COASTAL SCIENCE & ENGINEERING
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December 17, 2009

Mr. Cliff Ogburn, Town Manager
Town of Nags Head
2200 South Lark Avenue
Nags Head NC 27959

Tel: 252-441-5508
Fax: 252-441-0776
Email: ogburn@townofnagshead.net

RE: Nags Head Beach Restoration Project (CSE 2203-10)
Post-Storm Report Following Hurricane *Ida*

Dear Cliff:

This letter summarizes results of a post-storm beach survey along Nags Head following Hurricane *Ida* (12-15 November 2009). It follows a preliminary report submitted by email shortly after CSE completed a condition survey (18-21 November). The purpose of the survey was to assess the amount of dune recession and volume change along the visible beach. CSE's survey encompassed the entire Nags Head shoreline, but the focus here is on the southern ~5.8 miles of beach which experienced the greatest damage. CSE's preliminary report documented 136 buildings left with no dune protection (cf – email dated 11/23/2009 6:36PM).

Introduction

A northeaster, coupled with remnants of Hurricane *Ida*, impacted Nags Head (NC) between 12 and 15 November 2009 and produced significant flooding, coastal erosion, and damage.

Ida made landfall on the Gulf of Mexico coast as a tropical storm on 10 November 2009. Two days later, it redeveloped as a coastal low-pressure system south of Cape Hatteras (NC) and intensified. Strong northeast winds (northeaster) occurred along the mid-Atlantic coastline due to a pressure gradient, which had developed between the coastal low (south of Cape Hatteras) and a high-pressure system over New England. The high-pressure system effectively blocked the northern advance of the coastal low, resulting in three (3) successive high tides with ~3.3 feet (ft) of storm surge and significant precipitation (~7 inches of rainfall) along Nags Head. The United States Army Corps of Engineers: Engineering Research & Development Center Field Research Facility (USACE FRF) recorded the largest wave (crest to trough), storm surge (water pushed toward the shore by the force of the storm winds), sustained winds, and wind gusts at ~21.3 ft, 3.7 ft, ~36.1 mph and ~49.7 mph (respectively). The wave crest was measured from the FRF Waverider buoy (36°15.461N 75°35.479W, depth of 26 meters). (USACE FRF website)

Methods

Due to the extensive damage caused by the "Veteran's Day Storm," Governor Bev Perdue (NC) signed an emergency declaration on 16 November 2009. To quantify the damage (specifically dune recession and beach erosion), CSE collected ~23,000 topographic data points (~3,000 along the toe and top of the scarp and ~20,000 from the toe of the scarp to approximately mean sea level) between 18 and 21 November 2009. Data were collected between Ocean Watch Court (station 720+00) and the intersection of Old Oregon Inlet and South Colony Roads (station 1025+00).

Four reaches were analyzed to quantify dune recession and beach erosion. Reach 1 extended from station 720+00 (Ocean Watch Court) to station 790+00 (near Governor's Street); Reach 2 from station 790+00 to station 920+00 (near James Street); Reach 3 from station 920+00 to station 1010+00 (Tern Street); and Reach 4 from 1010+00 to 1025+00 (intersection of Old Oregon Inlet and South Colony Roads).

The northeaster was classified based on the Dolan-Davis classification scheme whereby the power of the storm is correlated with a specific class. The power was calculated by multiplying the storm's duration by the square of the significant wave height. The classification scheme is based on 1,347 storms which have affected the North Carolina coast over a 42-year period. Storms are divided into five classes with the weakest storms, Class 1 and 2, comprising about 75 percent of all northeasters impacting the Outer Banks of North Carolina. The extreme northeaster, Class 5, has a recurrence interval of 67 years and a significant wave height of ~7 m.

Average dune recession was quantified by comparing the distance from the baseline to the +11-ft NGVD contour (at ~500-ft intervals) along profiles generated from data collected in both March (pre-storm) and early November (post-storm) 2009. No data were available to quantify accretion or erosion in the dune field between March and November 2009. Thus, all calculated losses between March and November 2009 were assumed to be generated by the November northeaster.

Volume changes above three pre-determined elevations (11 ft, 2.18 ft, and 0.58 ft NGVD) were calculated with CSE's in-house software (Beach Profile Analysis Software) to quantify volume losses in the dune field and provide an estimate of the average amount of erosion along the active beach. Volume changes above 11 ft, 2.18 ft, and 0.58 ft NGVD quantify changes in the foredune, above mean high water (MHW), and above mean sea level (MSL) (respectively).

Results

Based on the +11-ft NGVD contour analysis, the average dune recession increased from north to south along Reaches 1 through 3. The average dune recession was ~1 ft, ~14 ft, and ~22 ft in Reaches 1, 2, and 3 (respectively) (Table 1). Reach 3 showed the greatest amount of isolated dune recession (~73 ft) at station 990+00 (between East Seagull Drive and Pioneer Street). Maximum

dune recession along Reach 2 occurred at station 900+00 (Jay Street) and was equivalent to ~46 ft. The maximum dune recession along Reach 1 (~14 ft) occurred at station 770+00 (between Gull and Gray Eagle Streets). Dune recession was ~8 ft on average along Reach 4, but volume changes below MHW (2.18 ft NGVD) were large with respect to northern reaches (discussed in subsequent paragraph).

TABLE 1. Dune recession results.

Reach	Limits	Linear (ft)	Change in distance (feet) to 11 foot NGVD contour from the baseline (Mar-09 to Nov-09)			
			Max	Min	Mean	St. Dev.
1	720+00 to 790+00	7,000	15.83	-14.22	-0.90	10.75
2	790+00 to 920+00	13,000	25.17	-45.58	-13.45	16.31
3	920+00 to 1010+00	9,000	9.43	-73.48	-21.96	25.18
4	1010+00 to 1025+00	1,500	-3.14	-17.16	-7.75	6.46
Note: A negative number (-) reflects landward displacement of the dune field						

Table 2 presents the volume change analysis. Average volume losses above MSL (0.58 ft NGVD) increased from north to south with Reach 4 showing the highest unit volume loss at ~11.5 cubic yards per foot (cy/ft). The average volume loss (above MSL) along all reaches (between stations 720+00 and 1025+00) was ~8.8 cy/ft. Losses between MHW and MSL (ie – on the beach face) were highest along Reach 4 (~0.9 cy/ft) and decreased from south to north. Losses between MHW and the 11-ft NGVD contour (ie – berm and dune field) increased from north to south, ranging from 3.2 cy/ft along Reach 1 to 8.50 cy/ft along Reach 4. Average volume losses above the 11-ft NGVD contour (representing losses in the dune field) were highest along Reach 2 at ~2.9 cy/ft and averaged ~2.4 cy/ft along all reaches.

TABLE 2. Volume change above the indicated contour between March (pre-storm) and November (post-storm) 2009.

Reach	Length (ft)	Volume change (cy)			Average Volume change (cy/ft)		
		11 ft NGVD	MHW (2.18 ft NGVD)	MSL (0.58 ft NGVD)	11 ft NGVD	MHW (2.18 ft NGVD)	MSL (0.58 ft NGVD)
Reach 1 (720+00 to 790+00)	7,000	-9495	-31808	-34308	-1.4	-4.5	-4.9
Reach 2 (790+00 to 920+00)	13,000	-37145	-108832	-113836	-2.9	-8.4	-8.8
Reach 3 (920+00 to 1010+00)	9,000	-23520	-95986	-102406	-2.6	-10.7	-11.4
Reach 4 (1010+00 to 1025+00)	1,500	-3121	-15875	-17198	-2.1	-10.6	-11.5
Total	30,500	-73281	-252501	-267748	-2.4	-8.3	-8.8

The power (m^2h) of the storm was calculated to equal 2,343. Based on the Dolan-Davis classification, the storm was a Class 5 (extreme storm). The power (m^2h) of a Class 4 (severe storm) ranges from 929 to 2322. Thus, this storm would be classified a strong Class 4 (severe storm) or a weak Class 5 (extreme storm).

Graphs were prepared for each profile (~500-ft spacing) to illustrate the approximate dune recession between March and November 2009. In March 2009, CSE collected elevation data at each profile

level (0.58 ft NGVD) to the top of the escarpment (top edge or extent of dune erosion). These data are illustrated by a thick, black, solid line on each graph. The purpose of the graphs is to illustrate the approximate erosion of the dune between the two dates, more specifically the recession of the dune due to the "Veteran's Day Storm." Graphs for each profile are included in Appendix A.

Discussion and Conclusion

As previously noted, Reach 3 (James to Tern Streets) shows the largest average and maximum isolated dune recession of the four reaches. The maximum dune recession (~74 ft) was recorded in the proximity of East Seagull Drive, and visual observations confirmed this area appeared to be impacted the most. On average, ~9 cy/ft were lost (above MSL) between Ocean Watch Court (station 720+00) and the intersection of Old Oregon Inlet and South Colony Roads (station 1025+00). In total, nearly 270,000 cy eroded between the foredune and MSL contour along the 5.8-mile southern half of Nags Head. It is assumed the majority of this volume loss occurred during the "Veteran's Day Storm." CSE's surveys were conduced 3-6 days after the storm before there was observable recovery of the beach. The volume loss above MSL over this section of Nags Head approximately equals the net yearly losses along Nags Head for the period 1994-2005. Because the calculations are limited to changes along the subaerial (visible beach), they likely underestimate the total losses due to the storm.

Dune recession, measured in detail via changes in the 11-ft NGVD (toe of dune) contour, averaged 12.8 ft along the 30,500-ft study area of southern Nags Head. This weighted average is well under the ~22-ft recession rate for the southernmost ~2 miles of Nags Head. One isolated station (990+00 between East Seagull Drive and Pioneer Street) experienced ~73 ft of dune recession. The northern half of Nags Head generally weathered the storm with only minor dune recession.

Please contact us at any time if you have any questions about our data collection methods, calculations, or results. Thank you again for the opportunity to assist the Town.

Sincerely,

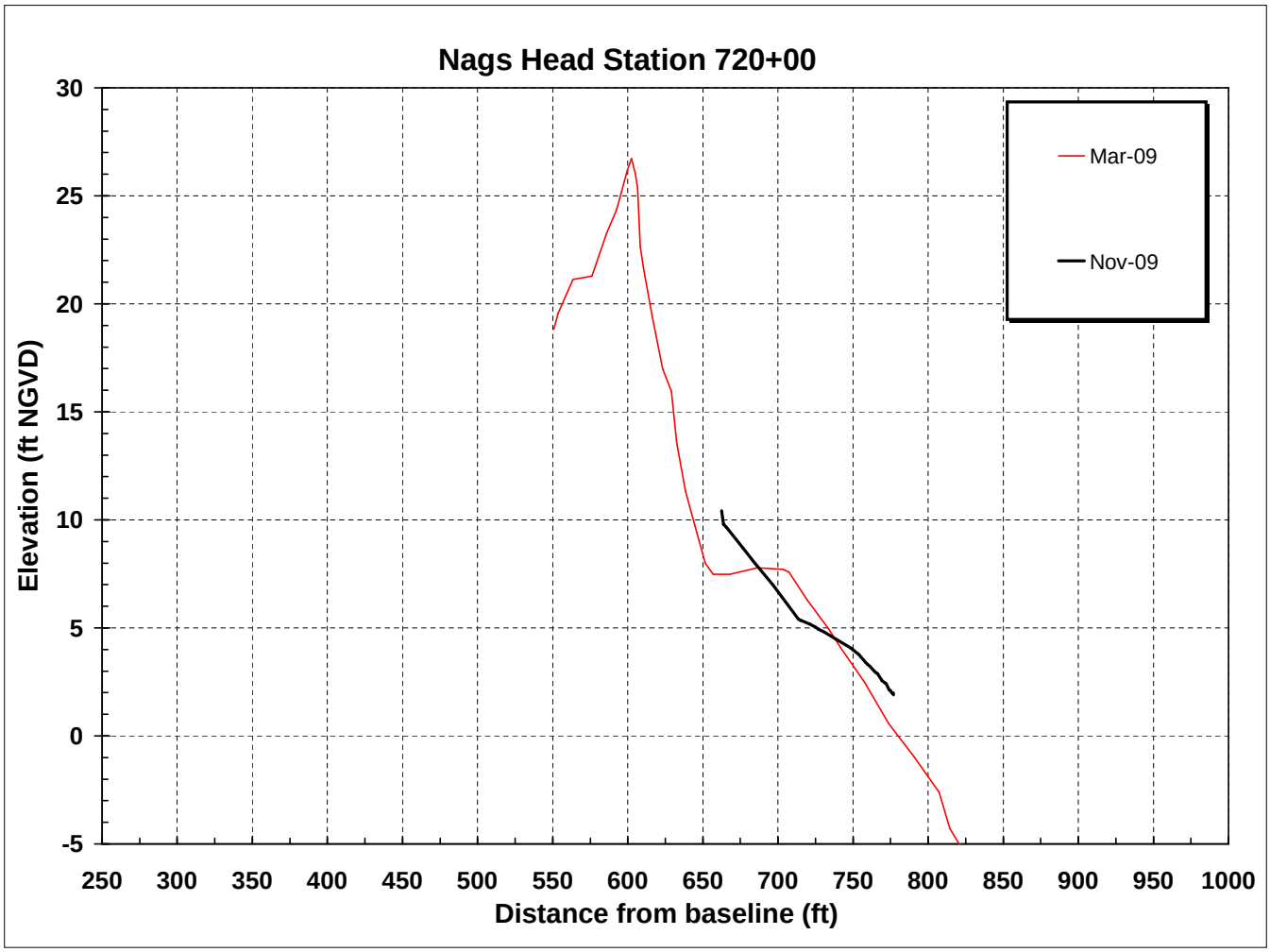
Coastal Science & Engineering (CSE)

Daniel Johnson
Project Manager

Enclosure – Appendix A

APPENDIX A

Representative Survey Profiles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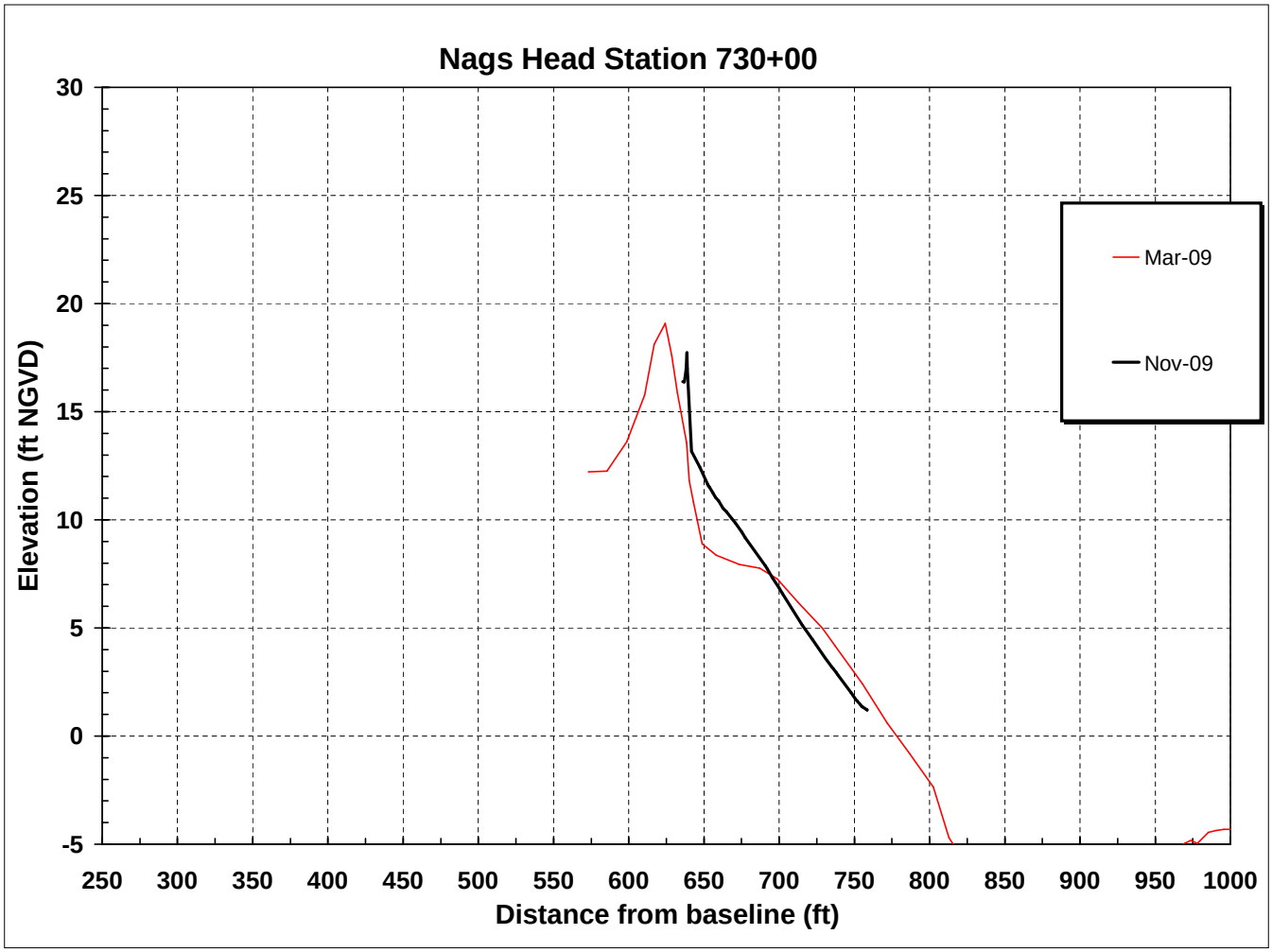
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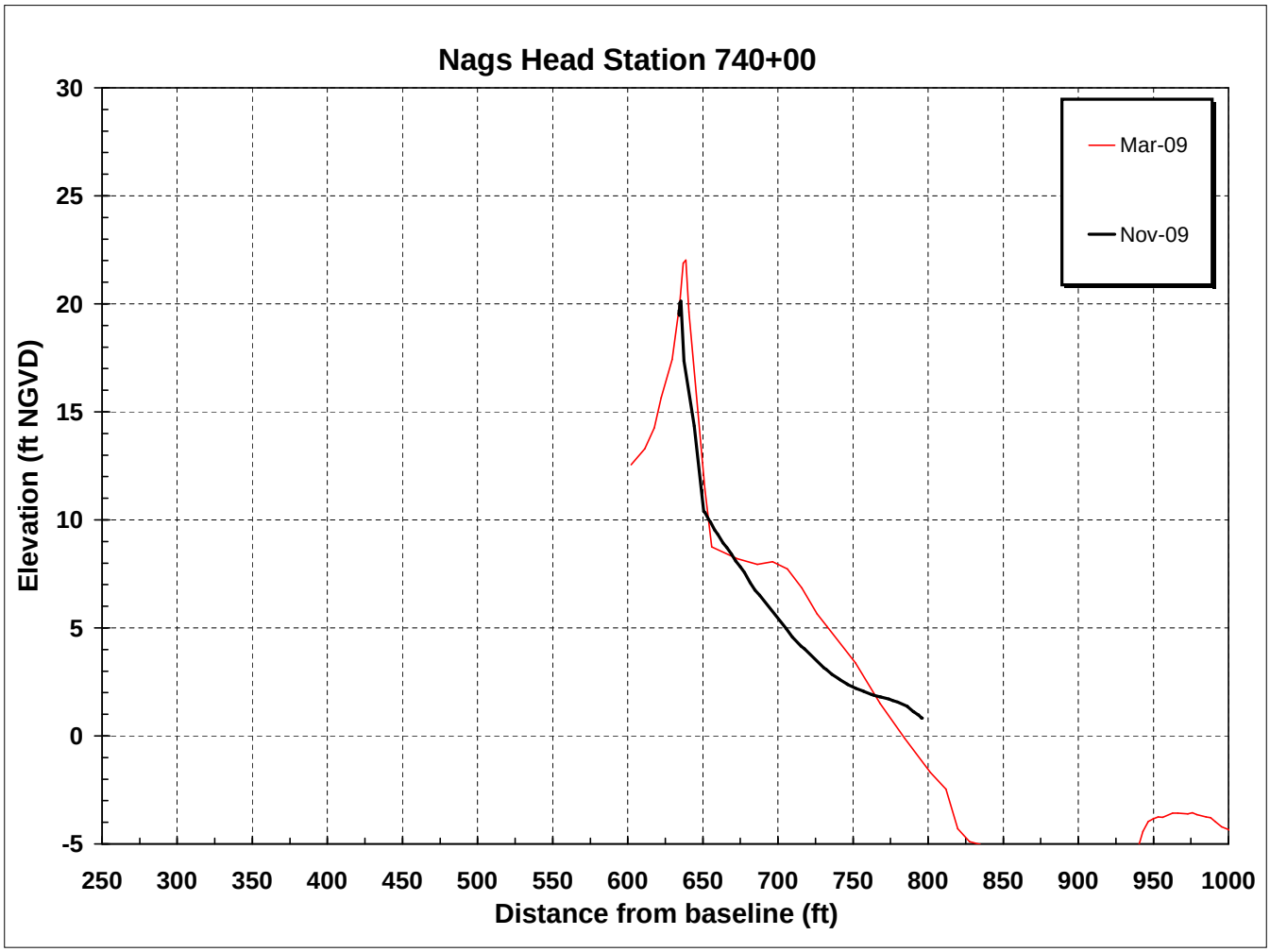
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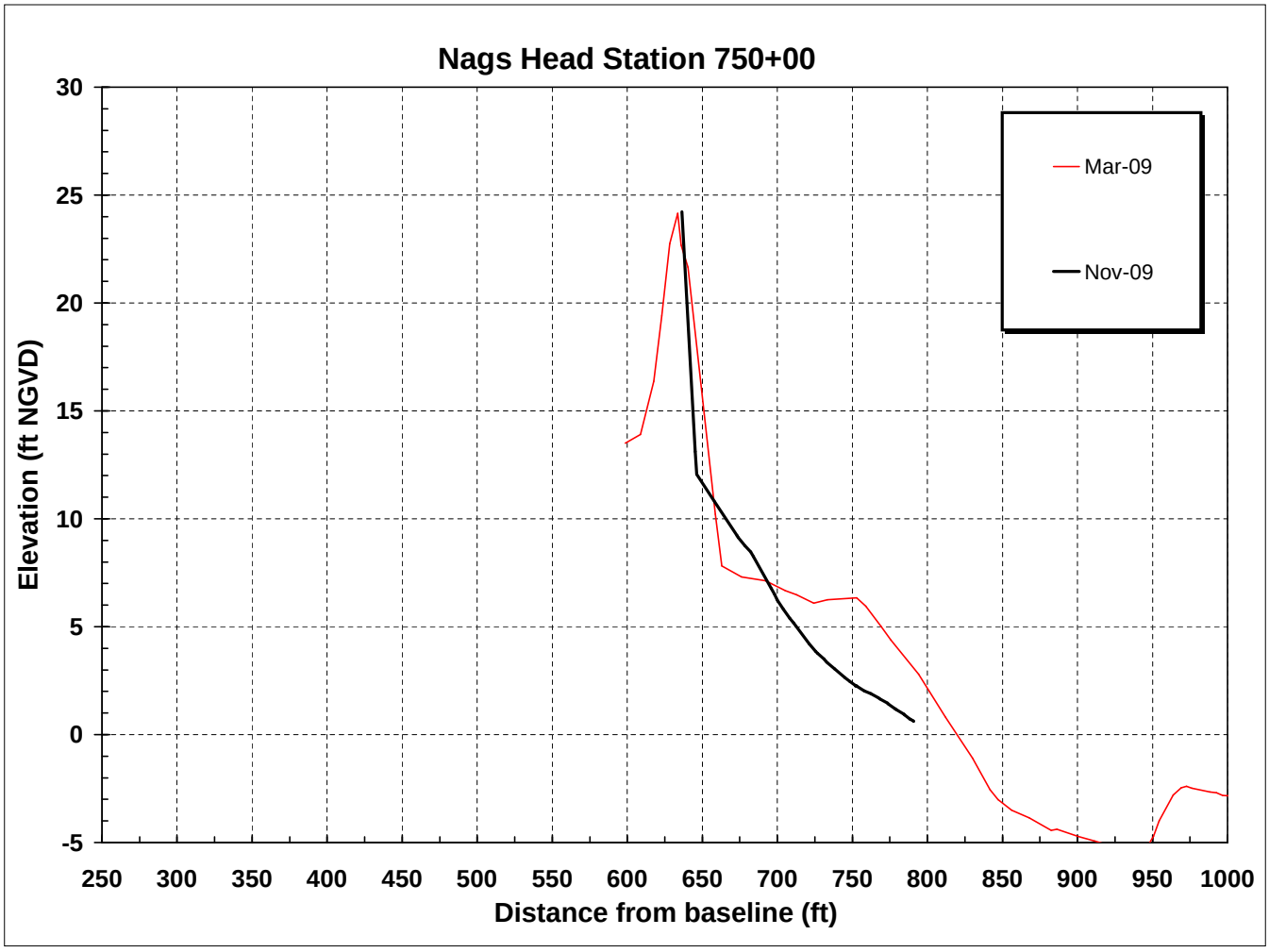
Distance from baseline (ft)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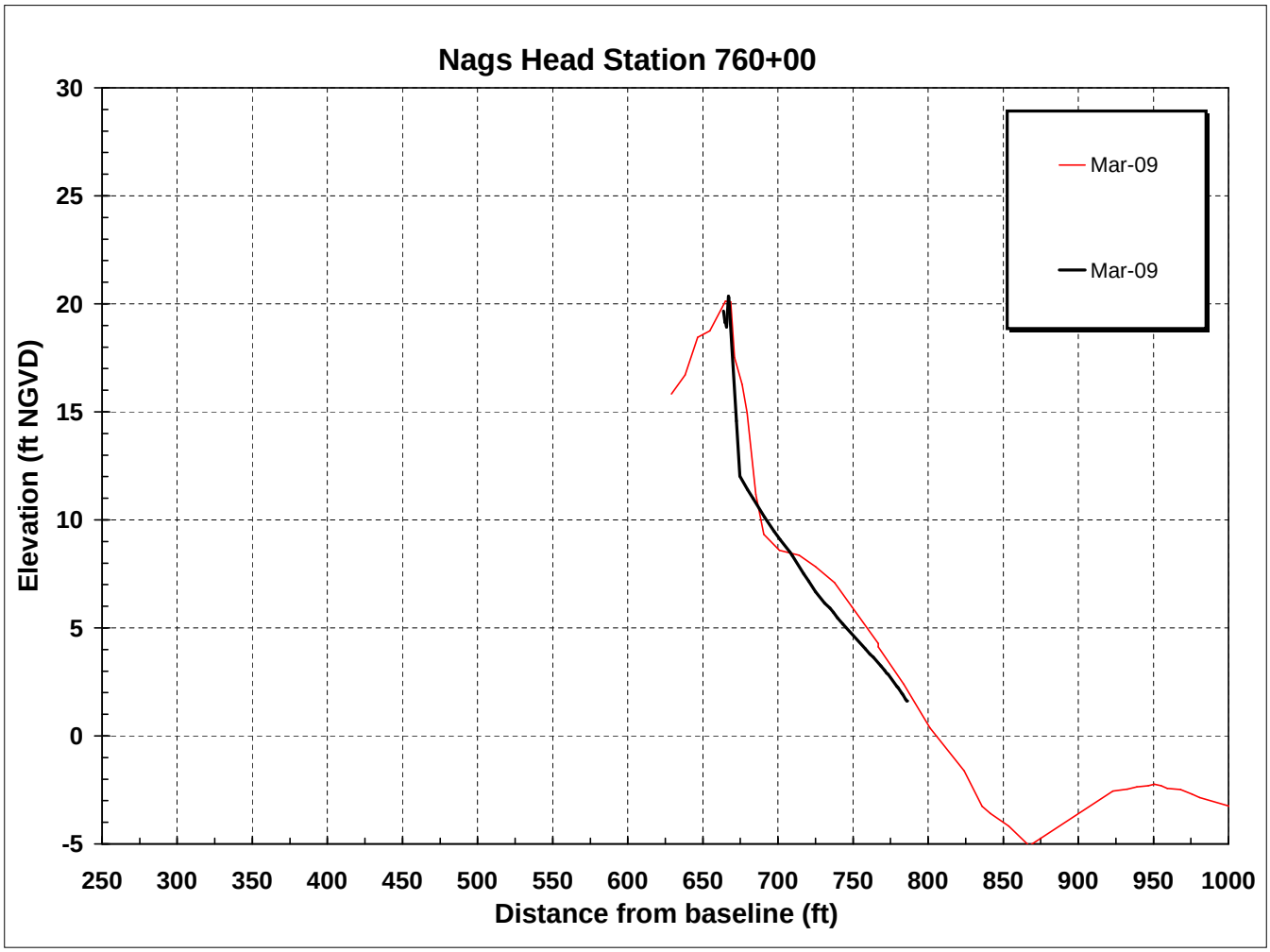
Distance from baseline (ft)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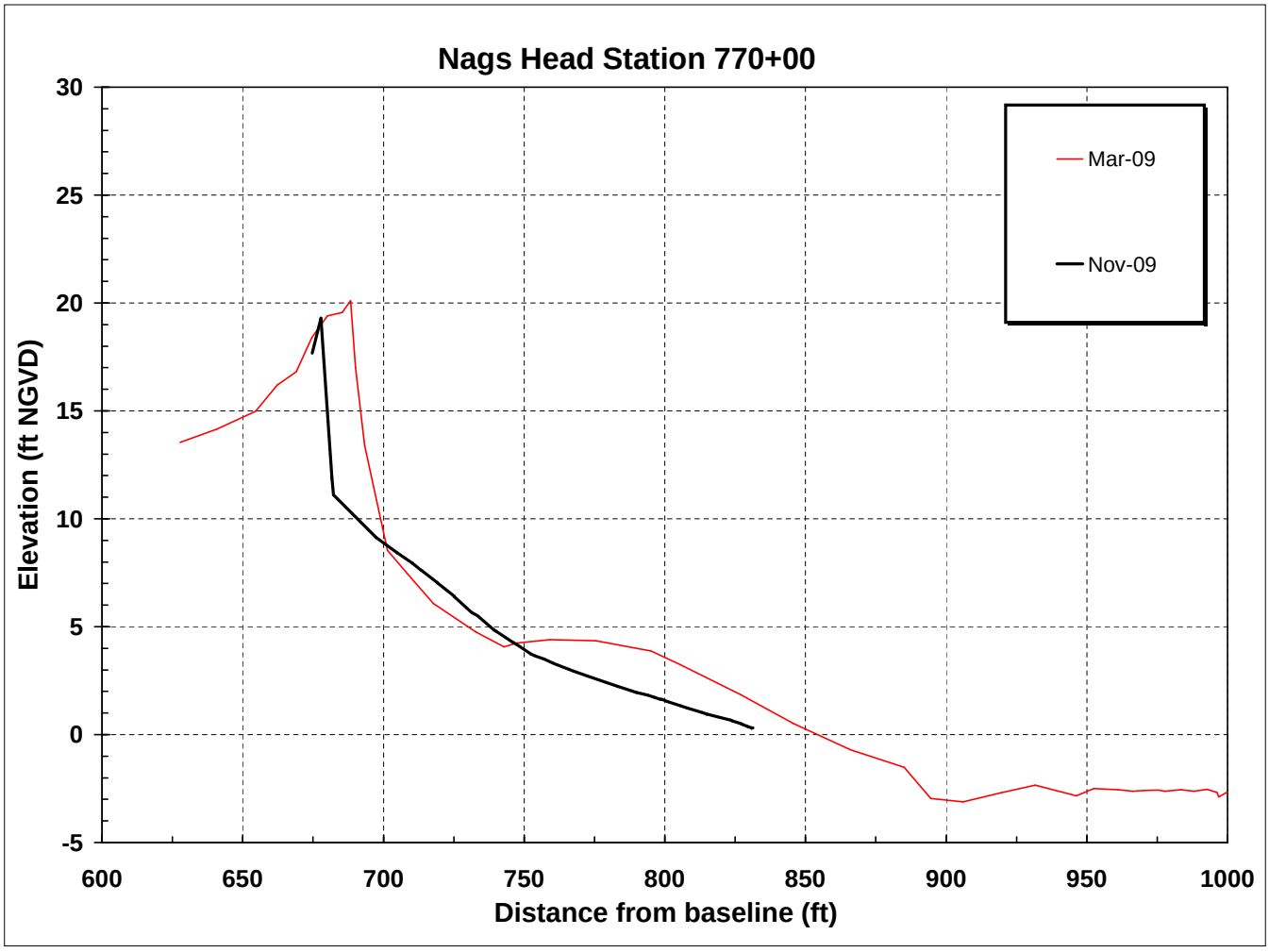
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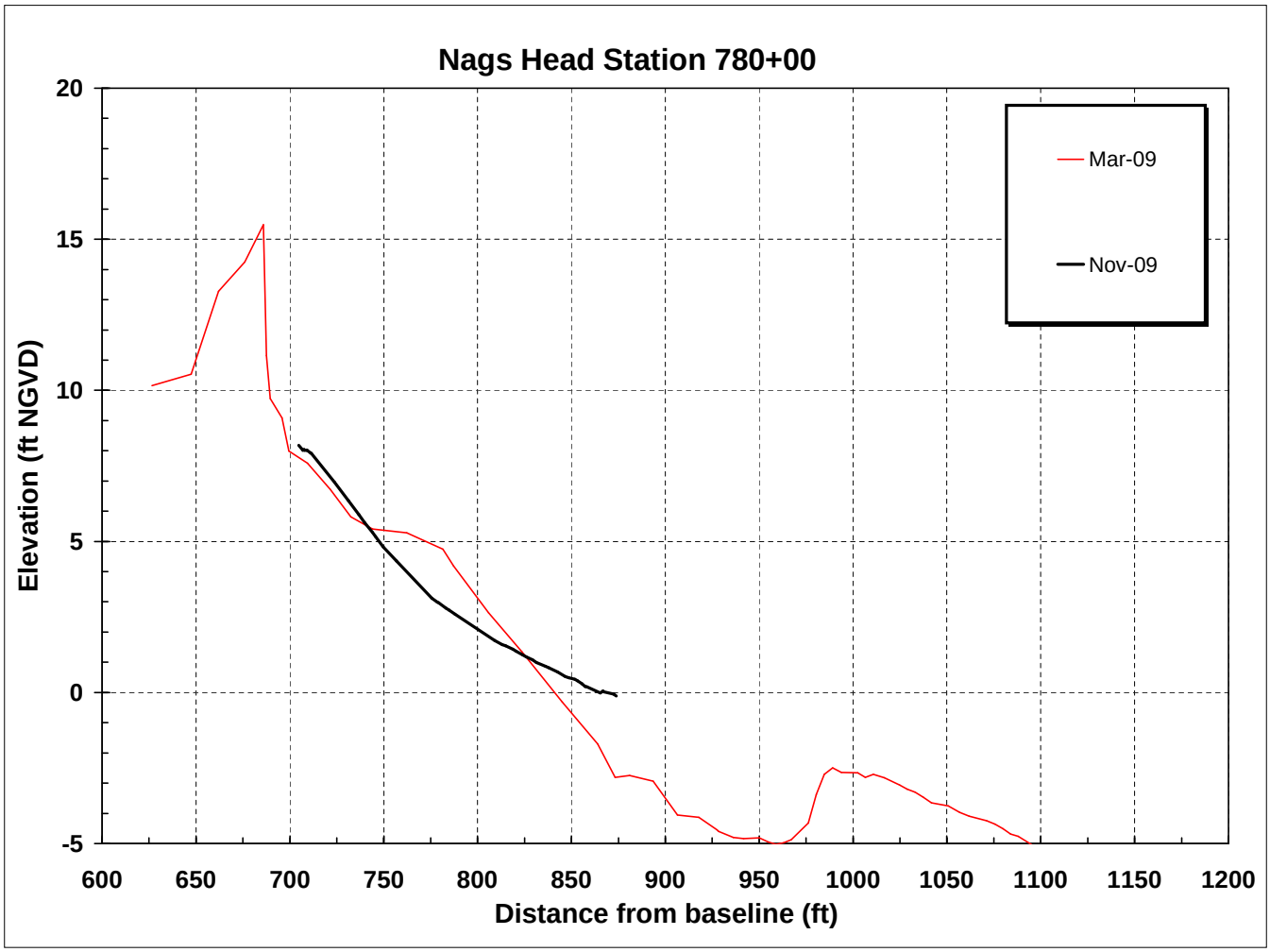
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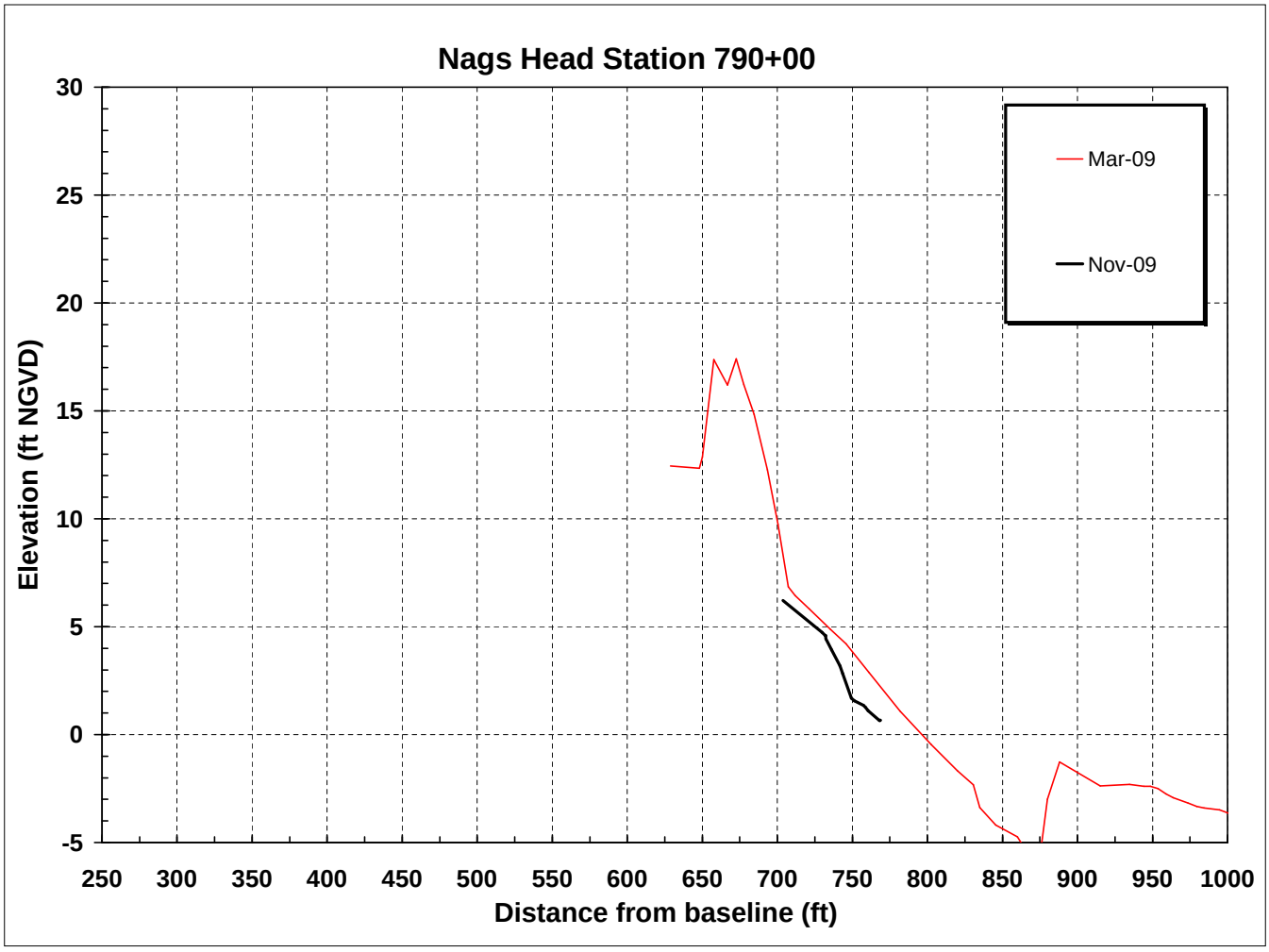
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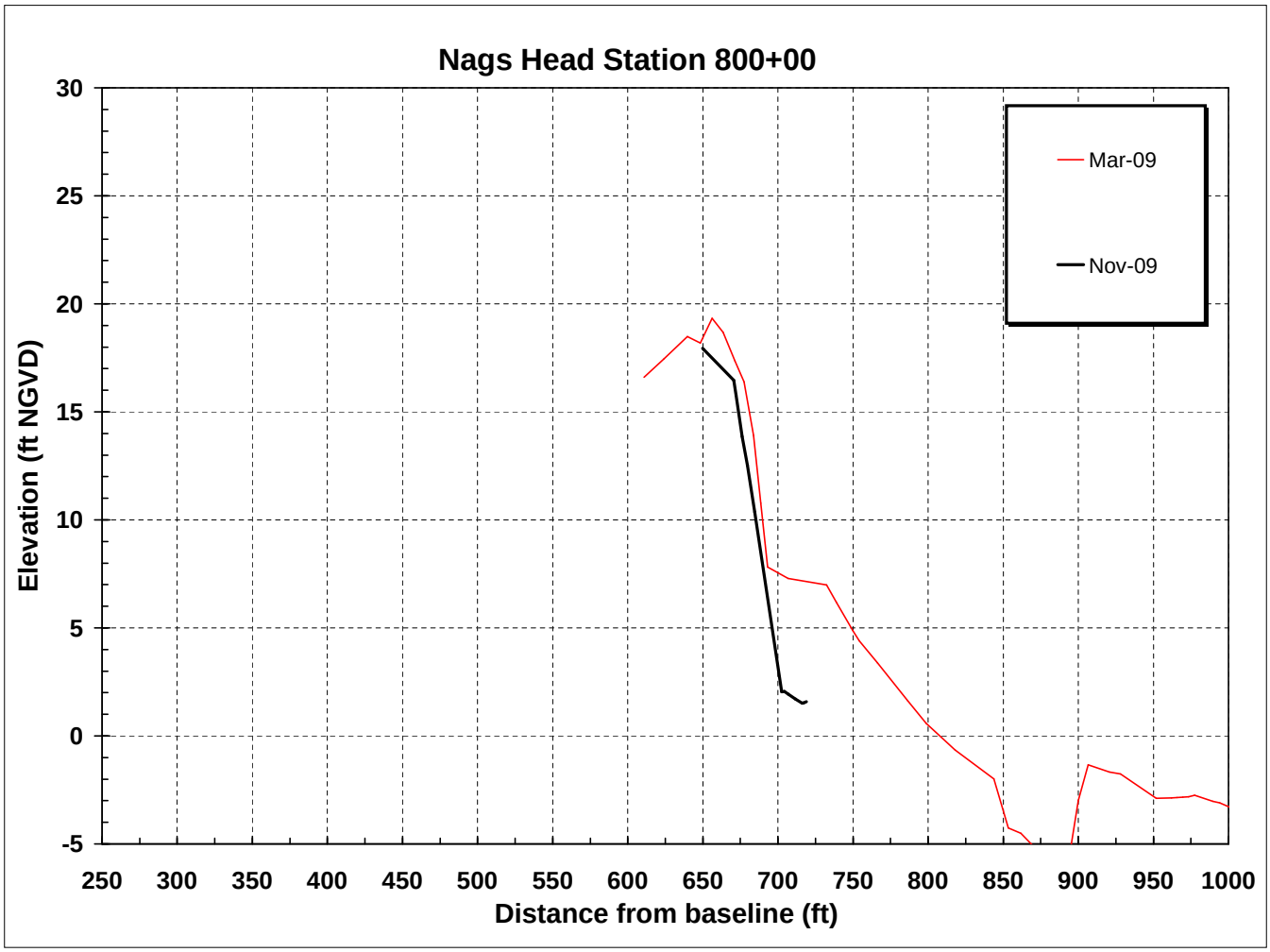
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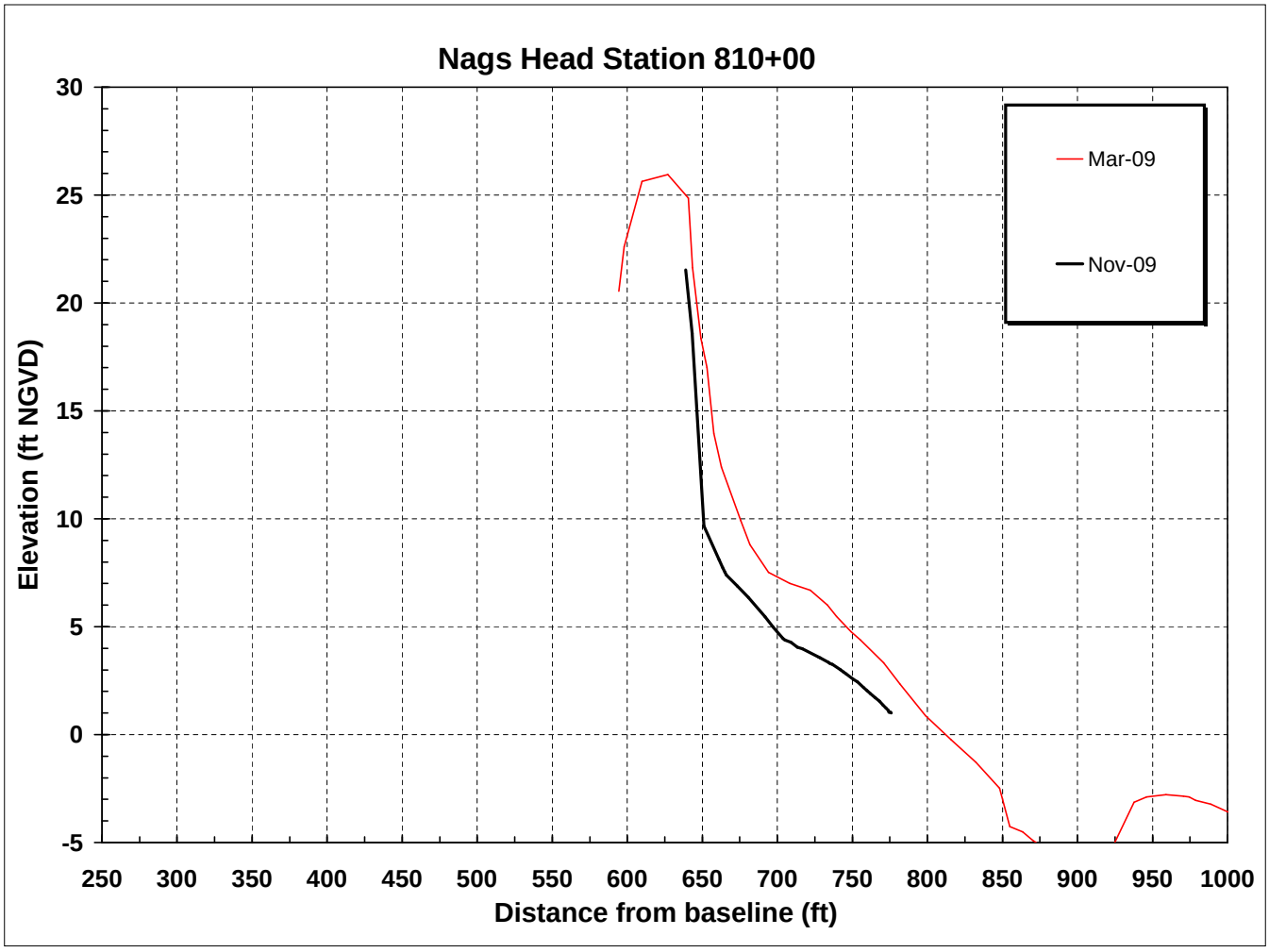
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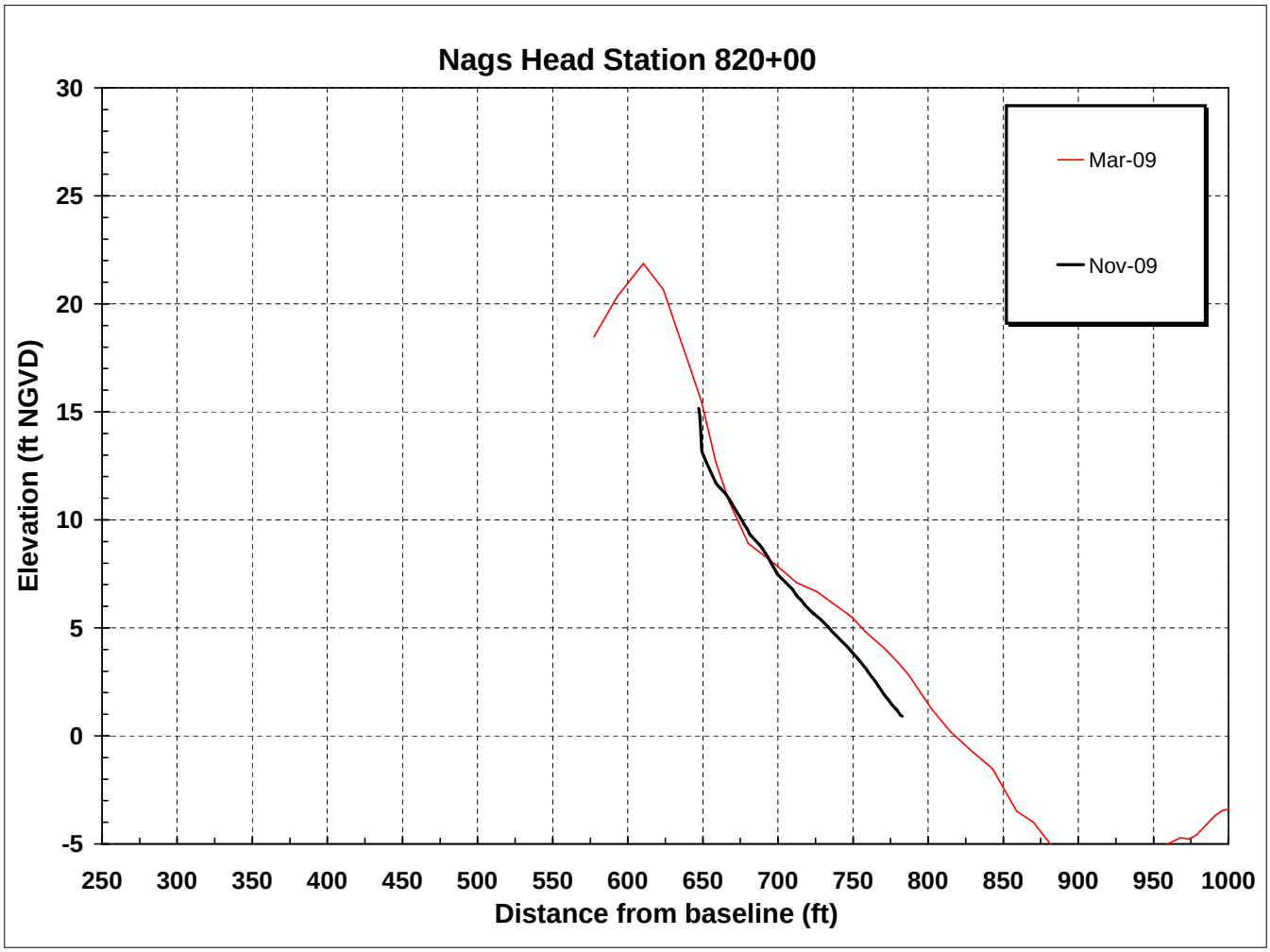
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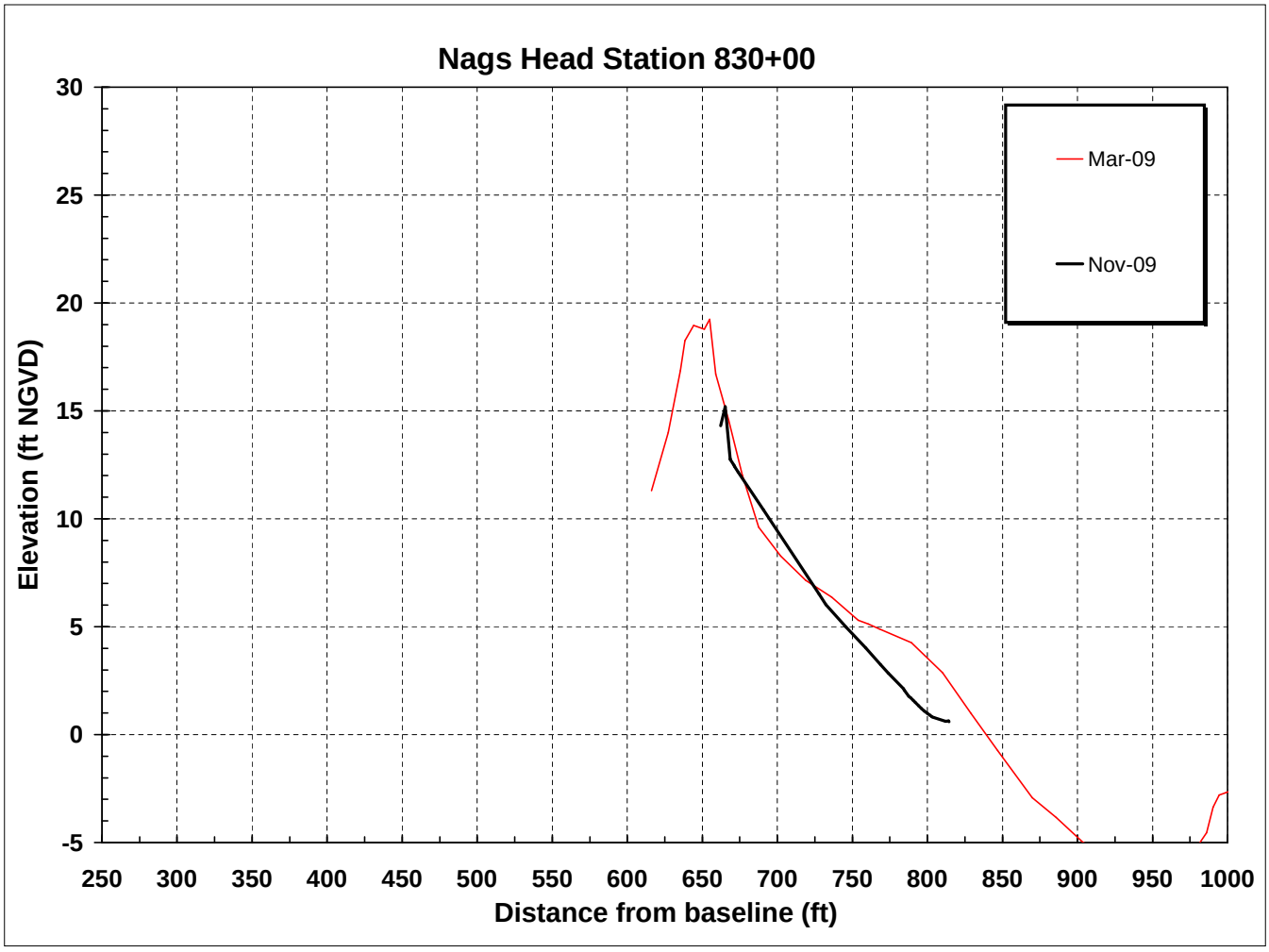
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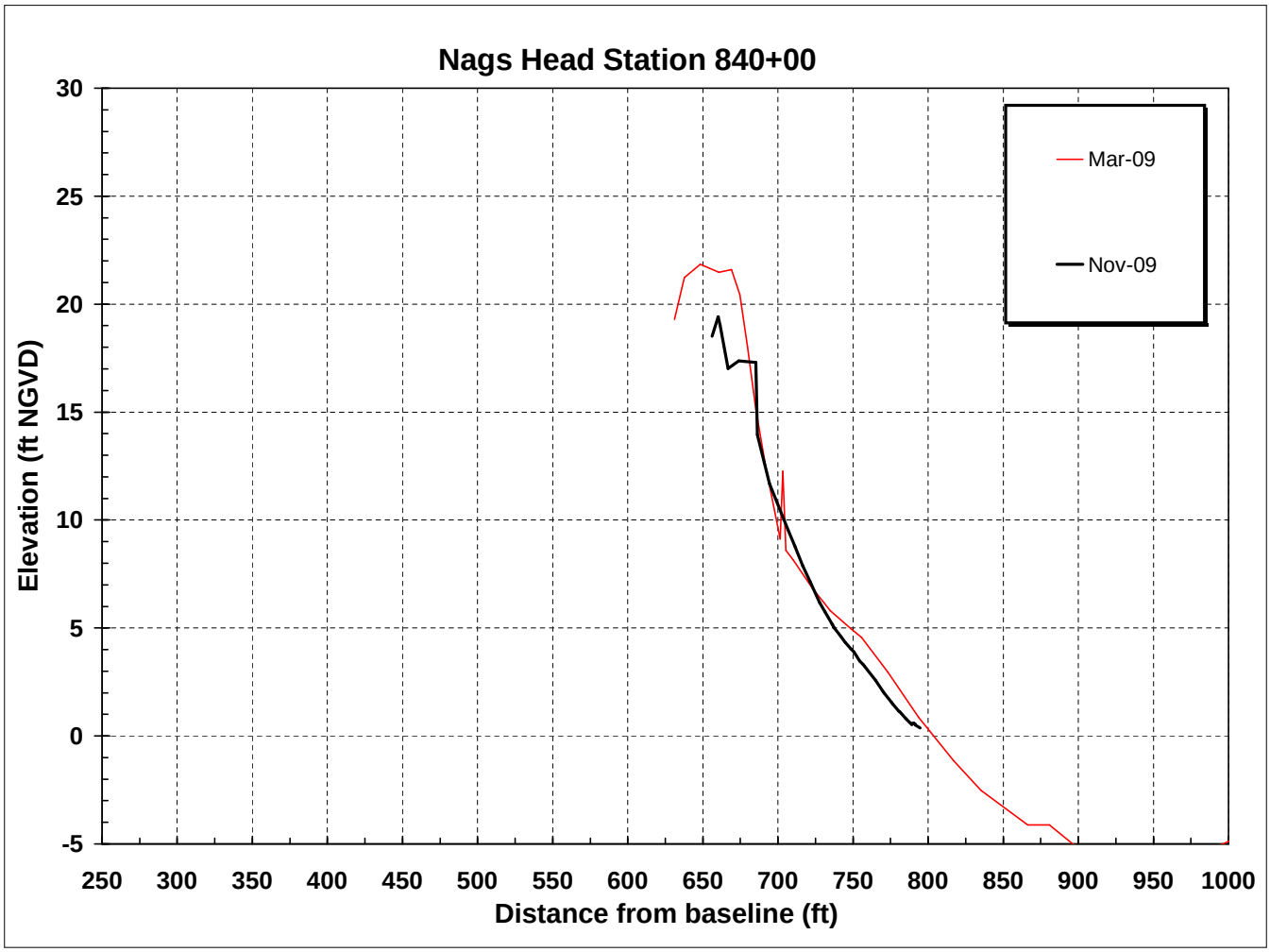
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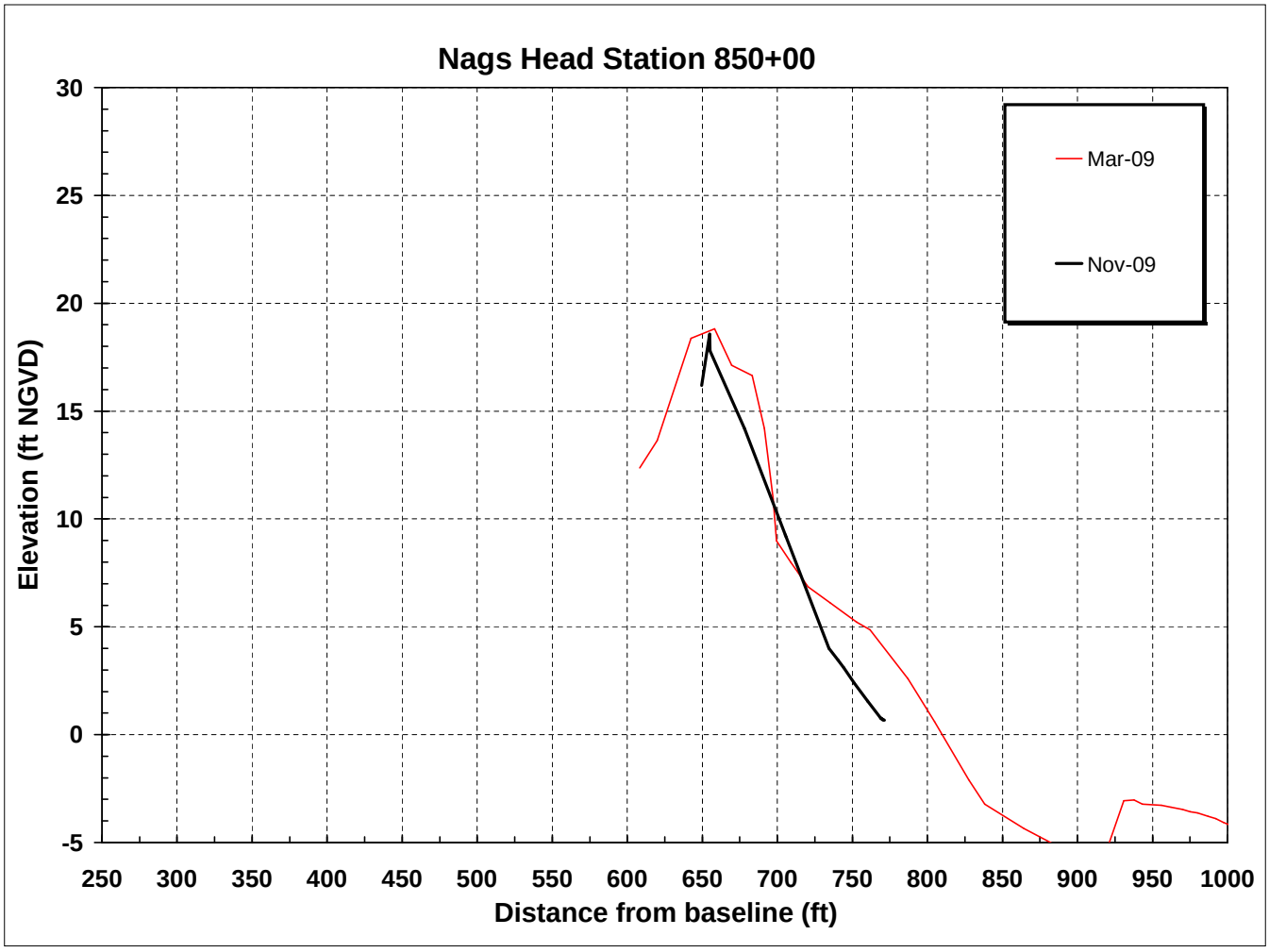
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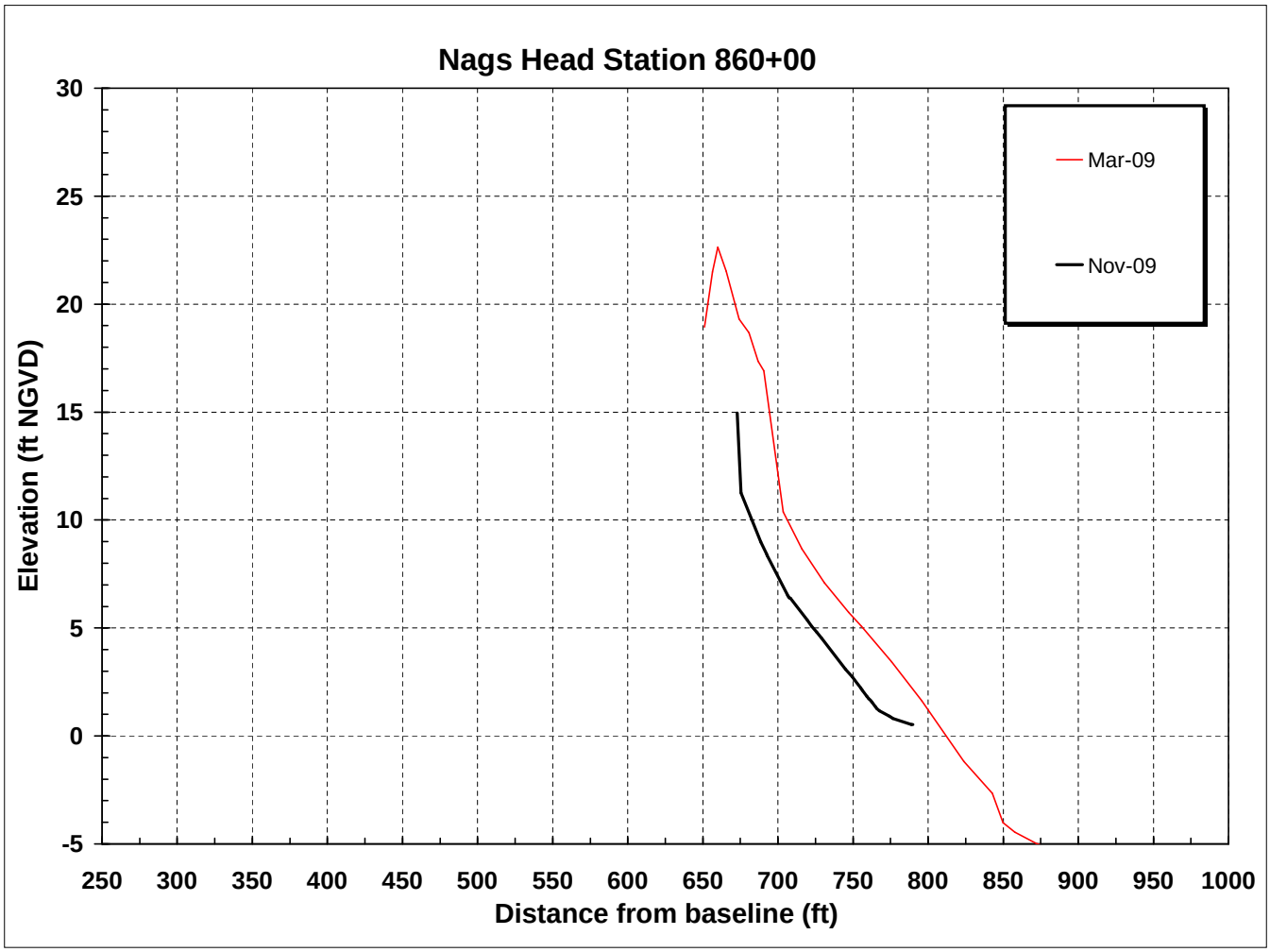
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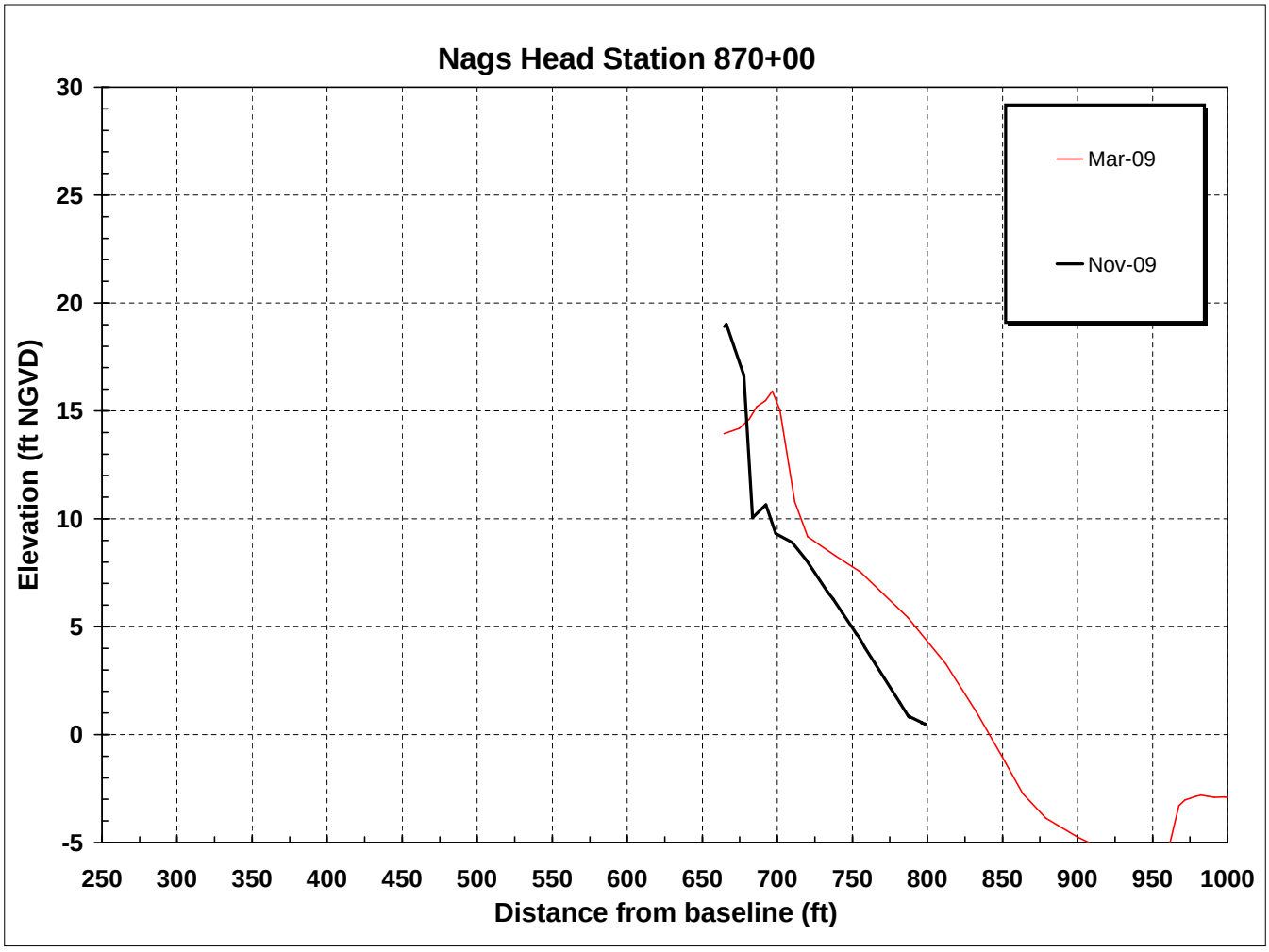
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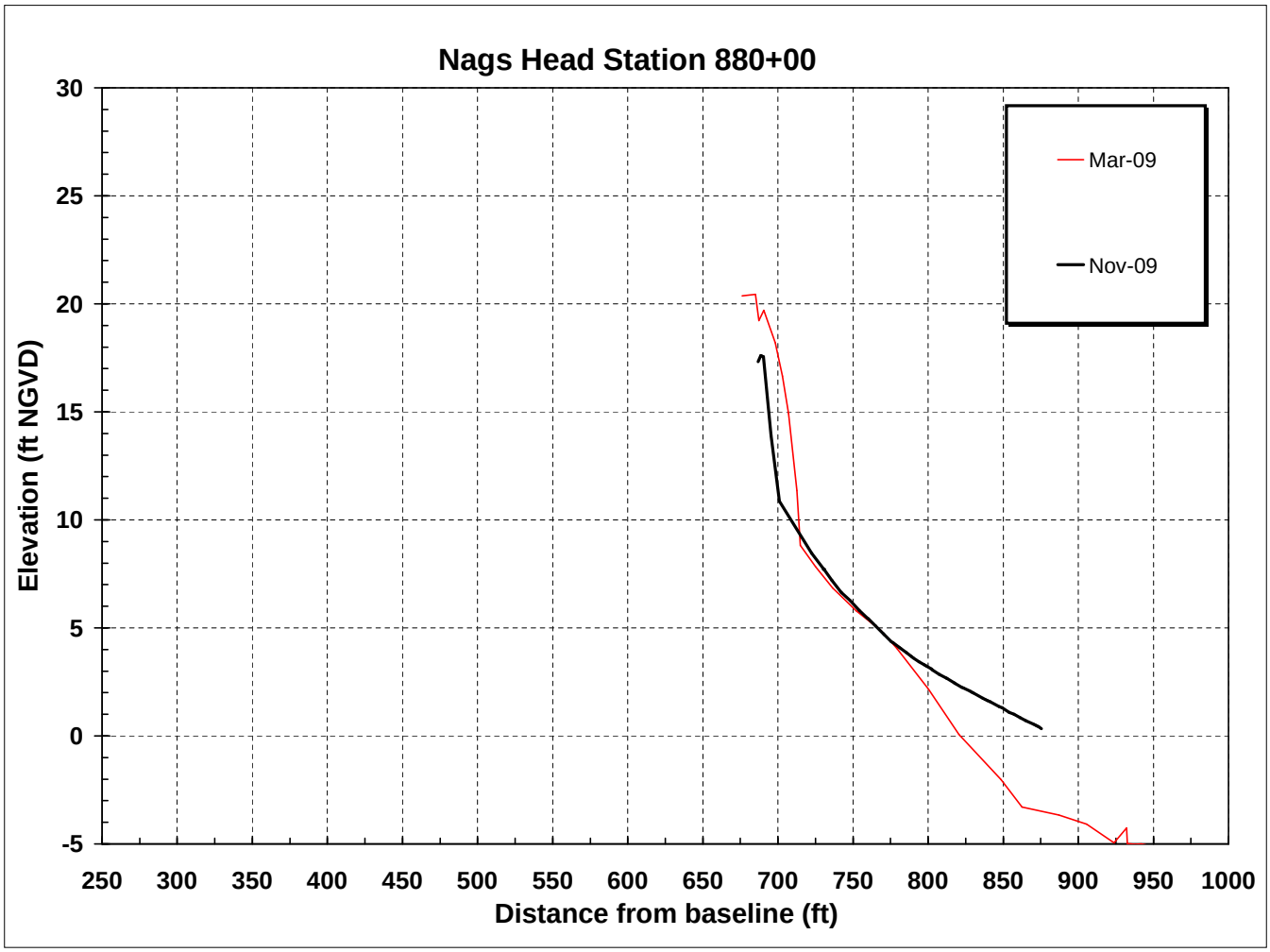
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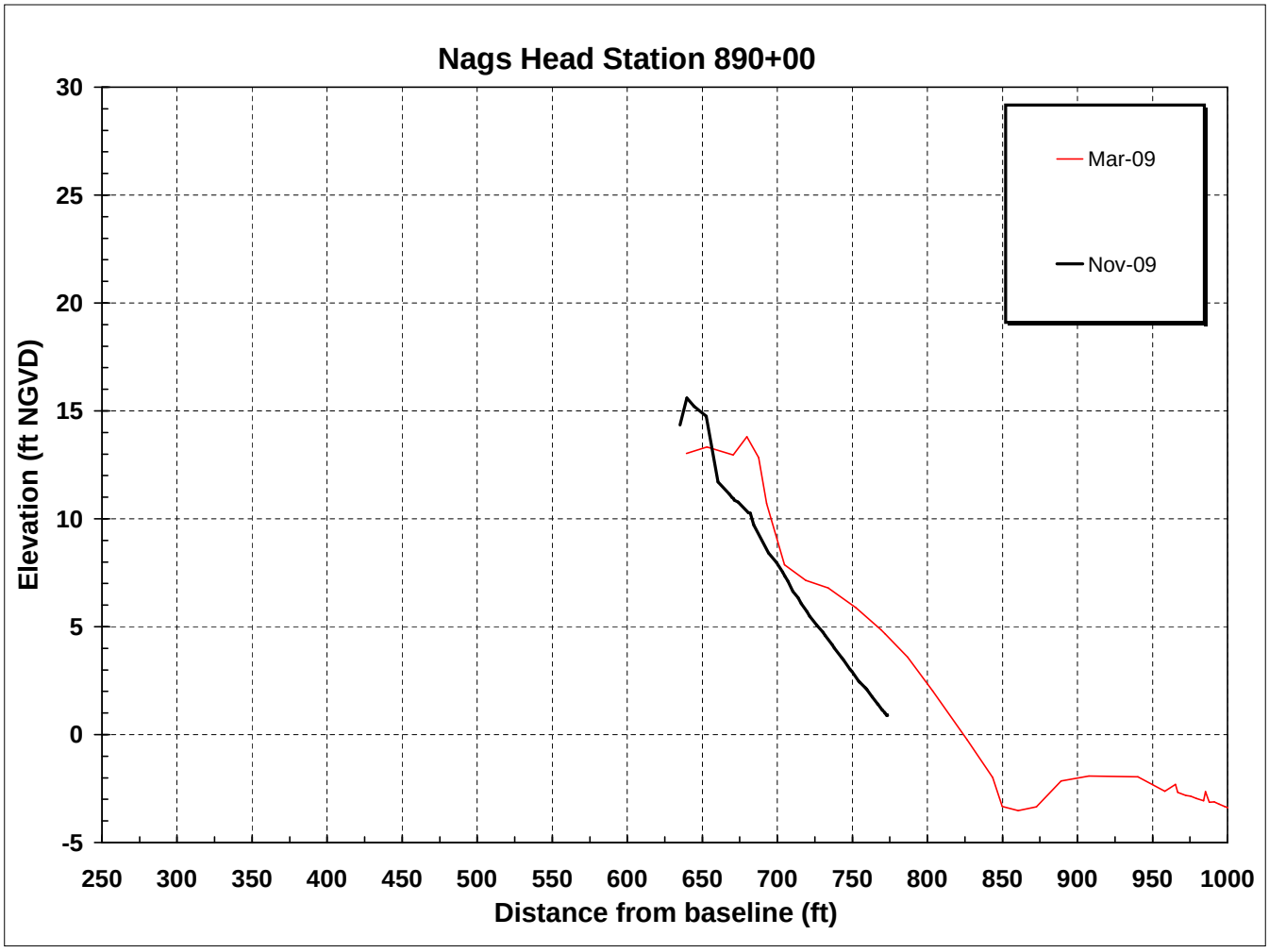
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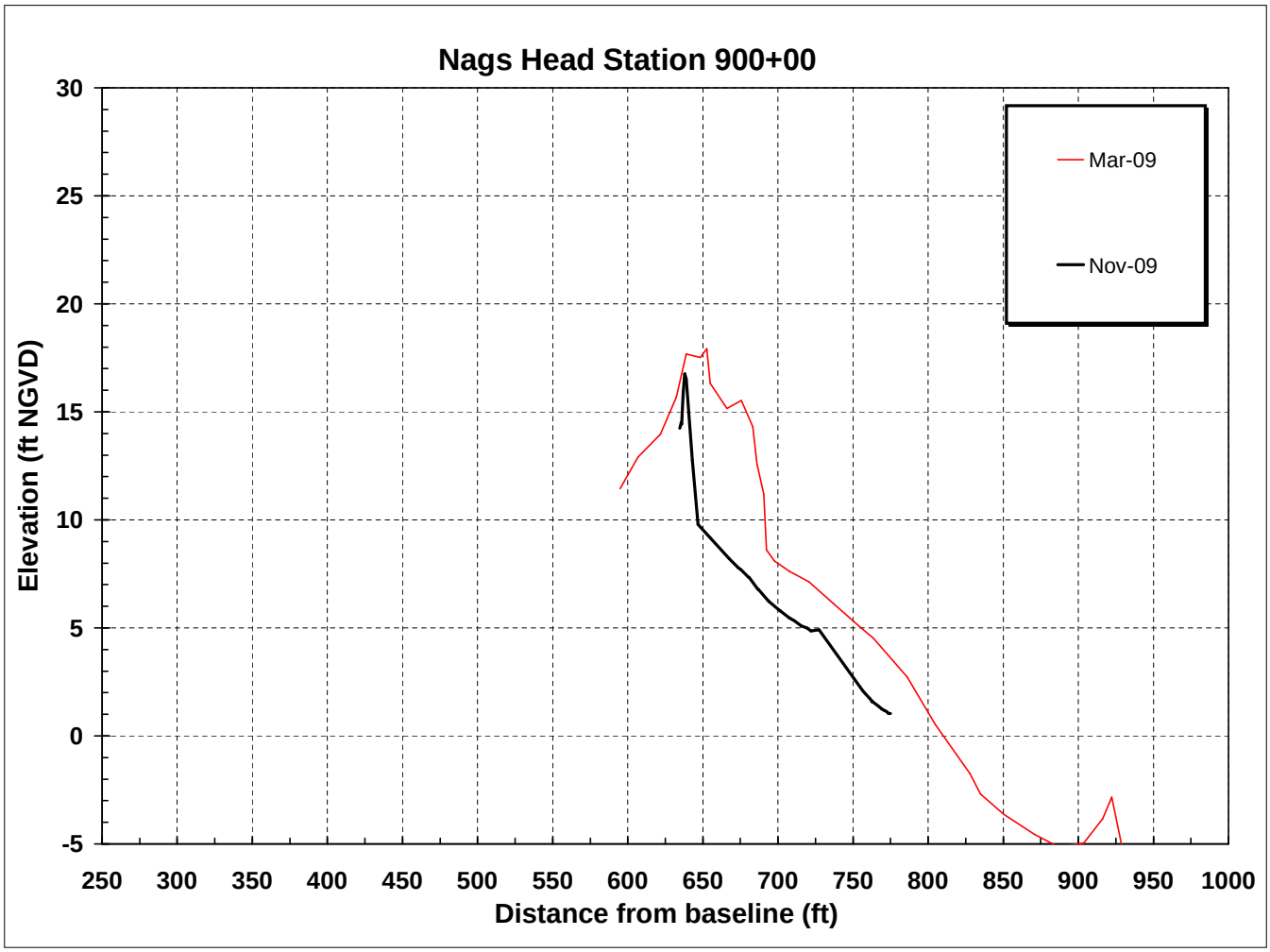
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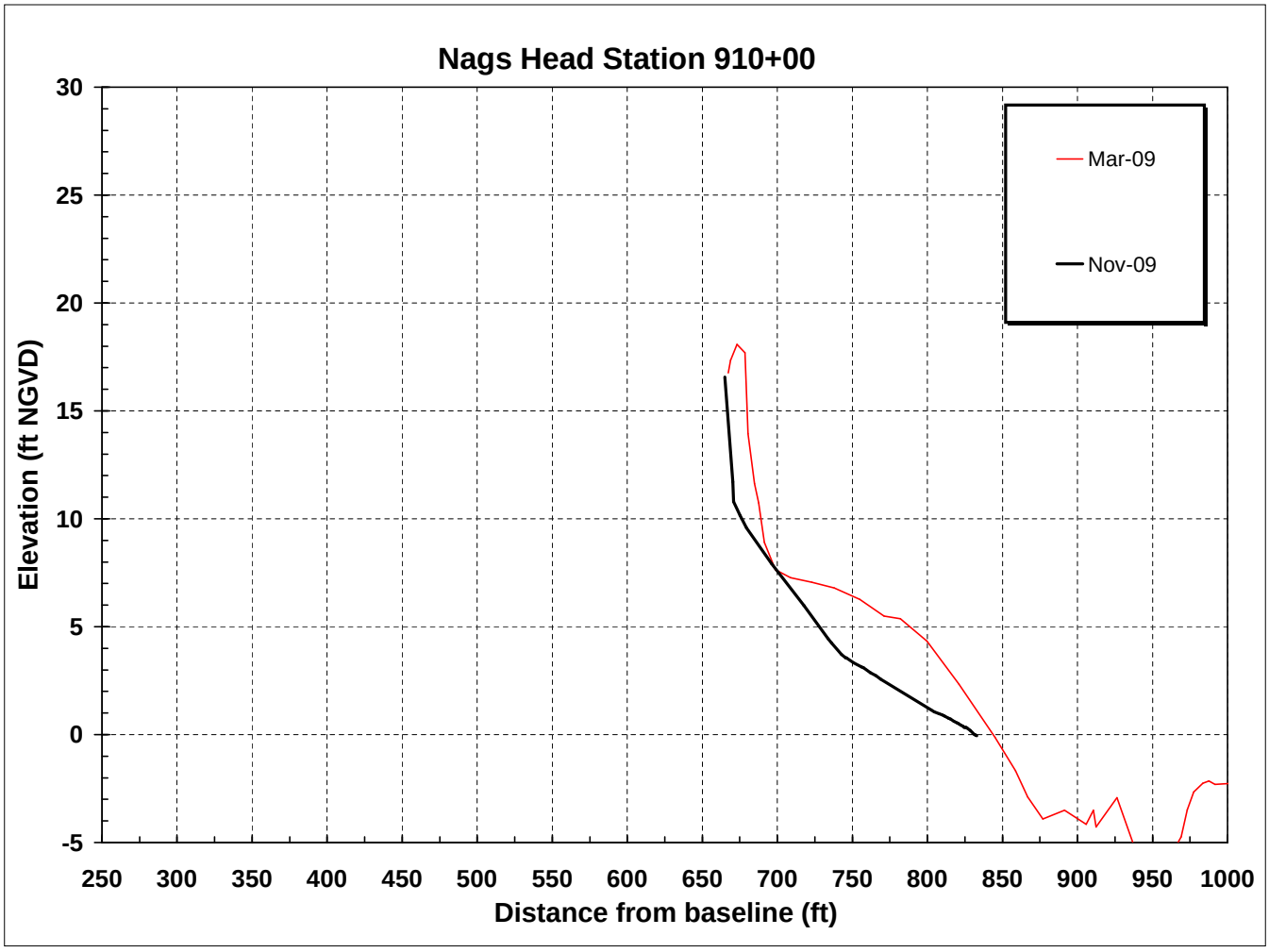
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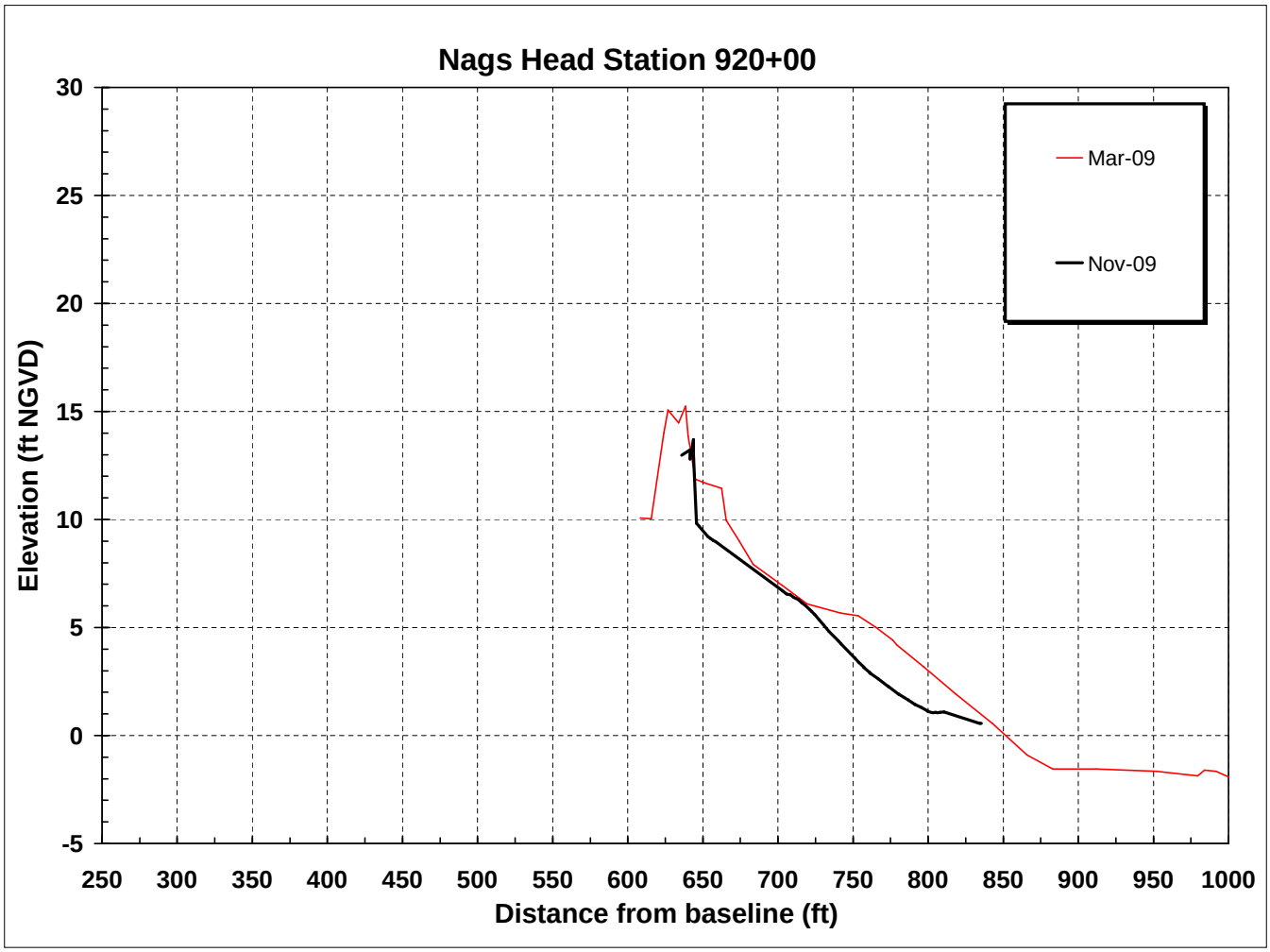
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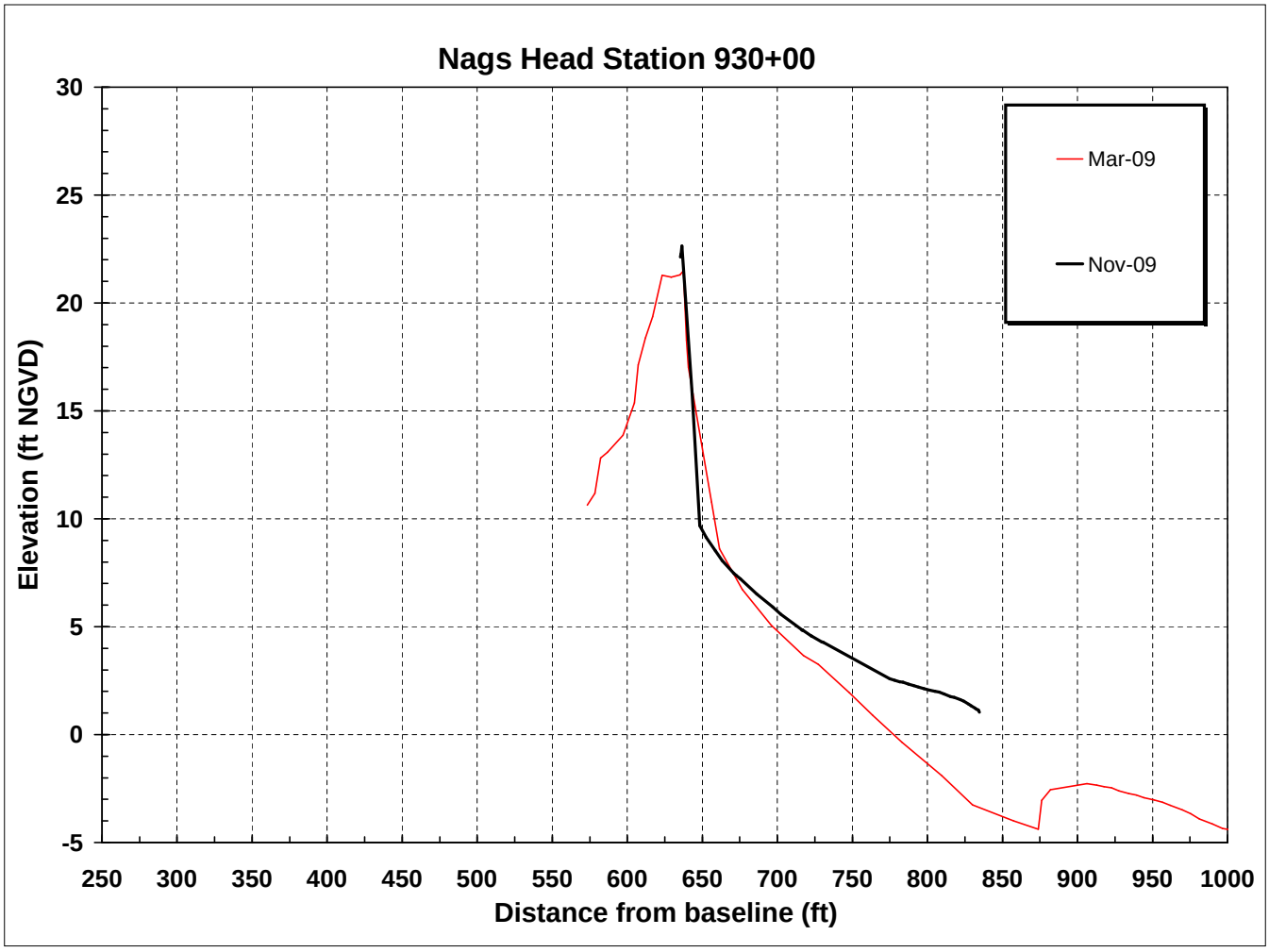
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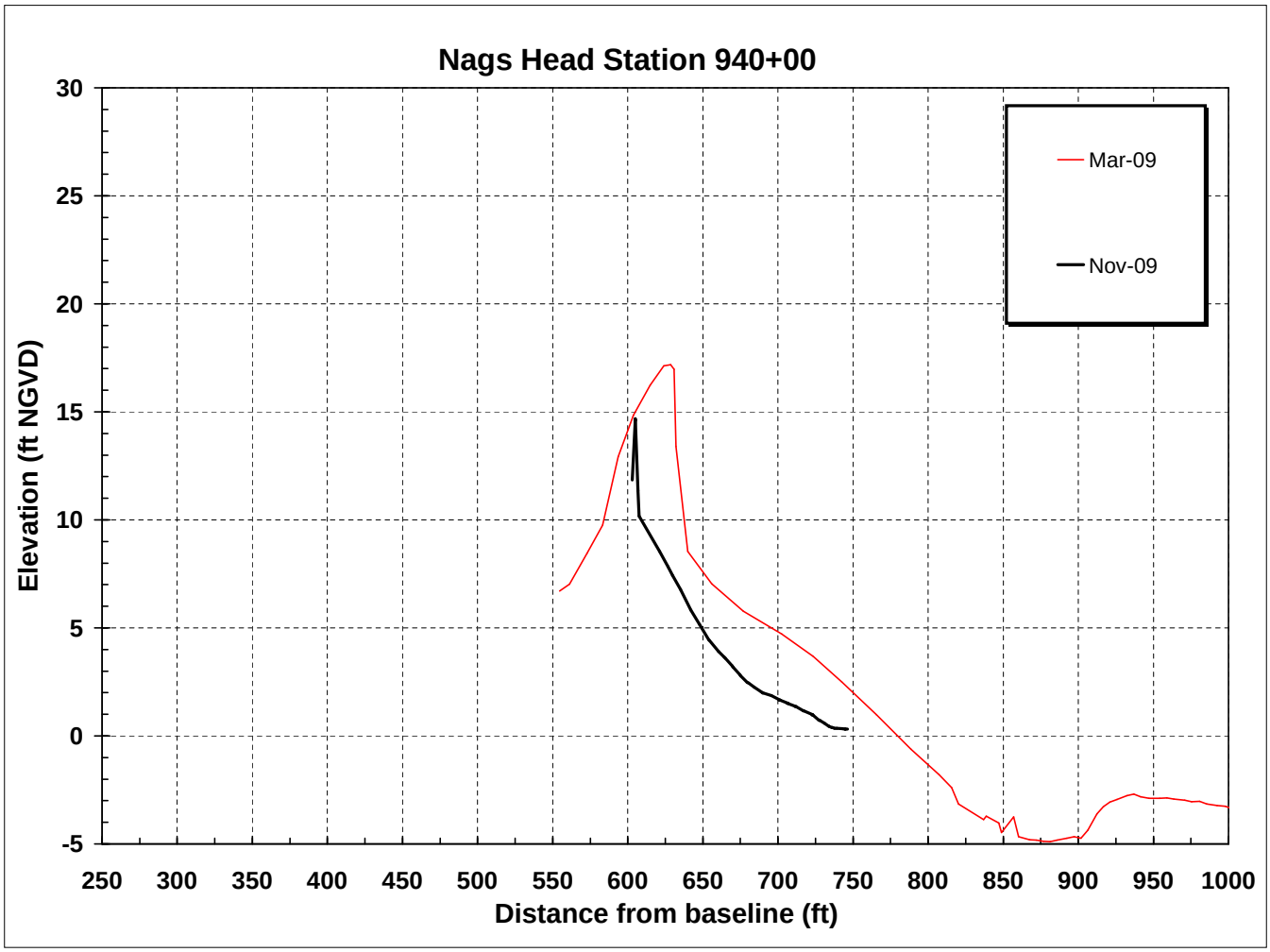
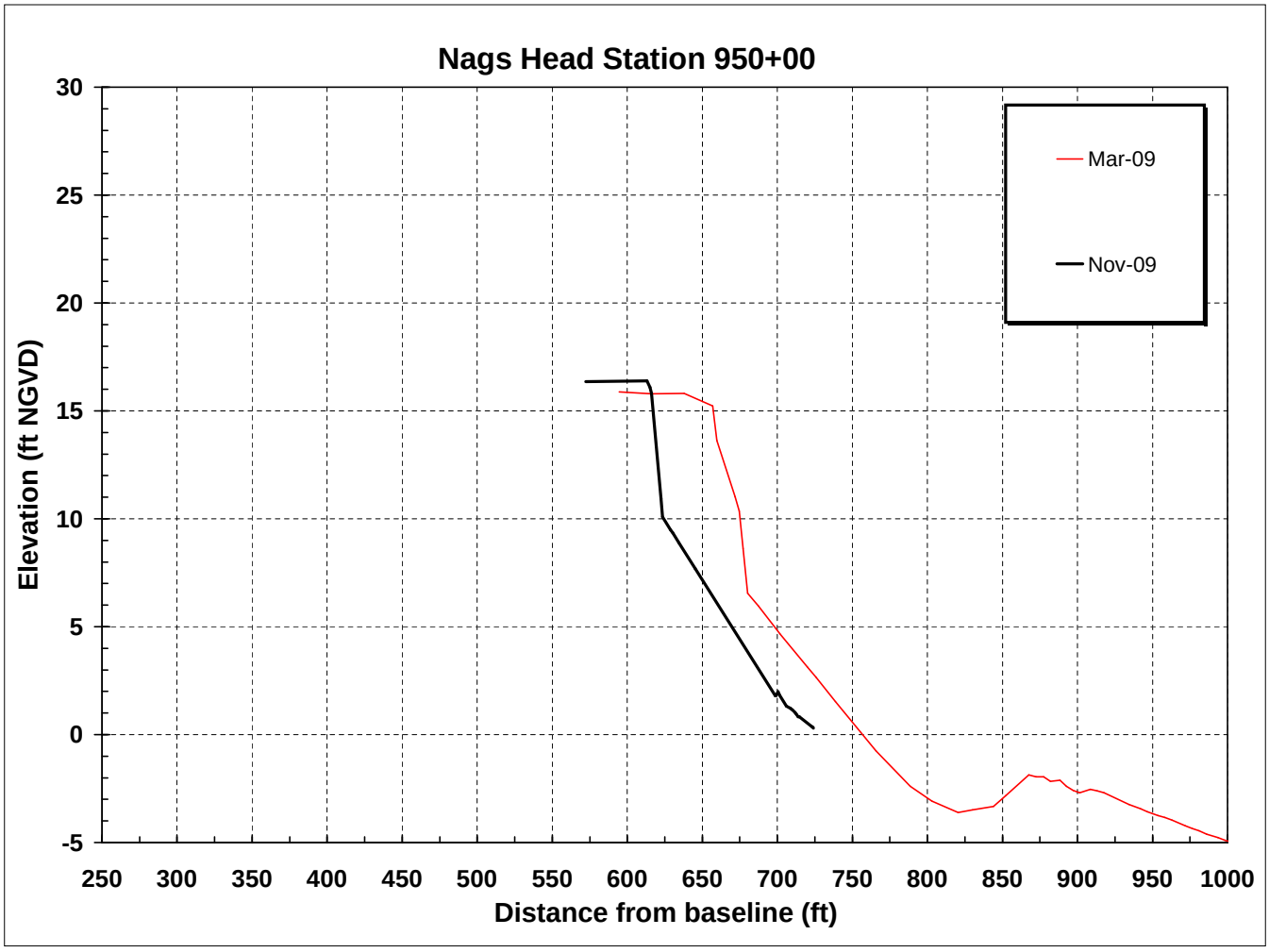
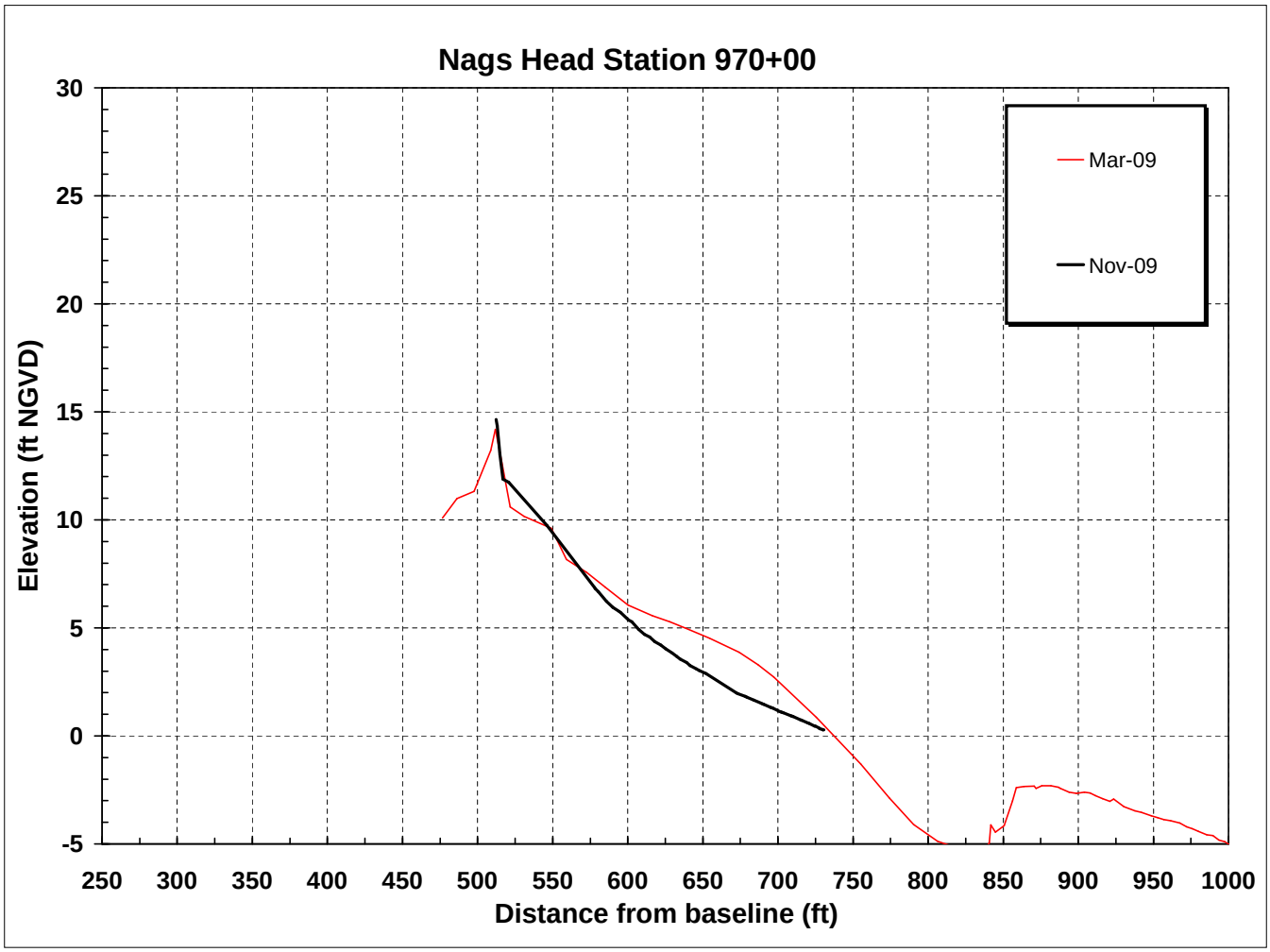
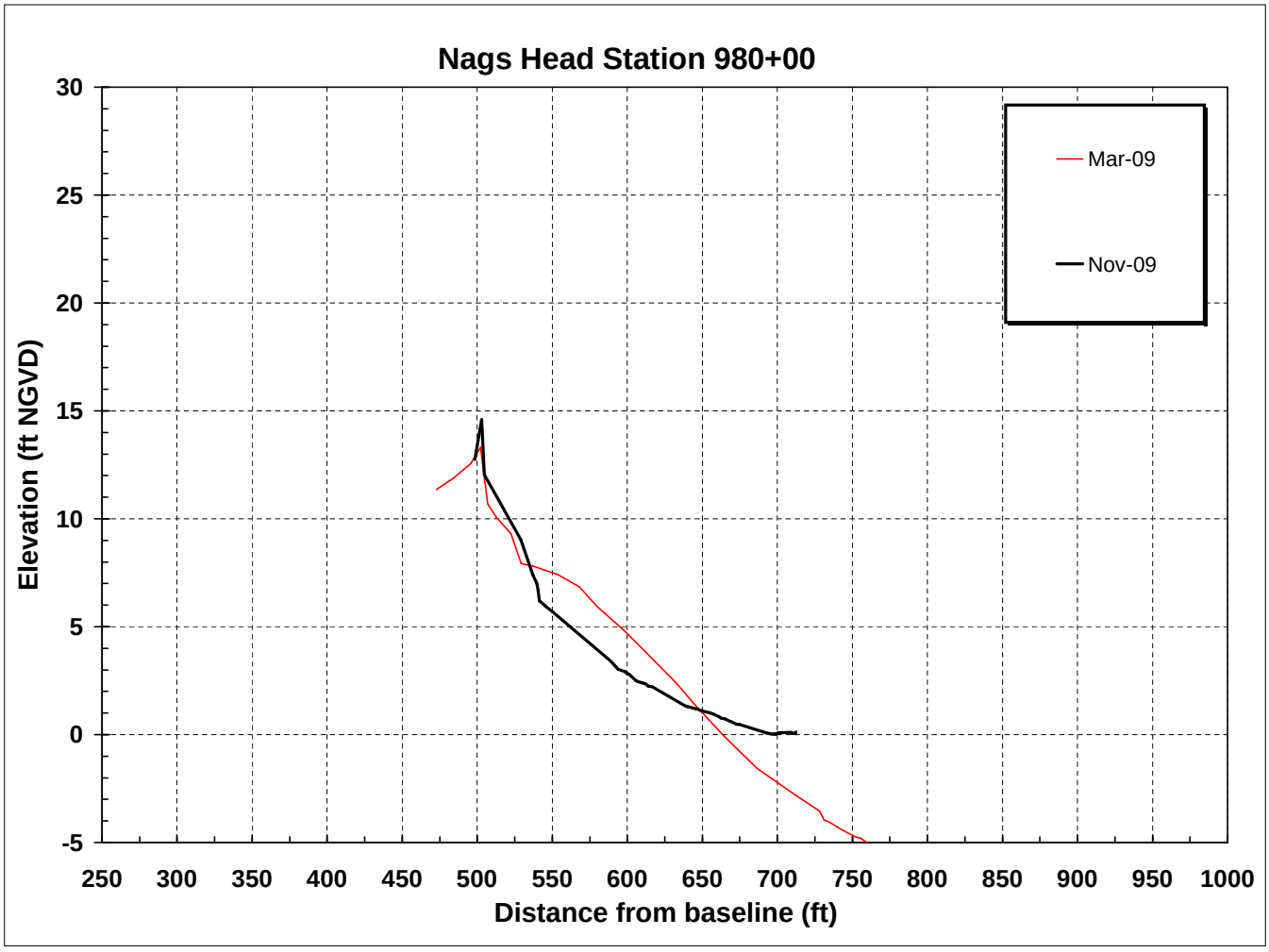
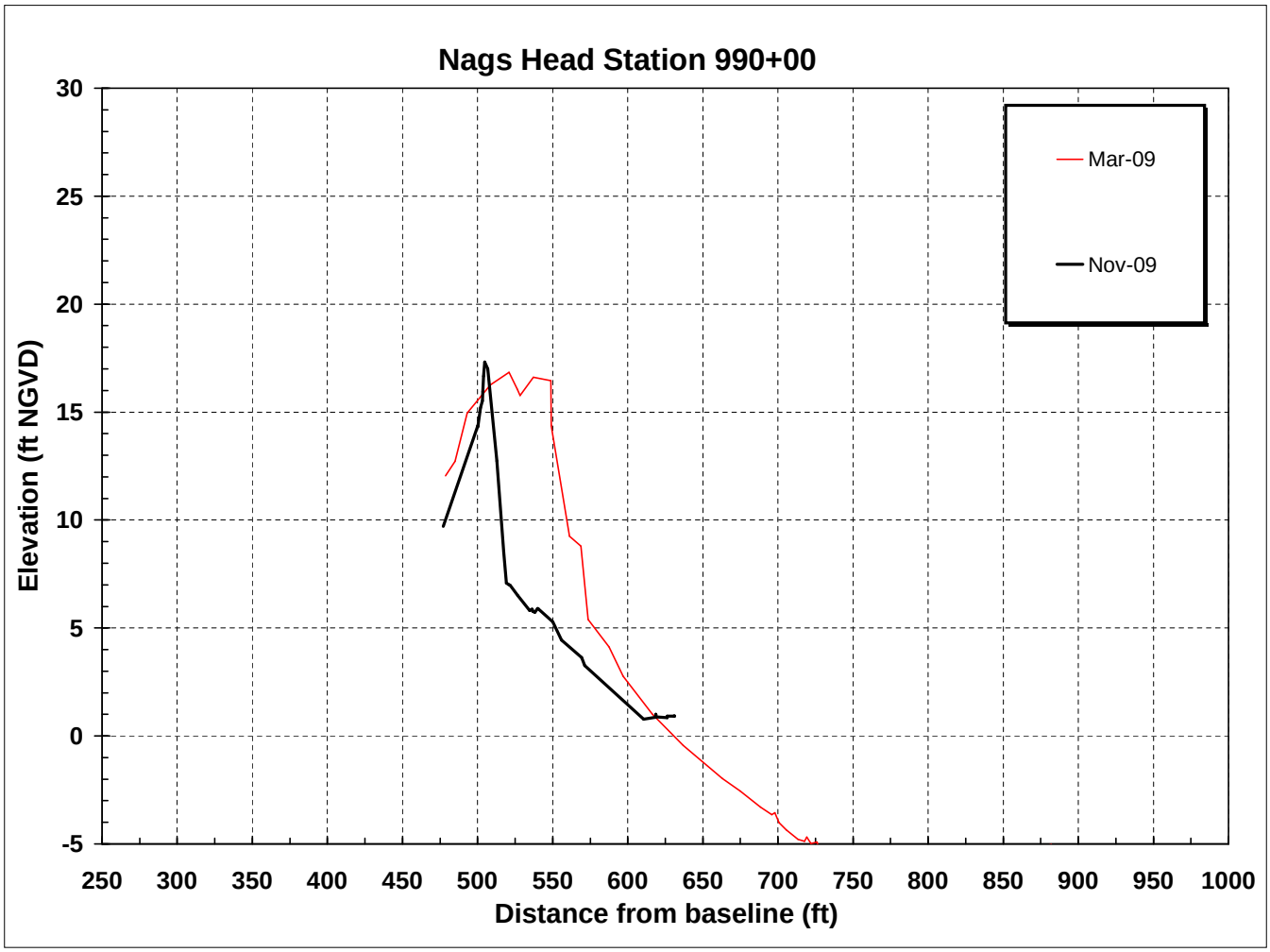
1000
Distance from baseline (ft)

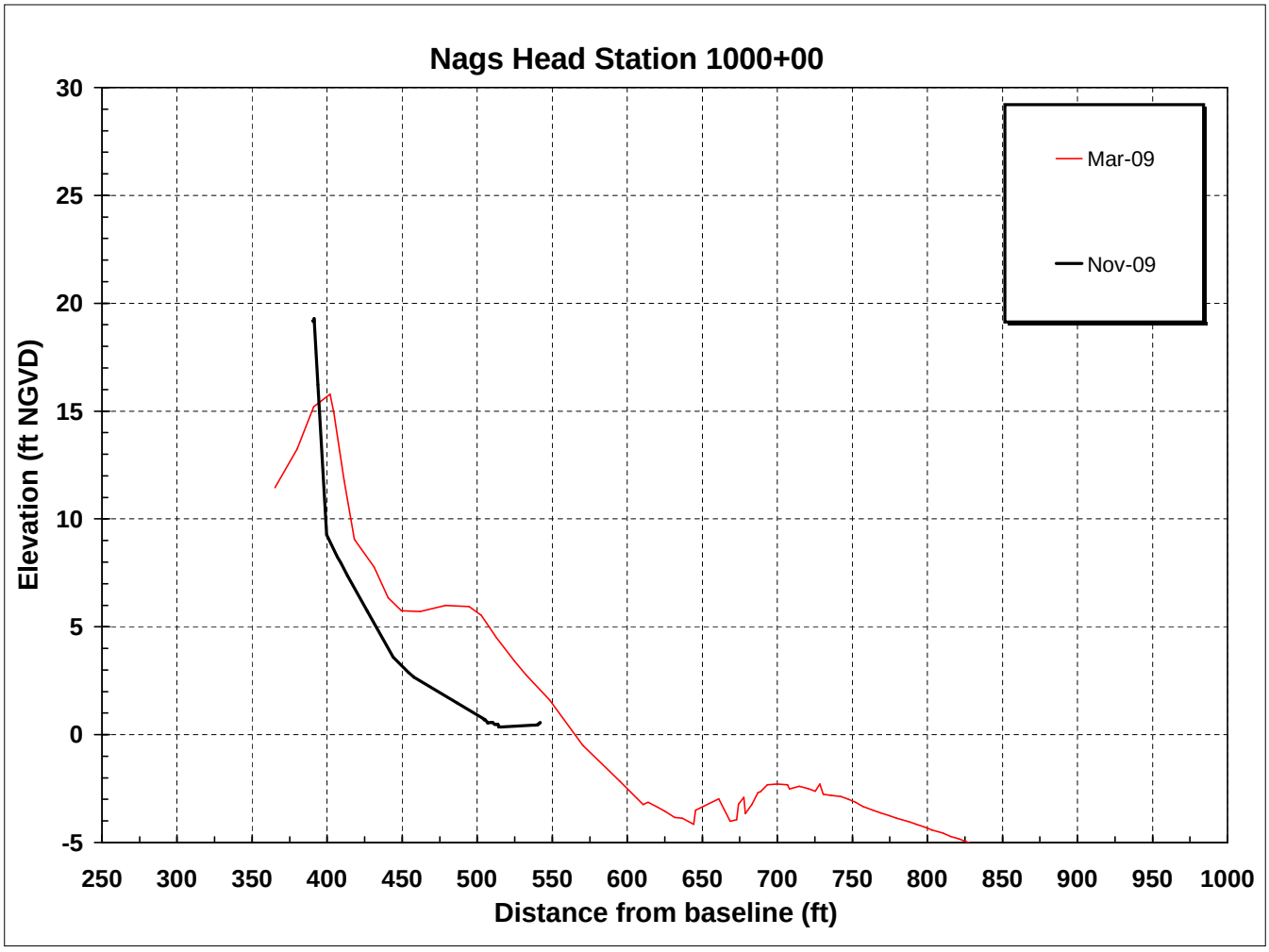

Nags Head Station 940+00
Mar-09
Nov-09
Elevation (ft NGVD)
30
25
20
15
10
5
0
-5
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
Distance from baseline (ft)

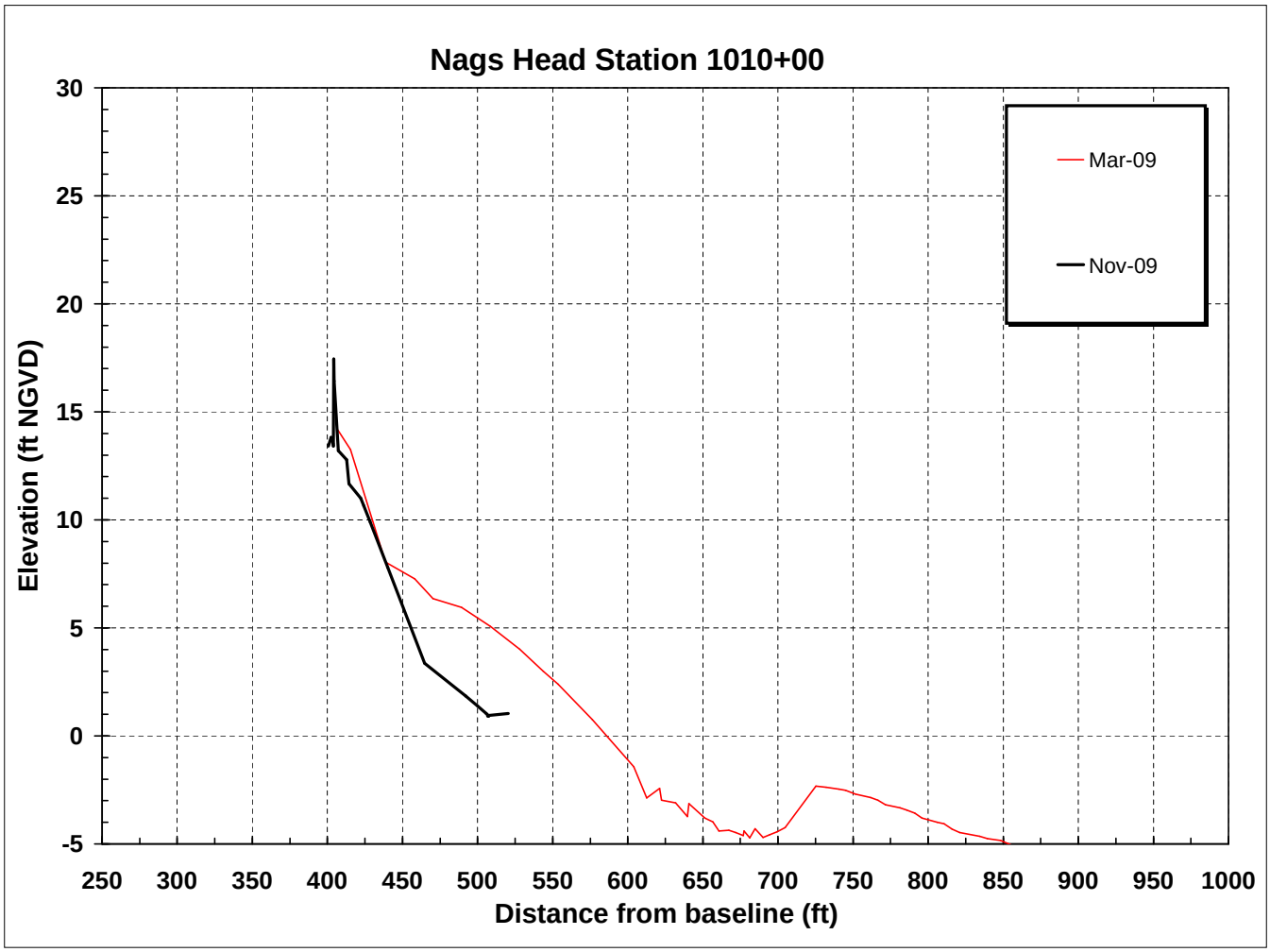

Nags Head Station 950+00
Mar-09
Nov-09
Elevation (ft NGVD)
30
25
20
15
10
5
0
-5
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
Distance from baseline (ft)

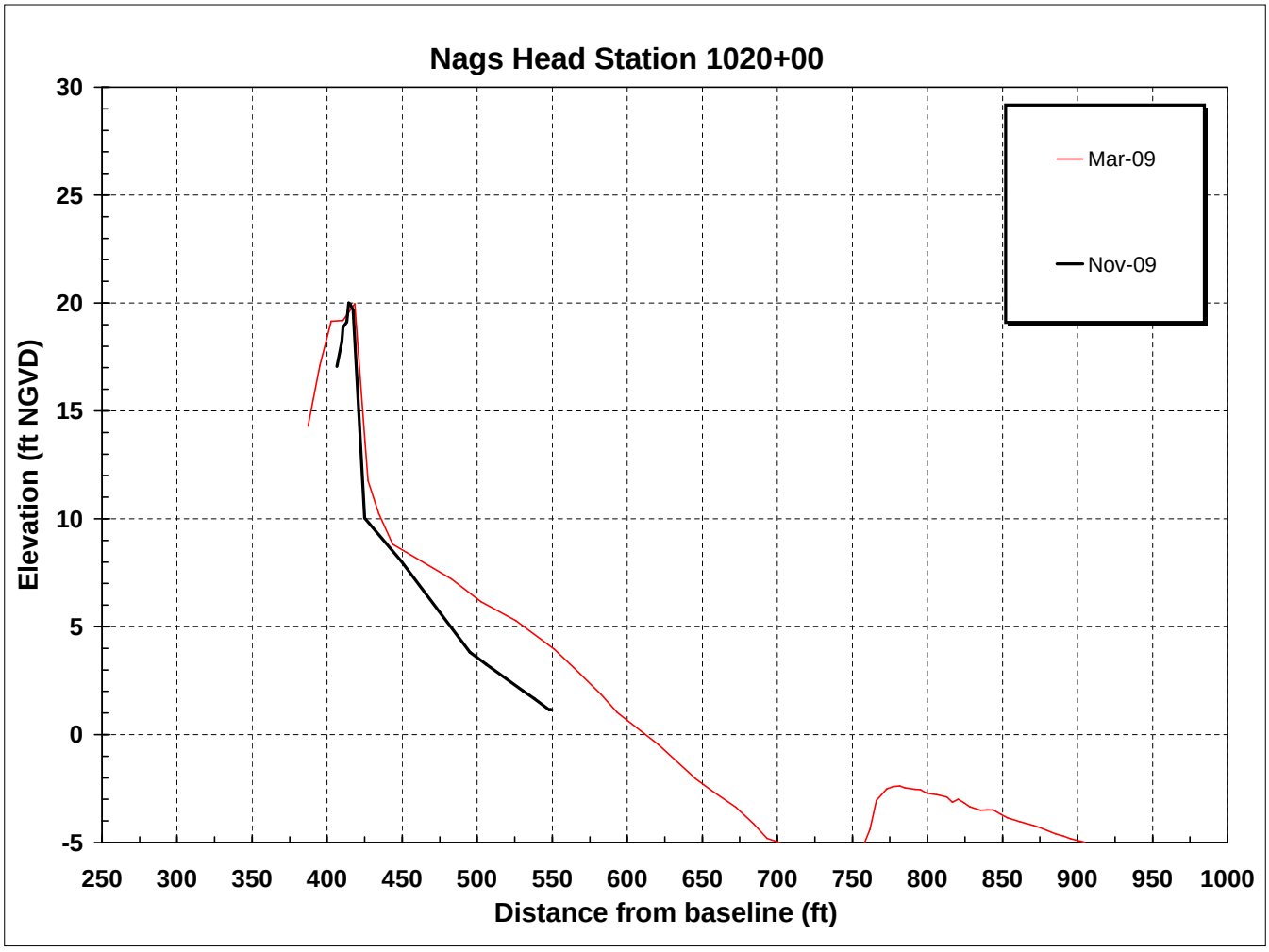

Nags Head Station 970+00
Mar-09
Nov-09
Elevation (ft NGVD)
30
25
20
15
10
5
0
-5
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
Distance from baseline (ft)

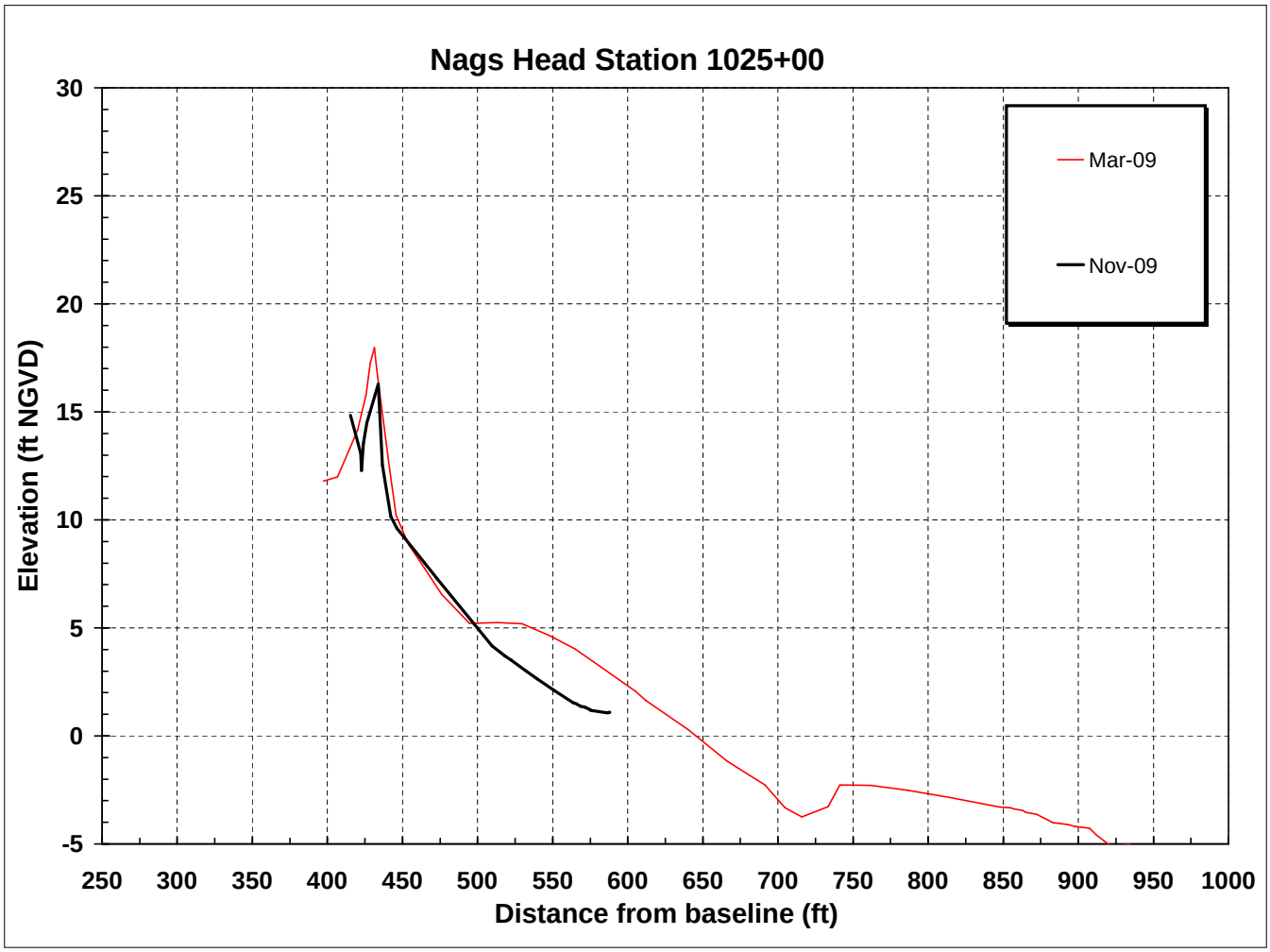

Nags Head Station 980+00
Mar-09
Nov-09
Elevation (ft NGVD)
30
25
20
15
10
5
0
-5
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
Distance from baseline (ft)


Nags Head Station 990+00
Mar-09
Nov-09
Elevation (ft NGVD)
30
25
20
15
10
5
0
-5
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
Distance from baseline (ft)


Nags Head Station 1000+00
Mar-09
Nov-09
Elevation (ft NGVD)
30
25
20
15
10
5
0
-5
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
Distance from baseline (ft)


Nags Head Station 1010+00
Mar-09
Nov-09
Elevation (ft NGVD)
30
25
20
15
10
5
0
-5
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
Distance from baseline (ft)


Nags Head Station 1020+00
Mar-09
Nov-09
Elevation (ft NGVD)
30
25
20
15
10
5
0
-5
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
Distance from baseline (ft)


Nags Head Station 1025+00
Mar-09
Nov-09
Elevation (ft NGVD)
30
25
20
15
10
5
0
-5
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
Distance from baseline (ft)