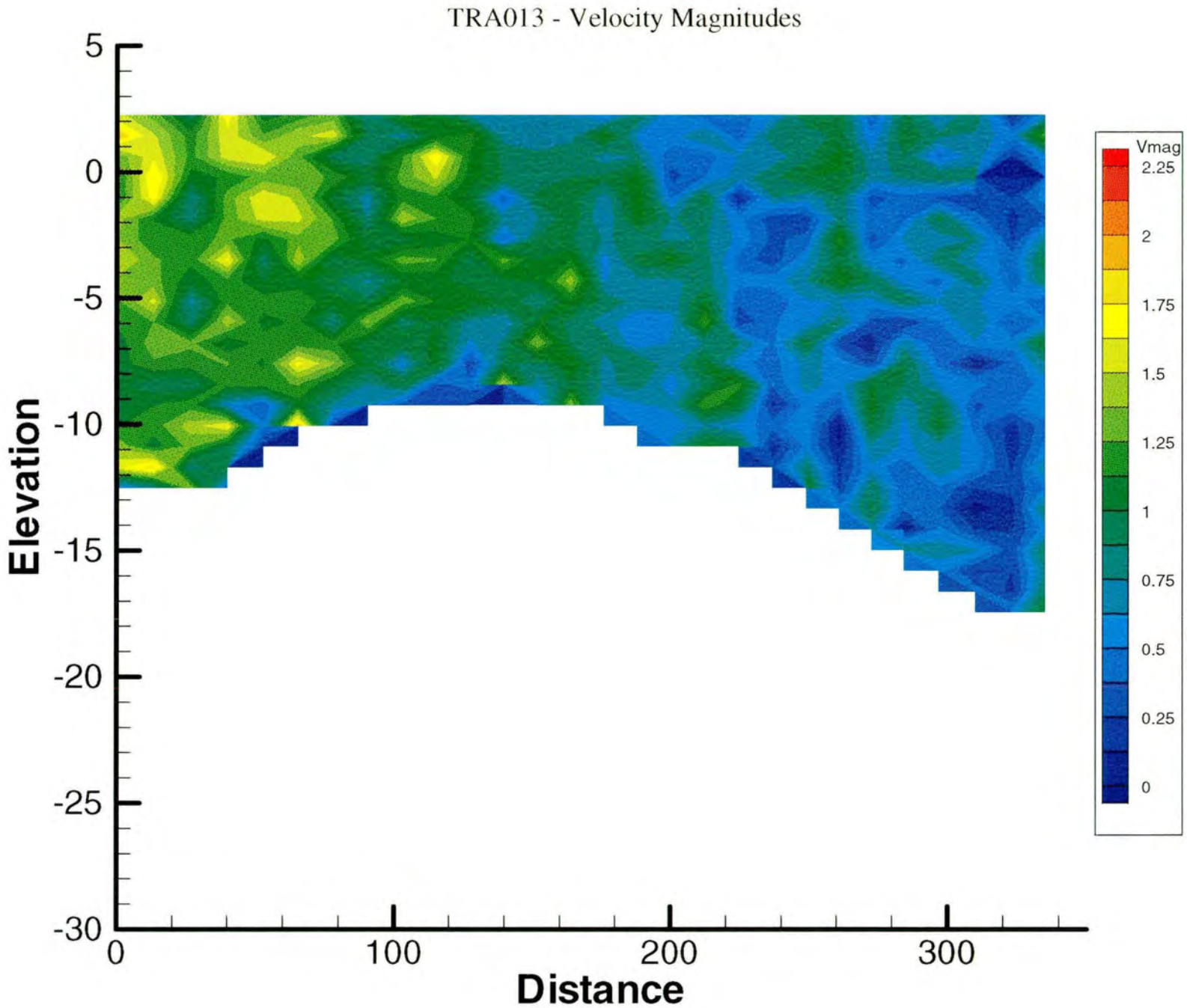

TRA009 - Velocity Magnitudes
Elevation
5
0
-5
-10
-15
-20
-25
-30
0
50
100
150
200
250
Distance
Vmag
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0


TRA010 - Velocity Magnitudes
Elevation
5
0
-5
-10
-15
-20
-25
-30
0
100
200
300
400
Distance
Vmag
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0

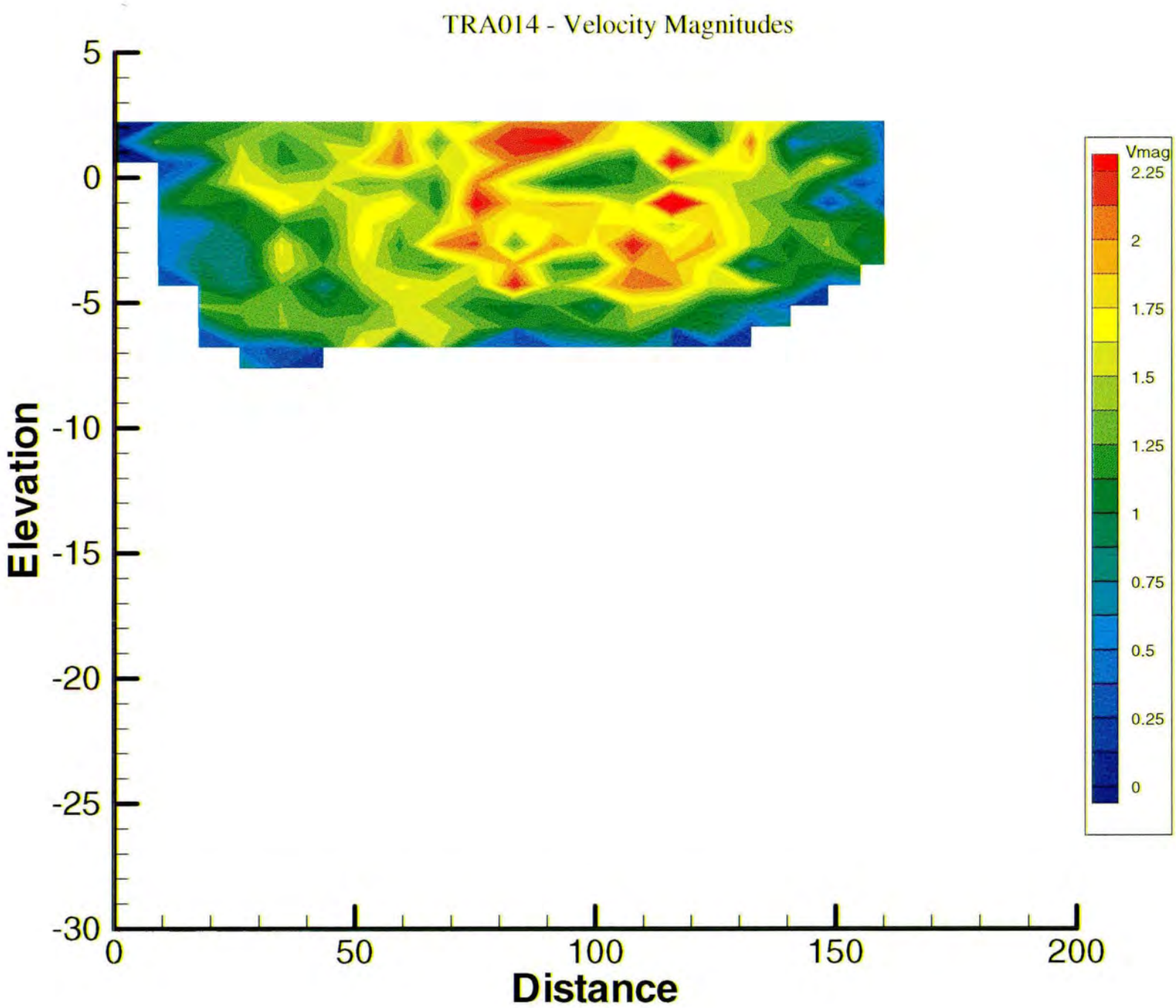

TRA011 - Velocity Magnitudes
Elevation
5
0
-5
-10
-15
-20
-25
-30
0
100
200
300
400
500
Distance
Vmag
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0

Frame 001 | 15 Jul 1999 | TRA TRANSECT DATA

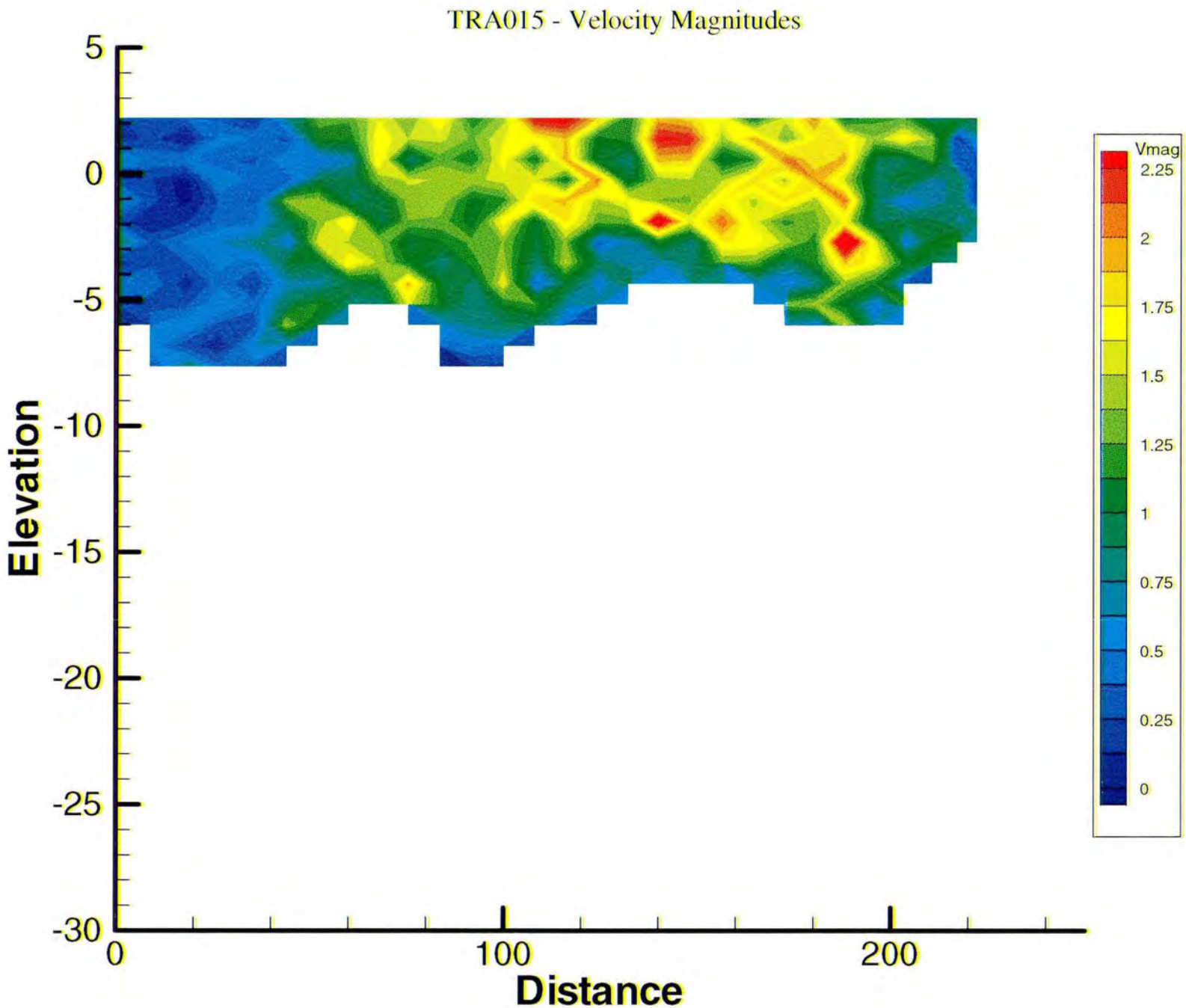


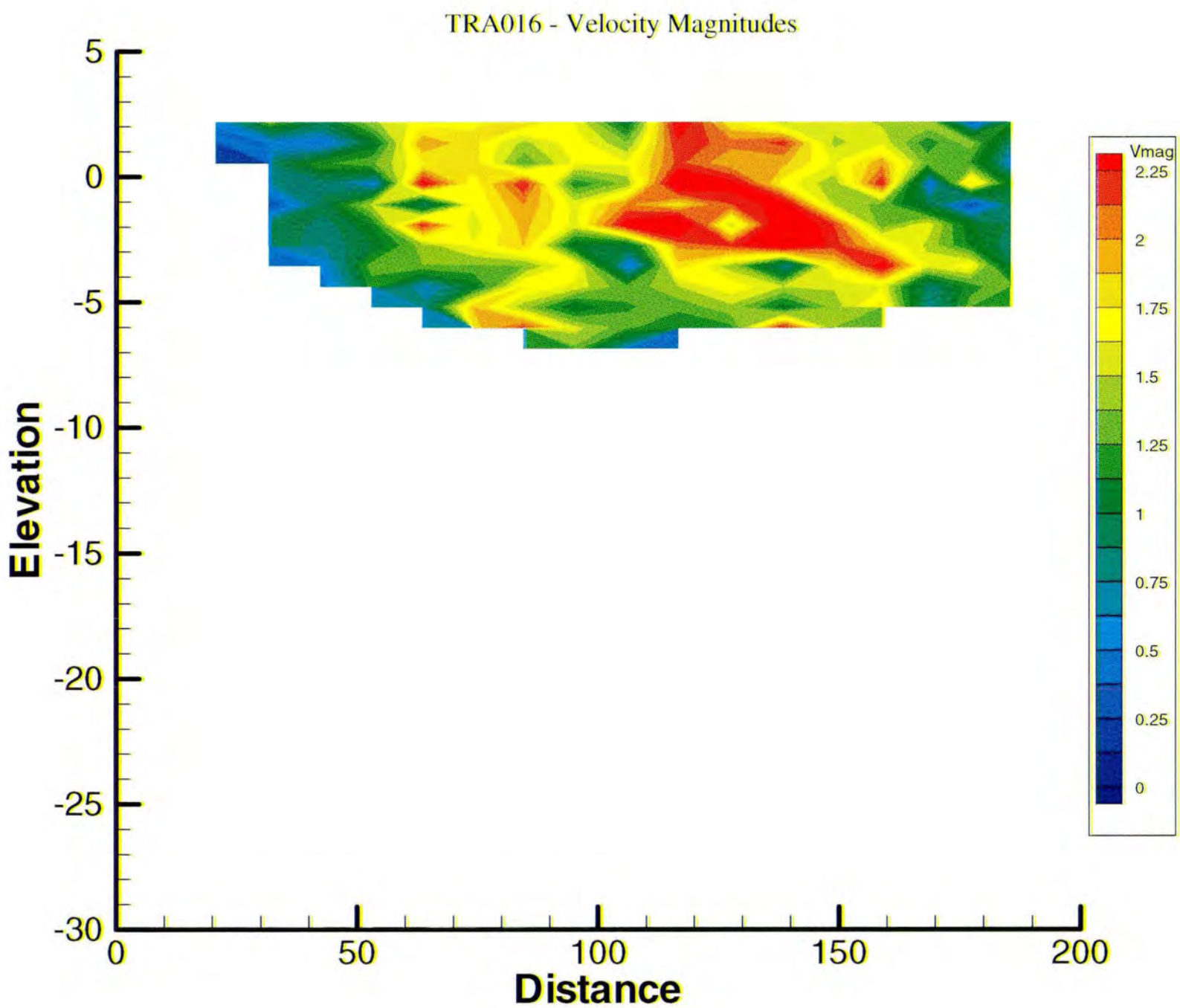

TRA013 - Velocity Magnitudes
Elevation
5
0
-5
-10
-15
-20
-25
-30
0
100
200
300
Distance
Vmag
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0

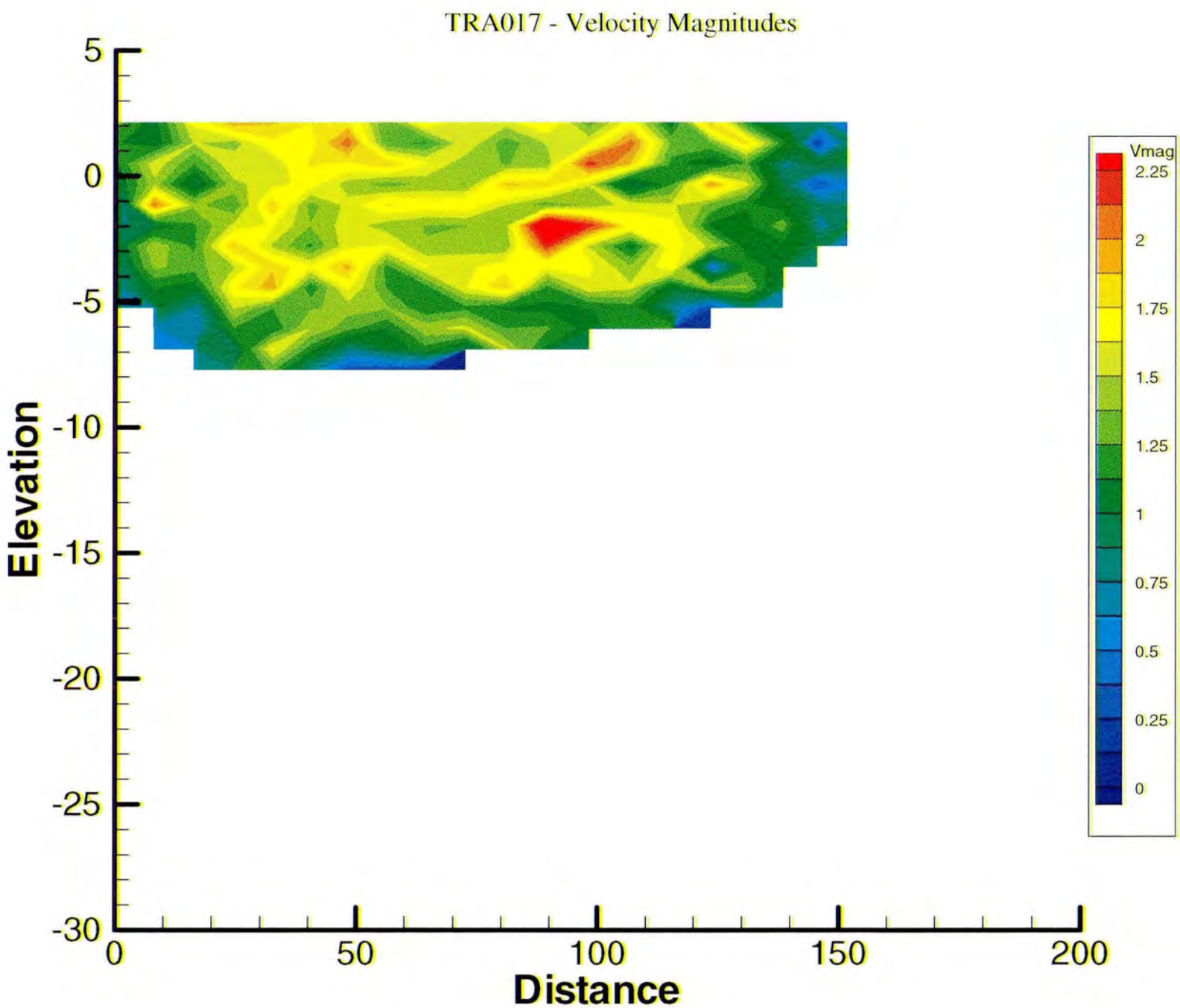
Frame 001 | 15 Jul 1999 | TRA TRANSECT DATA



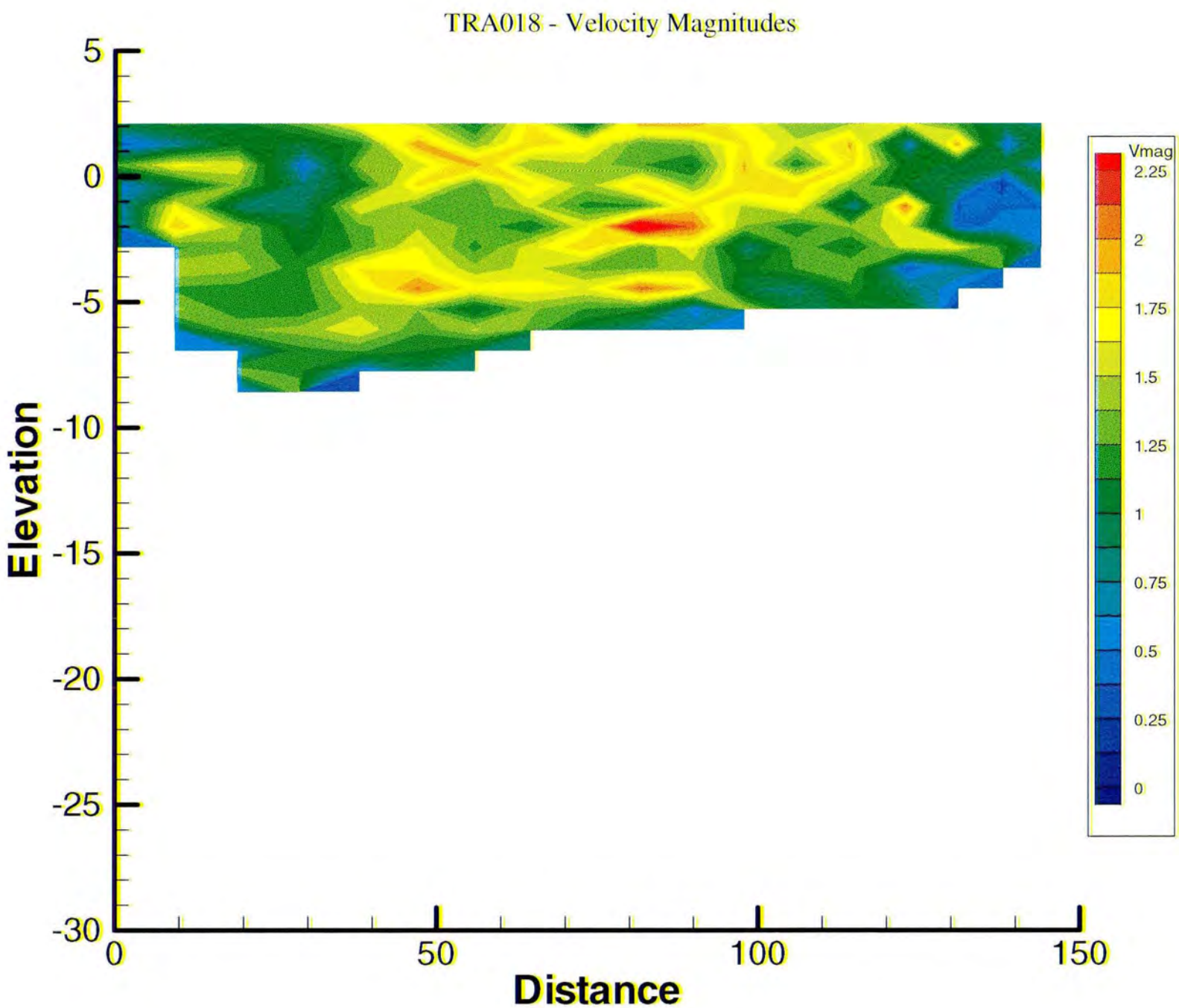
Frame 001 | 15 Jul 1999 | TRA TRANSECT DATA

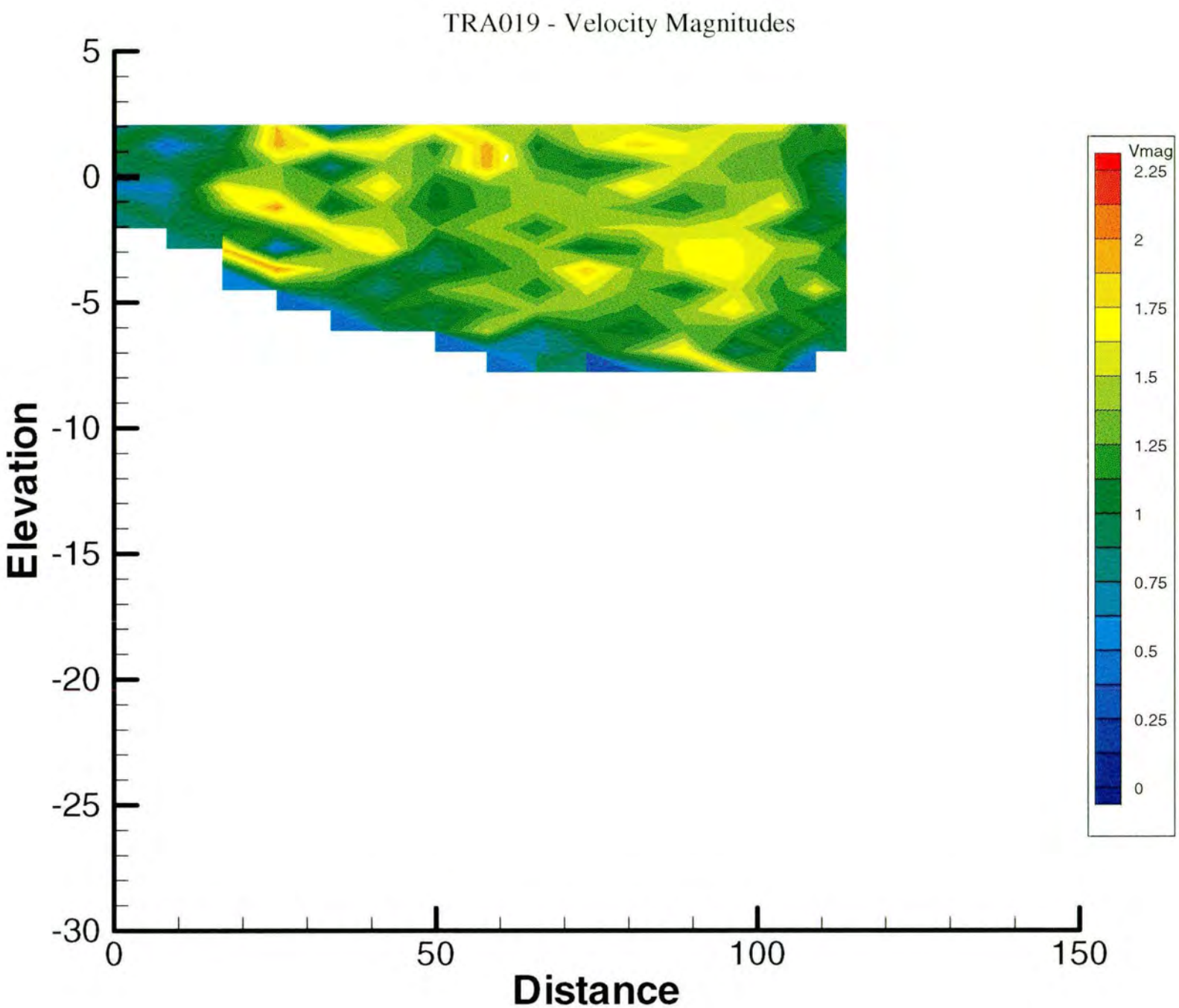


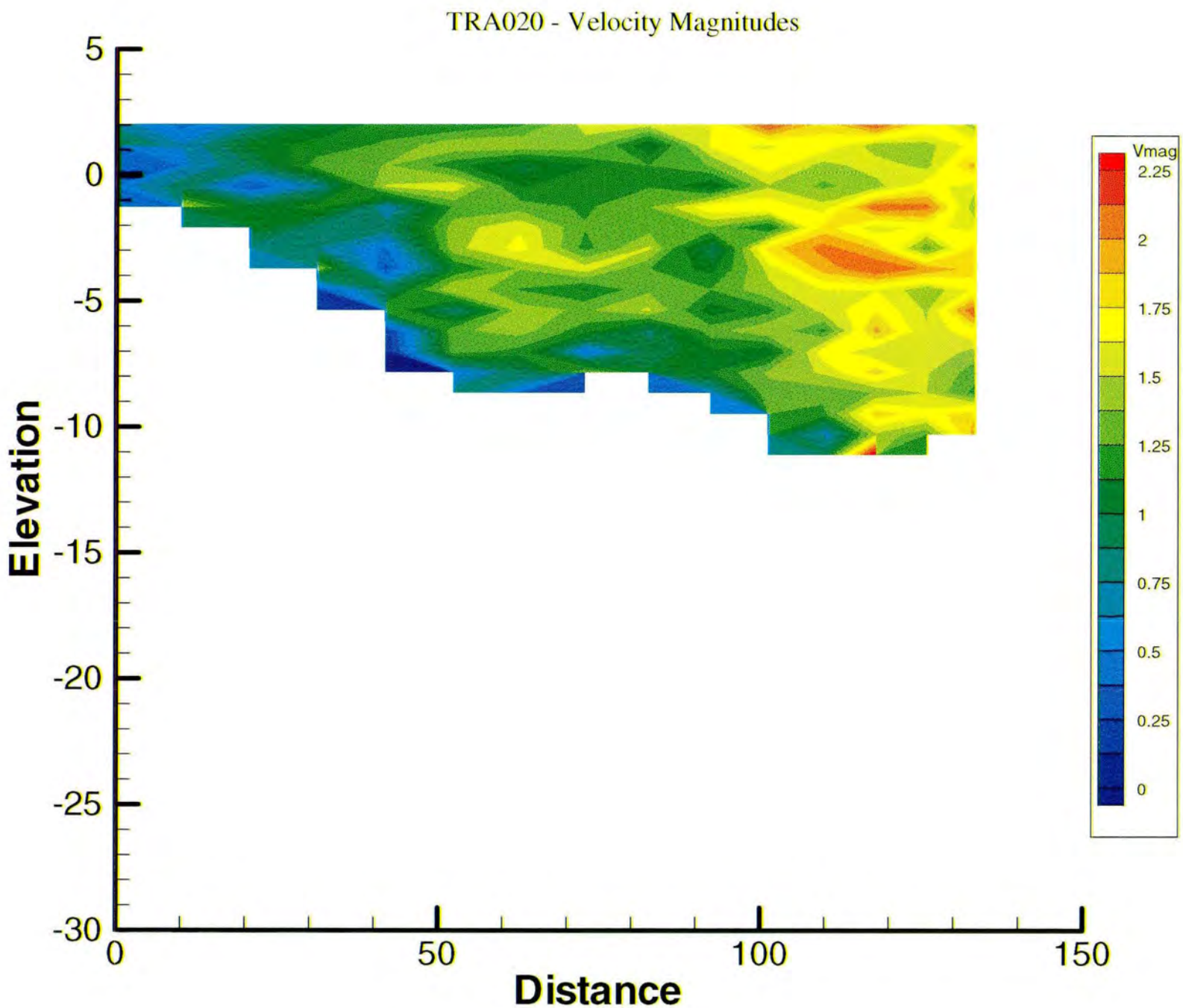

TRA016 - Velocity Magnitudes
Elevation
5
0
-5
-10
-15
-20
-25
-30
0
50
100
150
200
Distance
Vmag
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0

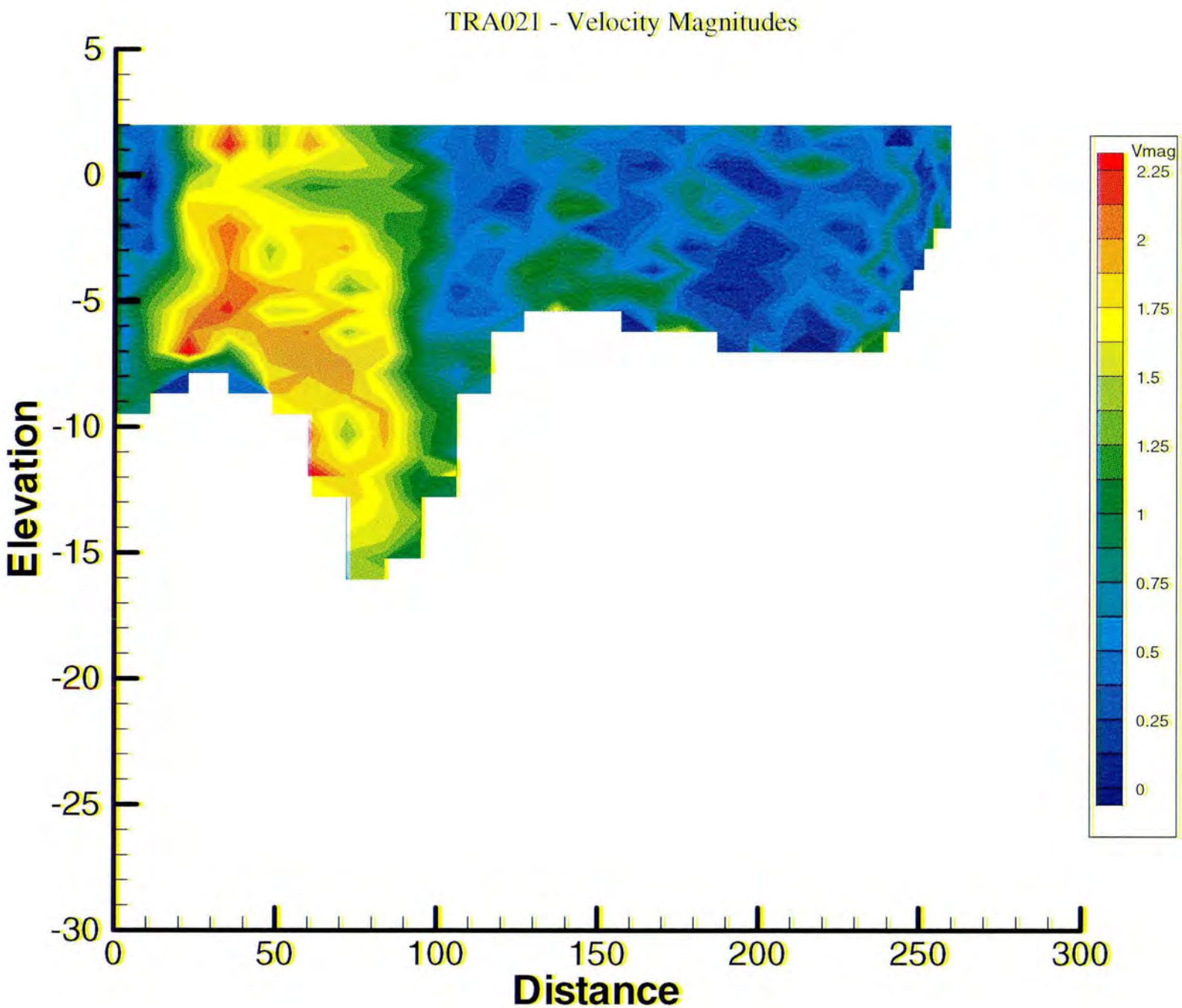

TRA017 - Velocity Magnitudes
Elevation
5
0
-5
-10
-15
-20
-25
-30
0
50
100
150
200
Distance
Vmag
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0

Frame 001 | 15 Jul 1999 | TRA TRANSECT DATA

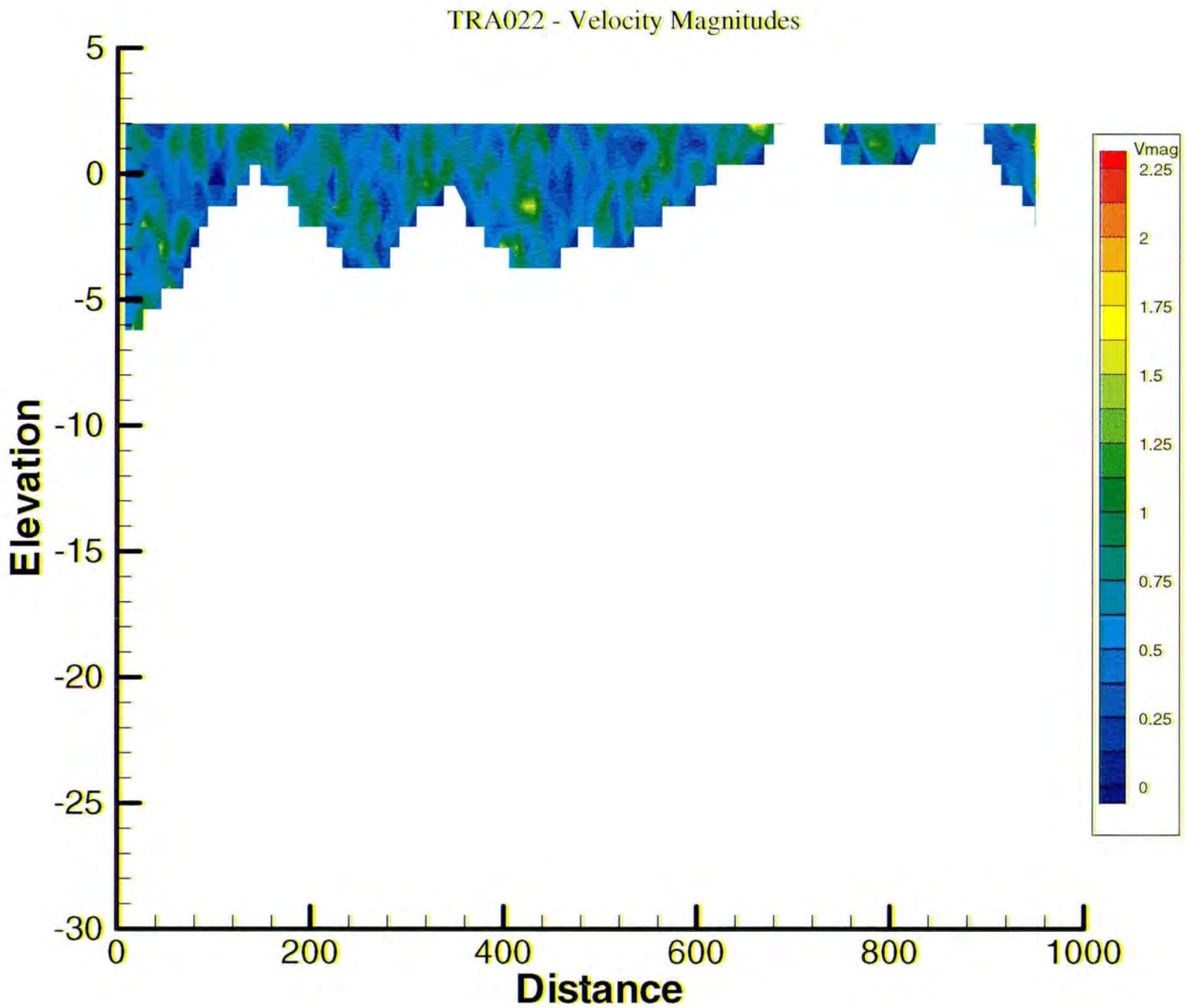


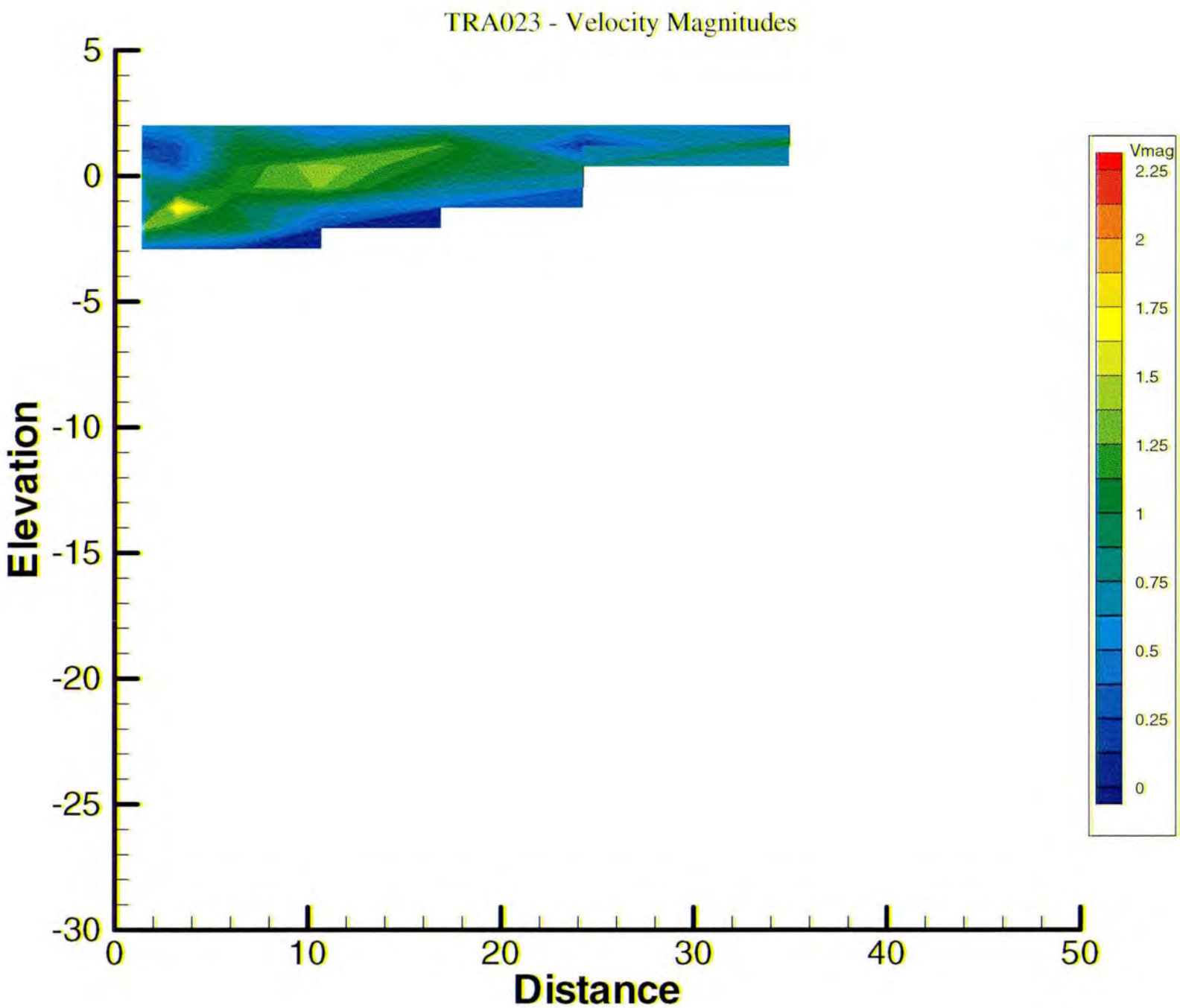
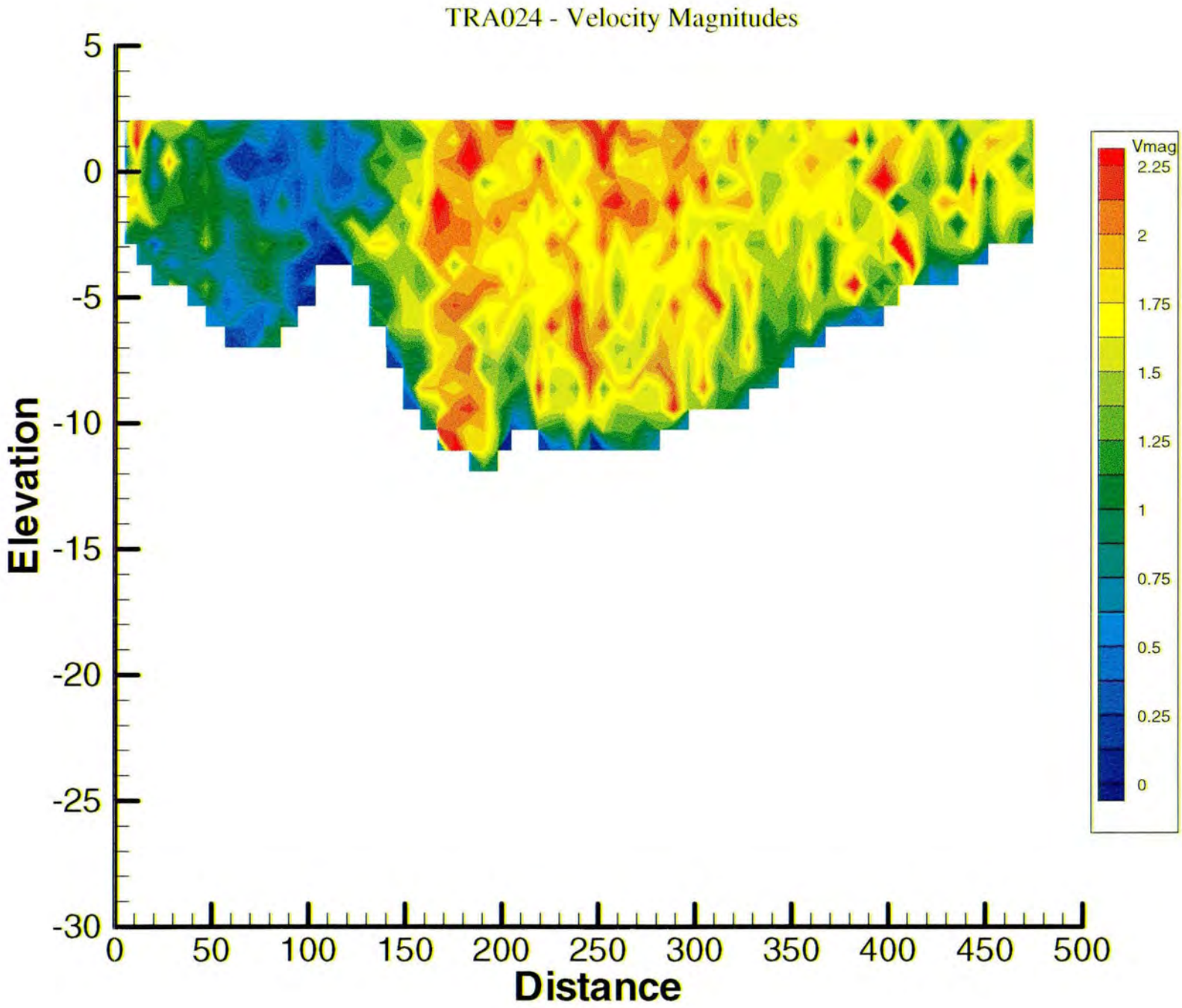

TRA019 - Velocity Magnitudes
Elevation
5
0
-5
-10
-15
-20
-25
-30
0
50
100
150
Distance
Vmag
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0


TRA020 - Velocity Magnitudes
Elevation
5
0
-5
-10
-15
-20
-25
-30
0
50
100
150
Distance
Vmag
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0


TRA021 - Velocity Magnitudes
Elevation
5
0
-5
-10
-15
-20
-25
-30
0
50
100
150
200
250
300
Distance
Vmag
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0

Frame 001 | 15 Jul 1999 | TRA TRANSECT DATA




TRA023 - Velocity Magnitudes
Elevation
5
0
-5
-10
-15
-20
-25
-30
0
10
20
30
40
50
Distance
Vmag
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0

Frame 001 | 15 Jul 1999 | TRA TRANSECT DATA