TAYLOR ENGINEERING, INC.

City of Cape May
Beach Data Collection & Future Needs Assessment

Cape May, New Jersey
April 2025

1100 North Front Street, Suite 304
Philadelphia, PA 19123
215-435-7386 | www.taylorengineering.com

City of Cape May Beach Data Collection
and Future Needs Assessment
Cape May, New Jersey

Prepared for

City of Cape May

by
Taylor Engineering, Inc.

1100 N Front Street, Suite 304
Philadelphia, PA, 19123
(904) 731-7040

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Taylor Project Number: C2023-109

Report production team: Wendy Laurent, P.E.; Kyle Rumaker, E.I.; Christopher Bender, Ph.D., P.E., BC.CE

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1.0 INTRODUCTION

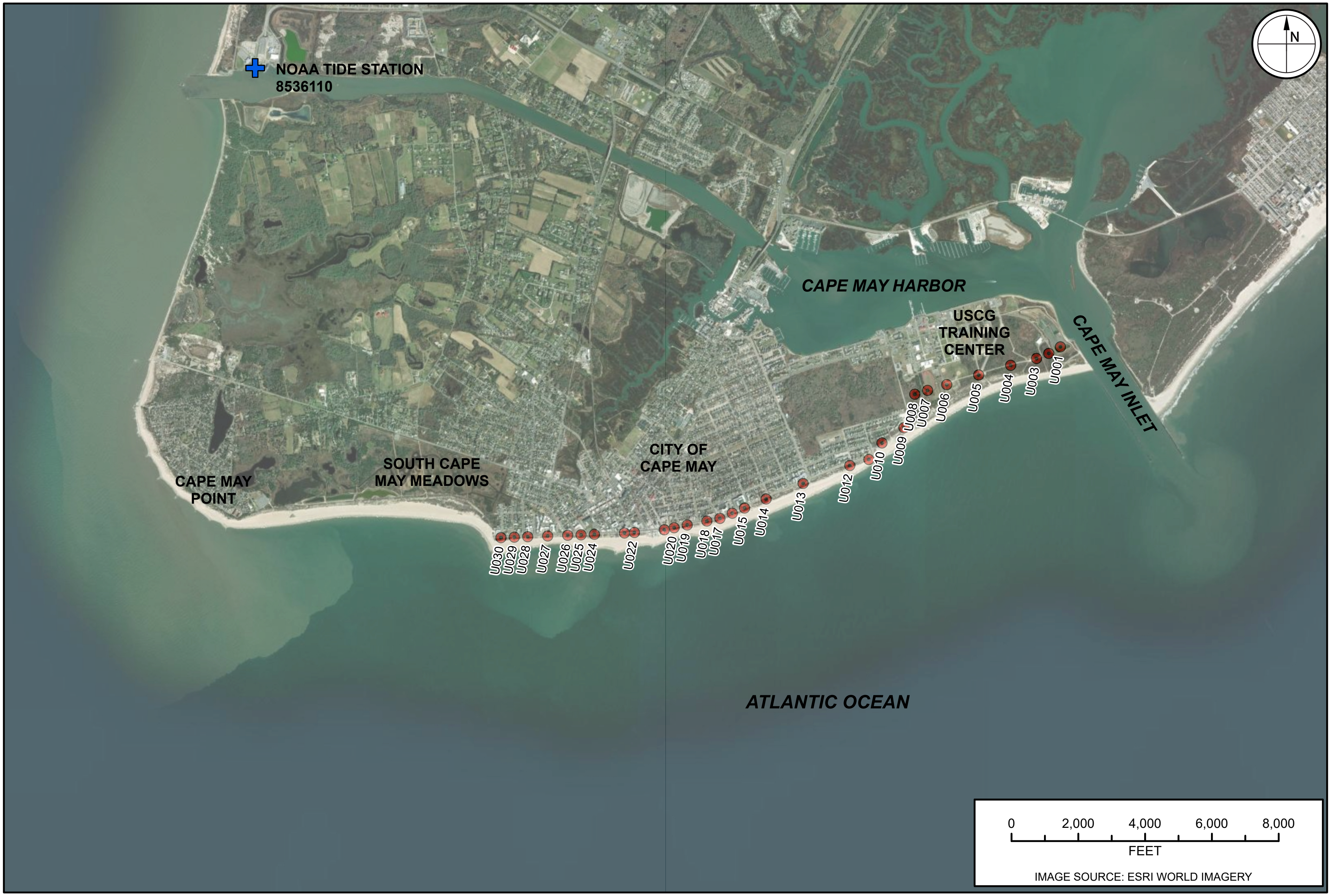
Maintaining a healthy beach is critical to maintaining a resilient coastal community. A beach's physical characteristics (length, width, slope, elevation, etc.) determine its ability to protect against a coastal storm and provide safety and recreation to its residents and visitors. Beach nourishment templates and sediment characteristics heavily influence the beach's equilibrium profile. The beach's profile, or its shape, affects the public's perception as they interact with the beach. The City of Cape May (City) and the U.S. Army Corps of Engineers (USACE) have actively maintained the City's beaches by conducting beach nourishment and inlet bypassing activities within City limits and on the adjacent beaches since the 1980's. Figure 1.1 shows the City beach and important local features— the City's beach extends from Wilmington Avenue to just east of Second Avenue; to the east is the U.S. Coast Guard (USCG) Training Center and Cape May Inlet, a federally maintained channel; to the west are the South Cape May Meadows, a natural meadow with ponds and wetlands; further west is Cape May Point and the Cape May Canal. Cape May City is one of the United States oldest summer resorts and was regarded as the "most socially prominent seashore resorts in the world before the Civil War, its prestige continuing well past 1900" (USACE 1976).

With concerns related to the shape of the beach and how it impacts safety, the City retained ACT Engineers and Taylor Engineering to complete a preliminary, investigative data review. The team completed a city-wide historical data collection effort; this report presents the results. Taylor Engineering characterized the evolution of the City's beach through the analysis of historic beach profile and nourishment data. The City requested historical survey data of beach and borrow areas, studies, construction plans, sediment analyses, and photos from the USACE Philadelphia District. The City also requested the New Jersey Department of Environmental Protection (NJDEP) beach profile surveys collected by Stockton University. The City transmitted this data to the team who then cataloged the data to allow easy access and updates during future project efforts. Taylor Engineering compiled the data into a timeline to illustrate the history of the City's beach. Taylor Engineering analyzed the survey data and determined the morphological changes across three time periods to document the beach evolution. At the conclusion of this report, Taylor Engineering provides a list of future actions and next steps that the City may evaluate for their future beach management activities that relate to quality of life and safety for their residents and visitors. Notably, this study completed a necessary site history and data review and provides a foundation to investigate complex coastal processes and for future work to evolve from.

1.1 Report Organization

This report, prepared for the City and the Beach Safety Committee, provides a comprehensive overview of the technical project plans and associated data. An accompanying presentation and work session will facilitate further dialogue between the City, the Committee, and the engineering team, providing an opportunity for clarification and in-depth discussion of key topics.

The report is organized as follows, following this introduction, Chapter 2.0 summarizes available data and provides a project history timeline this includes summaries of previous studies (Section 2.1), topographic and bathymetric surveys conducted in the City (Section 2.2), beach nourishment history (Section 2.3), beach structure history (Section 2.4) water level history and with sea level rise (SLR) predictions (Section 2.5), and an overview of historic storm events (Section 2.6). Chapter 3.0 presents the historic shoreline performance and beach morphology changes. This chapter analyzes five data sets and presents mean high water (MHW) shoreline position change (Section 3.1), changes in the beach width (Section 3.2), and the average berm elevation (Section 3.3). In conclusion, Chapter 4.0 summarizes the results of this report and presents recommendations for future studies for the City to consider.



TAYLOR ENGINEERING INC.
10199 SOUTHSIDE BOULEVARD
SUITE 310
JACKSONVILLE, FL 32256
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CITY OF CAPE MAY BEACH NEEDS ASSESSMENT

FIGURE 1.1
OVERVIEW MAP

CAPE MAY CO.,
NEW JERSEY

PROJECT	C2023-109
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SHEET	1 OF 1
DATE	MAR 2025

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2.0 PROJECT HISTORY

Understanding the project history and coastal management decisions is critical to understanding a beach's current state and predicting how it may react in the future. This chapter summarizes pertinent data to understanding the City's beach, this includes: previous studies (Section 2.1), available topographic and bathymetric datasets (Section 2.2), nourishment events (Section 2.3), and a brief overview of the construction and maintenance of coastal structures which the project team recommends be further investigated in the future (Section 2.4). Additionally, this chapter defines the tidal datum and presents future SLR projections (Section 2.5) and summarizes major historic storms for this region (Section 2.6).

Figure 2.1 presents an overview of the project history through 2024 while subsequent chapters provide greater detail. Laying out the project history in this manner shows the timing of significant events which is important to understanding the project lifecycle and the historic storms that have impacted the beach. For example, the performance of the beach project is dependent on the storm history and storm-induced erosion that may occur as a result of a passing storm. The erosion impacts may trigger the need for permit modifications that allow for an emergency nourishment event. It is expected that the City holds an NJDEP Beach and Dune Maintenance Permit and has an approved Beach Management Plan that would need modification. Together, these documents combined with the federal authorization define acceptable routine beach maintenance activities.

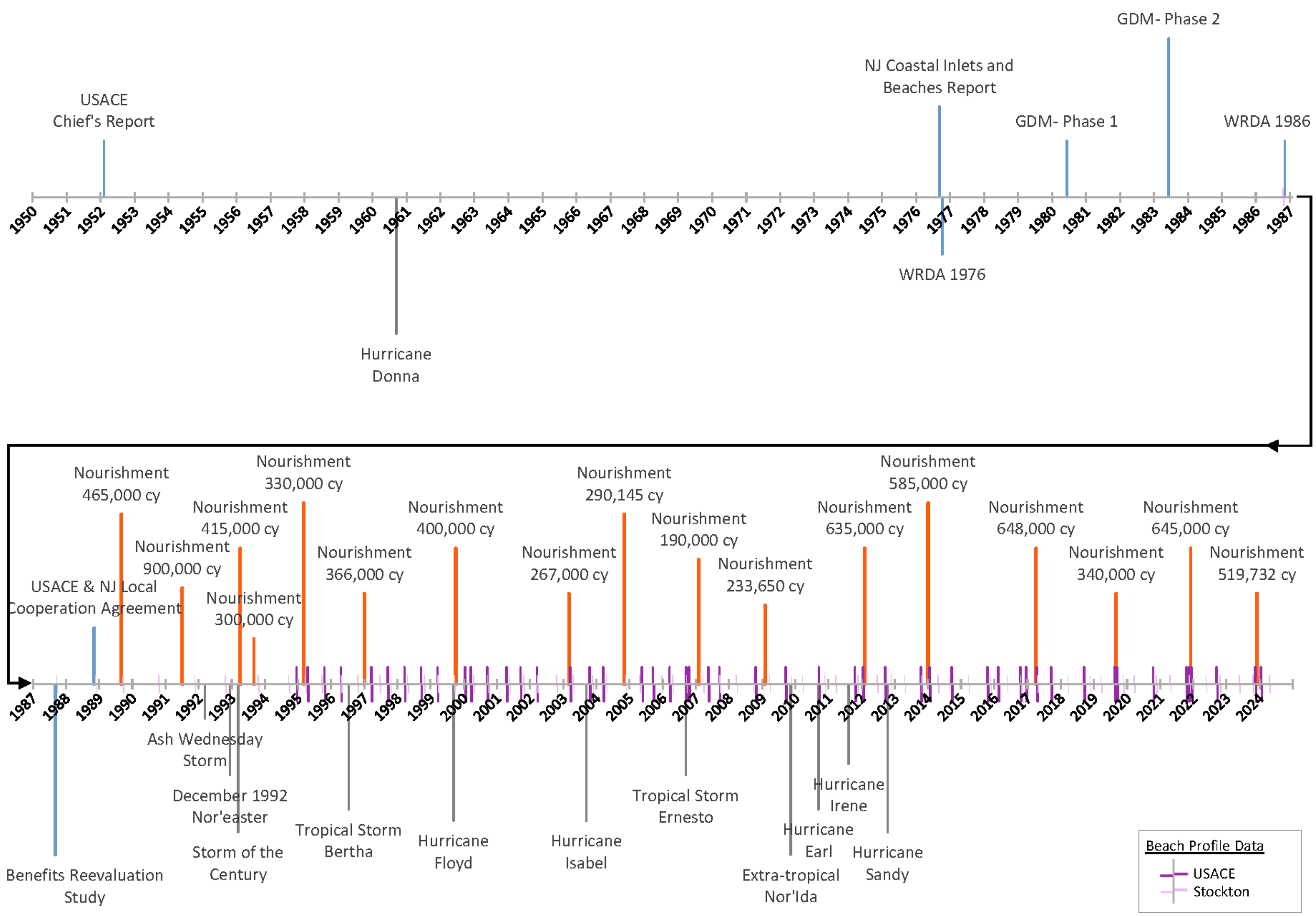

Figure 2.1 City of Cape May Beach Timeline

2.1 Previous Studies

To better understand the City's beaches, Taylor Engineering reviewed previous studies related to the coastal system. The list of studies below provides a brief narrative of their findings and details. Notably, although mentioned throughout early references, documentation of the Cape May City Beach Erosion Control project is not included. The 1980 General Design Memorandum (GDM) does note that Congress authorized the project in 1954, and it was modified in 1960 and 1962. The project plan consisted of sand placement throughout the City limits (Wilmington Avenue to west of Second Avenue) extending the berm 100 to 200 ft; periodic placement of a feeder beach to the east to sustain the fill and feed the erosion hot spot near Wilmington Avenue; construction of five timber groins; and the extension of five stone groins (USACE 1980).

The text below briefly describes the pertinent previous studies related the coastal system. Importantly, each study included detailed analyses, specific goals, and varying constraints, which makes it difficult to provide a develop a brief summary to encompass all project aspects. Specific information related to the intention of each study report's content and management strategies should be individually investigated in the original report.

- Cold Spring Inlet (Cape May Harbor), N.J., Report of the Chief of Engineers, United States Army-Department of the Army, Office of the Chief of Engineers, Washington, D.C., February 1952

  The 1952 Chief's report on Cold Spring Inlet (Cape May Harbor, NJ) indicates that the shores to the west of the inlet are unstable and in need of protection, this includes Cape May City. The proposed plan calls for restoration and protection from Wilmington Avenue to 3,000 west of Windsor Avenue (or just beyond what is now Second Avenue). The beach fill is to be 100-200 ft wide above MHW through placement of 832,000 cubic yards (cy) within the City and 300,000 cy to the east. The report conveys that should a need be demonstrated, the local sponsor and USACE should consider construction of five timber groins and extension of five stone groins. The Chief recommended federal participation of the project.

- New Jersey Coastal Inlets and Beaches, Hereford Inlet to Delaware Bay Entrance to Cape May Canal, House Document No. 94-641, Washington, D.C., September 1976

  This document contains multiple communications and letter reports detailing the project and conditions of the beach and surrounding coastal systems since 1930. Notably, the interim report mentions sand has not been placed in the groin field within the City limits and although effective in maintaining fill, the beach is narrow. The report mentions increased volumetric changes with an average loss of 193,000 cy annually between 1937 and 1955 increasing to 594,000 cy between 1955 and 1965. A 1975 letter from the Chief of Engineers suggests placement and maintenance of a 100 ft berm at an elevation of +10 ft-Mean Low Water (MLW) with a slope of 1V:30H and a dune from the Cape May Inlet jetty to west of Wilmington Avenue; construction of groins at Trenton and Baltimore Avenues, rehabilitation and maintenance of other groins within the project; and rehabilitation and maintenance of the seawall.

  The compilation of reports suggests the federal government and City adopted the erosion control project presented in the 1952 Chief's report that was modified in 1960 and 1962 to include: (1) widening of the beach between Wilmington Avenue to west of Second Avenue through placement of a beach 100 to 200 ft above MHW; (2) creation and placement of a 300,000 cy feeder beach 3,000 ft east of Wilmington Avenue; (3) construction of five new timber groins (Baltimore Avenue, Trenton Avenue, and 1,100 ft, 2,200 ft, and 3,300 ft west of Windsor Avenue); (4) extension of five stone jetties (Windsor Avenue, Jackson Street, Stockton Place, Queen Avenue, and Philadelphia Avenue).

Notably, within the reports it is mentioned that bypassing alone through a deposition basin would not provide sufficient volume of sediment and recommended supplemental nourishment. The reports note the beach slope to be approximately 1V:30H above MLW and 1V:200H from MLW to depths of approximately -10 ft-MLW. Just west of the City's beach project slopes are noted to be much steeper—averaging 1V:12H to depths of approximately -4 to 5 ft-MLW then 1V:55H until depths of approximately -20 ft-MLW.

- The Water Resources Development Act of 1976 (WRDA 1976), Public Law 94-587, Congress, October 1976

  In the Water Resource and Development Act (WRDA) of 1976, Congress authorized the "design memorandum stage of advanced engineering and design" for the project area extending from Hereford Inlet to the Cape May Canal.

- Cape May to Lower Township, New Jersy, Phase I General Design Memorandum, United States Army Corps of Engineers (USACE)- Philadelphia District, August 1980

  The USACE completed a GDM that included a beach erosion control and storm protection study for the Atlantic Coast of New Jersey from Cape May Inlet to Lower Township investigating a number of shoreline stabilization methods including breakwaters, groins, seawalls, and beach fill. A comprehensive history of past structures and maintenance is included within the study's appendices. USACE noted consistent shoreline retreat during 1880 to 1899, 1899 to 1928, 1928 to 1955, 1955 to 1965, and 1949 to 1978. The USACE analyzed volumetric changes from 1937 to 1965 predicting an average sediment loss of 336,000 cy/year. Historic slopes average 1V:30H above MLW and 1V:200H between MLW and a depth of approximately -10 ft-MLW.

  The study's recommended alternative includes a weir-breakwater and deposition basin, groin rehabilitation and construction, seawall rehabilitation, and beach fill. The study developed a nourishment design template with a berm width varying between 25 and 180 ft at an elevation of 8 ft-National Geodetic Datum of 1929 (NGVD29) transitioning to a nearshore slope of 1V:25H. USACE investigated five potential sand sources for the proposed project. The weir-breakwater sheltering the deposition basin is pending based on demonstration of need.

- Cape May Inlet to Lower Township, New Jersey, Phase II General Design Memorandum, USACE, June 1983

  The USACE completed Phase II of the GDM shortly after Phase I and recommended continued monitoring of the feeder beach and the interaction with the groin field and a wave fraction study spurred from questions during plan review. The Phase II recommended plan and analysis are largely the same as Phase I, with differences in "engineering details of project features, costs, and economic benefits."

The plan reflects the Phase I plan and includes groin extensions, a weir-breakwater system, and beach fill activities; the addition of storm sewer outfall extensions and shoreline monitoring is included in this Phase II GDM. The proposed beach template remains the same with a berm width varying between 25 and 130 ft at the feeder beach and 25 ft from Wilmington Avenue to Third Avenue; the foreshore slope is 1V:25H from a berm elevation of 8 ft-NGVD29. Renourishment of the beach is proposed every two years with the bypassing of 360,000 cy of sediment from the deposition basin on the northeast side of the Cape May Inlet.

- The Water Resources Development Act of 1986 (WRDA 1986), Public Law 99-662, Congress, November 1986

  In WRDA 1986, Congress authorized the construction of the project presented in the Phase I and II GDMs.

- Cape May Inlet to Lower Township, New Jersey, Benefits Reevaluation Study, USACE, September 1987

  The USACE conducted a benefits reevaluation study to assess the advantages of the recommended improvement plan for the Cape May Inlet to Lower Township project, with a strong focus on storm damage reduction benefits. The USACE evaluated a storm-induced erosion study on a series of beach widths ranging from zero, or 'no action' plan (no improvement), and the recommended plan outlined in the Phase I and Phase II GDMs. The results of this study demonstrate a benefit to cost ratio of 1.70, incorporating benefits from prevention of erosion damages, reduced costs of maintaining beach structures, reduced cost of maintaining the navigation channel, wave runup reduction, and recreation. The project's storm related erosion benefits justify the project, and it is recommended that the project be approved.

- Local Cooperation Agreement Between the Department of the Army and the State of New Jersey for Construction of the Cape May Inlet to Lower Township, NJ Project, November 1988

  The local cooperation agreement between the USACE and the state of NJ in 1988 announced the state of NJ as the local sponsor of the "Cape May City Project" which includes the initial beach fill placement between Buffalo Avenue and Third Avenue, periodic nourishment, shoreline monitoring, extensions to the groins at Trenton Avenue and Baltimore Avenue and extending 11 storm sewer outfalls.

2.2 Topographic and Bathymetric Data

Historically, USACE, NJ, and the City of Cape May collected topographic and bathymetric data documenting the City's beach and borrow areas. Stockton University Coastal Research Center (Stockton) collects the state and City's data. Figure 2.2 depicts the approximate transect locations associated with these datasets and their spatial variability, Table 2.1 lists the nearest street to help reference the transects. Although reports indicate surveys dating back to project planning in the early 1900's, the team was only able to obtain surveys from 1986 onward. Table 2.2 provides a list of the provided topographic and bathymetric datasets, their spatial extents, and their data source.

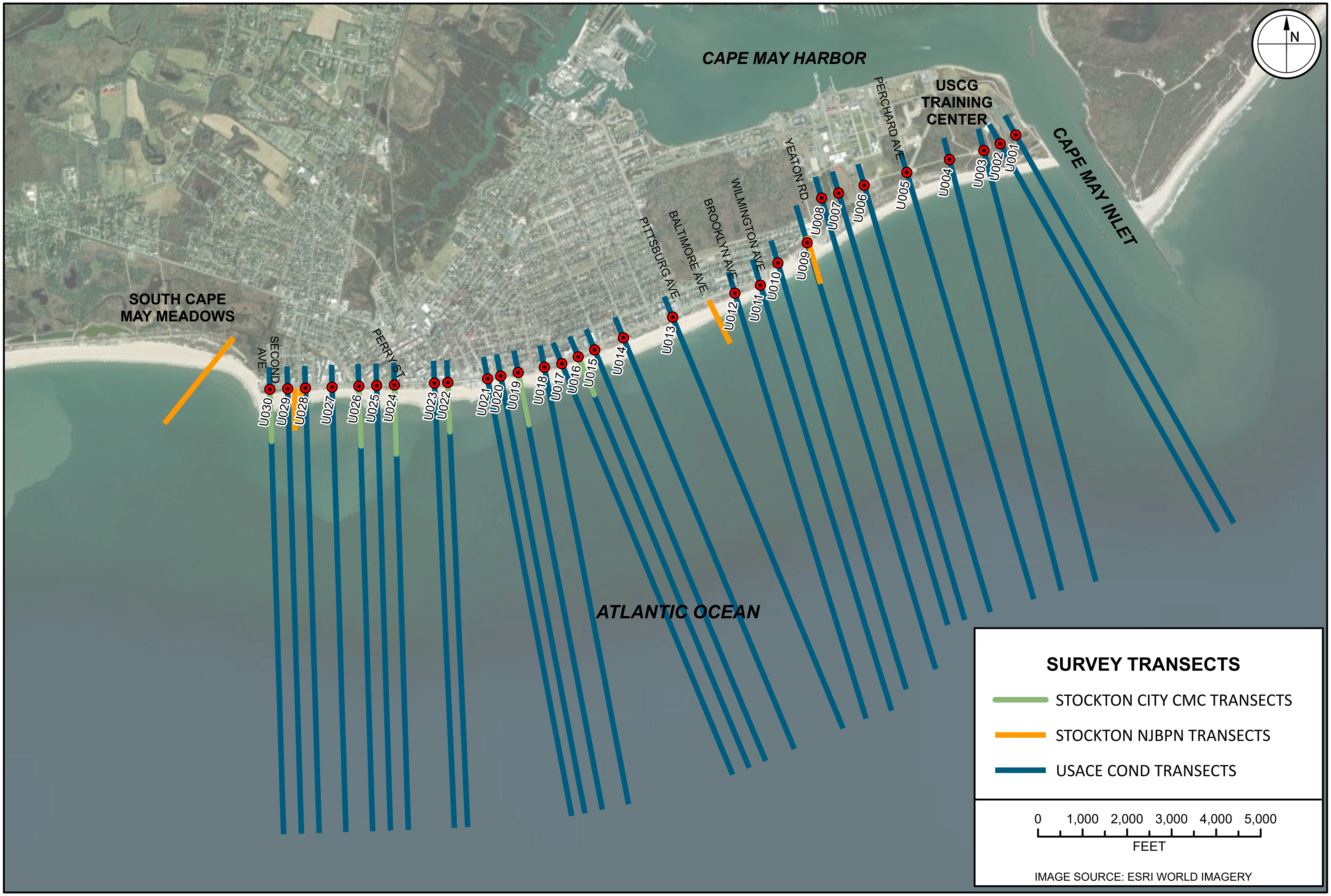

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FIGURE 2.2
SURVEY TRANSECT LOCATIONS

CAPE MAY CO., NEW JERSEY

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Table 2.1 Approximate Survey Transect Locations

Transect	Agency	Approximate Location
U-1	USACE	Cape May Inlet Jetty
U-2	USACE	USCG Training Center
U-3	USACE	USCG Training Center
U-4	USACE	USCG Training Center
U-5	USACE	USCG Training Center
U-6	USACE	USCG Training Center
U-7	USACE	USCG Training Center
U-8	USACE	USCG Training Center
S-1 NJBPN	Stockton	Yeaton Rd
U-9	USACE	Yeaton Rd
U-10	USACE	Between Yeaton Rd & Wilmington Ave
U-11	USACE	Wilmington Ave
U-12	USACE	Brooklyn Ave
S-2 NJBPN	Stockton	Baltimore Ave
U-13	USACE	Between Pittsburg Ave & Trenton Ave
U-14	USACE	Reading Ave
U-15	USACE	Philadelphia Ave
U-16	USACE	Between Philadelphia Ave & Madison Ave
S-1 CMC	Stockton	Between Philadelphia Ave & Madison Ave
U-17	USACE	Madison Ave
U-18	USACE	Between Madison Ave & Queen St
U-19	USACE	Between Queen St & Jefferson St
S-2 CMC	Stockton	Between Queen St & Jefferson St
U-20	USACE	Between Jefferson St & Howard St
U-21	USACE	Howard St
U-22	USACE	Ocean St
S-3 CMC	Stockton	Ocean St
U-23	USACE	Decatur St
U-24	USACE	Perry St
S-4 CMC	Stockton	Perry St
U-25	USACE	Between Congress St & Windsor Ave
U-26	USACE	Grant St
S-5 CMC	Stockton	Grant St
U-27	USACE	Between Grant St & Patterson Ave
U-28	USACE	Between Patterson Ave & South Broadway
S-3 NJBPN	Stockton	South Broadway
S-4 NJBPN	Stockton	Between South Broadway & 1st Ave
U-29	USACE	1st Ave
U-30	USACE	2nd Ave
S-6 CMC	Stockton	2nd Ave
S-5 NJBPN	Stockton	Cape May Meadows

Table 2.2 Topographic and Bathymetric Data for Cape May, NJ

Agency	Survey Date	Notes
Stockton	October 1986	Wading Depth
Stockton	September 1987	Wading Depth
Stockton	November 1988	Wading Depth
Stockton	September 1989	Wading Depth
Stockton	October 1990	Wading Depth
Stockton	November 1991	
Stockton	October 1992	
Stockton	October 1993	
Stockton	September 1994	
USACE	December 1994	Partial Wading Depth
Stockton	March 1995	
USACE	April 1995	Partial Wading Depth
Stockton	September 1995	
USACE	October 1995	Partial Wading Depth
USACE	April 1996	Partial Wading Depth
Stockton	April 1996	
Stockton	October 1996	
USACE	March 1997	Partial Wading Depth
Stockton	June 1997	
USACE	September 1997	Partial Wading Depth
Stockton	October 1997	
USACE	March 1998	Partial Wading Depth
Stockton	April 1998	
USACE	September 1998	Partial Wading Depth
Stockton	October 1998	
USACE	March 1999	Partial Wading Depth
Stockton	March 1999	
Stockton	September 1999	
USACE	January 2000	Partial Wading Depth
USACE	March 2000	Partial Wading Depth
Stockton	April 2000	
USACE	September 2000	
Stockton	September 2000	
USACE	April 2001	
Stockton	May 2001	
USACE	September 2001	
Stockton	October 2001	
USACE	March 2002	
Stockton	March 2002	
Stockton	October 2002	
USACE	March 2003	
Stockton	April 2003	

Agency	Survey Date	Notes
USACE	October 2003	
Stockton	November 2003	
USACE	March 2004	
Stockton	April 2004	
Stockton	November 2004	
Stockton	April 2005	
USACE	May 2005	
USACE	September 2005	
Stockton	December 2005	
USACE	March 2006	
Stockton	April 2006	
USACE	September 2006	
Stockton	September 2006	
USACE	October 2006	Partial Wading Depth
Stockton	March 2007	
USACE	May 2007	
USACE	September 2007	
Stockton	September 2007	
Stockton	March 2008	
Stockton	September 2008	
USACE	October 2008	
Stockton	March 2009	
USACE	September 2009	
Stockton	November 2009	
Stockton	March 2010	
USACE	September 2010	
Stockton	November 2010	
Stockton	March 2011	
USACE	October 2011	Pre-Construction Survey
Stockton	November 2011	
USACE	January 2012	Post-Construction Survey
Stockton	June 2012	
USACE	September 2012	
Stockton	November 2012	
Stockton	April 2013	
USACE	October 2013	Pre-Construction Survey
Stockton	October 2013	
USACE	January 2014	Post-Construction Survey
Stockton	April 2014	
Stockton	August 2014	
USACE	September 2014	
Stockton	March 2015	
USACE	October 2015	
Stockton	November 2015	

Agency	Survey Date	Notes
USACE	February 2016	Post-Storm Survey
Stockton	May 2016	
USACE	October 2016	
Stockton	October 2016	
USACE	December 2016	Pre-Construction Survey
USACE	April 2017	Post-Construction Survey
Stockton	April 2017	
USACE	September 2017	
Stockton	September 2017	
Stockton	March 2018	
USACE	September 2018	
Stockton	November 2018	
Stockton	March 2019	
USACE	August 2019	Pre-Construction Survey
USACE	September 2019	Post-Construction Survey
Stockton	November 2019	
Stockton	March 2020	
USACE	October 2020	
Stockton	November 2020	
Stockton	April 2021	
USACE	October 2021	
USACE	November 2021	Pre-Construction Survey
Stockton	November 2021	
USACE	December 2021	Post-Construction Survey
Stockton	May 2022	
USACE	September 2022	
Stockton	October 2022	
Stockton	May 2023	
Stockton	October 2023	
USACE	November 2023	Pre-Construction Survey
USACE	January 2024	Post-Construction Survey

2.3 Nourishment History

USACE is authorized to nourish the City's beaches under the authority of the Rivers and Harbor Act of 1907 and WRDA 1986; federal authorization for this project expires in 2039. Together, the City of Cape May, the state of NJ, and USACE have sponsored numerous beach nourishment and bypassing operations. Sand sources for the project have included offshore borrow areas, nearshore sediment traps/basins, the Cape May Inlet, and upland sources.

The project mitigates the effects of the federal Cape May Inlet channel and also includes flood and coastal storm damage reduction benefits. The authorized nourishment interval is two years (USACE, 1987). Based on the nourishment data provided by USACE, the average interval between projects from August 1989 to December 2023 is approximately three years.

Table 2.3 provides an overview of the beach nourishment history and details the construction templates. Across the 17 federal beach nourishment projects listed in Table 2.3, USACE has placed approximately 7.5 million cy of sand in this project area. Notably, many of the projects feature variable berm widths and placement at hotspots within the USCG Training Center and the City's public beach. Of the analyzed nourishment plans, only the 1991 nourishment spanned the full project area. USACE did not transmit the plans for the 1993 through 1997 nourishment events, but their volumes are included in Table 2.3. Figure 2.3 details the approximate placement boundaries for each project, note that many of the placement events are focused on the hotspots adjacent to the Inlet's jetty and surrounding Wilmington Avenue. Following nourishment events, it is likely that ocean waves and currents will move the sediment alongshore providing benefits beyond these hotspot placement areas.

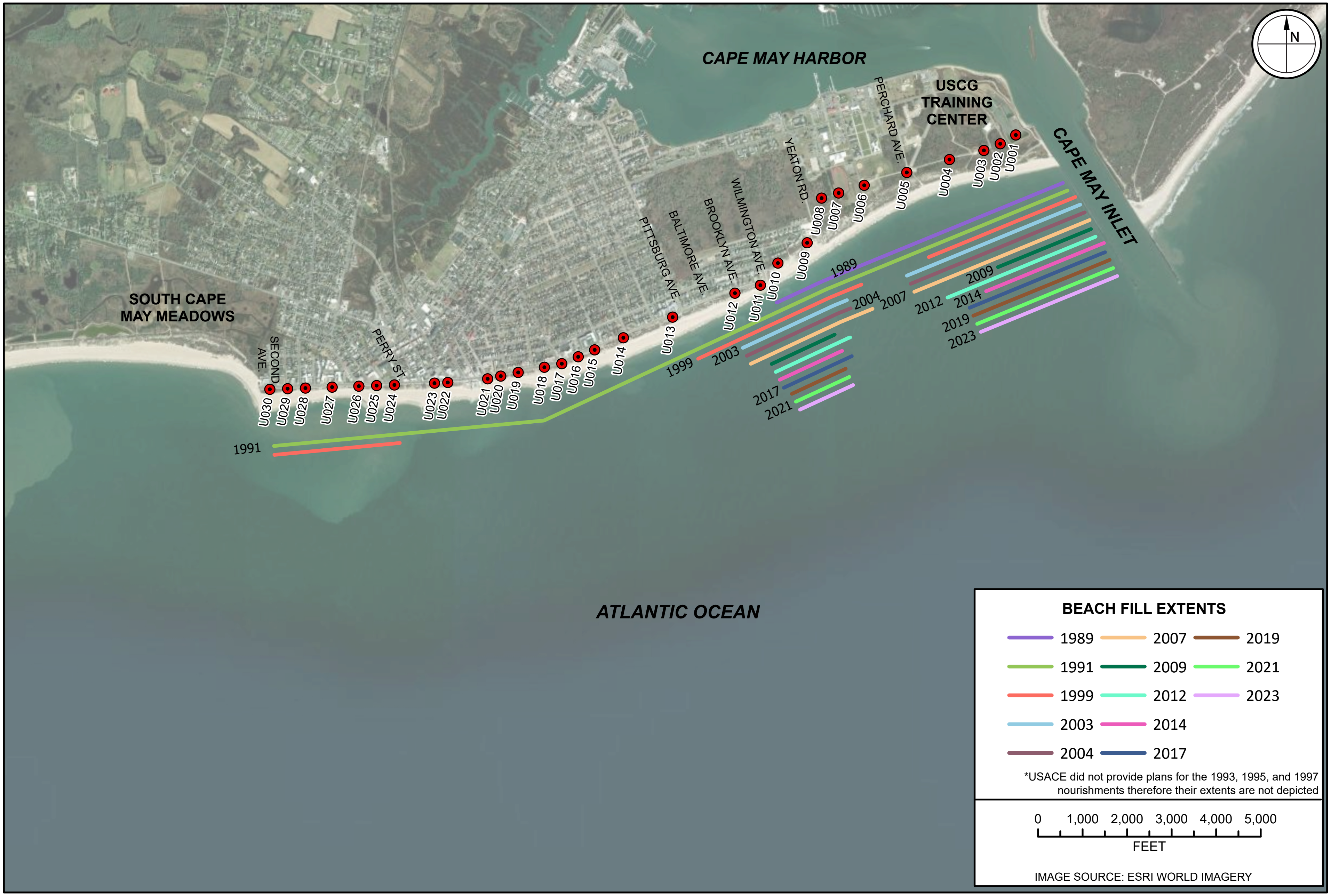
Figure 2.4 depicts the fill template variations over time. Within the project's history the USACE has changed the berm width and location throughout the project area however the berm elevation has remained relatively consistent at +6.7 ft-North American Vertical Datum of 1988 (NAVD88) with minor variations to the hundredth of a foot. The nearshore slope of the beach has seen changes over the project's lifetime starting at 1V:25H in 1989, transitioning to 1V:20H above MLW and 1V:10H below MLW for the 1991-2007 projects, then again steepening to 1V:10H in 2009-2014, and in the most recent nourishment events (2017-2023) the template featured a 1V:10H slope within the USCG Training Center and 1V:15H within the City's limits.

Of note, it is possible that sand placement events may have occurred within the City's beach area prior to or between the Table 2.3 project dates. The American Shore and Beach Preservation Association (ASBPA) maintains the National Beach Nourishment Database, which includes additional beach nourishment records predating the 1988 nourishment (ASBPA, 2024). These records are not included within this report as the database relies on user-submitted data that is not verified and lacks specific placement details such as extents, source, contractor, etc.

Table 2.3 City of Cape May Beach Nourishment History

Construction Completion Date	Plan Set Date	Placed Volume (cy)	Approximate Project Extent	Project Extent (Stations)	Berm Height (ft)	Berm Width (ft)	Nearshore Slope	Borrow Area	Notes
August 1989	September 1988	465,000	Cape May Inlet Jetty to Wilmington Ave	00+62 to 75+90	+8.0 ft-NGVD29 *+6.71 ft-NAVD88*	Varies	1V:25H	North of Cape May Jetty, Borrow Area M1	Inlet bypassing
July 1991	September 1990	900,000	Cape May Inlet Jetty to Second Ave	00+62 to 196+00	+8.0 ft-NGVD29 *+6.71 ft-NAVD88*	Varies	1V:20H to MLW; 1V:10H below MLW to existing grade	Cape May Inlet, Offshore Area M1	Inlet bypassing
April 1993		415,000							
September 1993		300,000							
March 1995		330,000							
January 1997		366,000							
October 1999	May 1999	400,000	Cape May Inlet Jetty to Perchard Ave; Yeaton Rd to Pittsburg Ave; Perry St to Second Ave	00+00 to 33+50; 50+00 to 100+00; 166+00 to 196+80	+6.72 ft-NAVD88	Varies	1V:20H to MLW; 1V:10H below MLW to existing grade	Offshore Area M1	
March 2003	July 2002	267,000	Cape May Inlet Jetty to Perchard Ave; Yeaton Rd to Baltimore Ave	00+00 to 39+50; 61+50 to 90+00	+6.72 ft-NAVD88	Varies	1V:20H to MLW; 1V:10H below MLW to existing grade	Offshore Area M1 Areas 4 & 5	
November 2004	April 2004	290,100	Cape May Inlet Jetty to Perchard Ave; Yeaton Rd to Brooklyn Ave	0+00 to 39+50; 61+00 to 90+00	+6.72 ft-NAVD88	Varies	1V:20H to MLW; 1V:10H below MLW to existing grade	Offshore Areas 4 & 5	

Construction Completion Date	Plan Set Date	Placed Volume (cy)	Approximate Project Extent	Project Extent (Stations)	Berm Height (ft)	Berm Width (ft)	Nearshore Slope	Borrow Area	Notes
February 2007	July 2006	190,000	Cape May Inlet Jetty to Perchard Ave; Yeaton Rd to Brooklyn Ave	0+00 to 39+50; 50+00 to 90+00	+6.72 ft-NAVD88	Varies	1V:20H to MLW; 1V:10H below MLW to existing grade	Cape May Inlet, Offshore Areas 4 & 5	Inlet bypassing
February 2009	July 2008	233,700	Cape May Inlet Jetty to Perchard Ave; Yeaton Rd to Brooklyn Ave	00+46 to 21+10; 67+05 to 86+00	+6.75 ft-NAVD88	Varies	1V:10H	Truck Haul	
February 2012	July 2011	635,000	Cape May Inlet Jetty to Perchard Ave; Yeaton Rd to Brooklyn Ave	00+50 to 25+14; 65+00 to 85+97	+6.75 ft-NAVD88; +6.72 ft-NAVD88	Varies	1V:10H	Offshore Areas K1-3	Back-passing from between Trenton Ave and Gurney St
January 2014	February 2013	585,000	Cape May Inlet Jetty to Perchard Ave; Yeaton Rd to Brooklyn Ave	00+00 to 25+09; 67+82 to 86+00	+6.7 ft-NAVD88	Varies	1V:10H	Offshore Areas K1-3	
April 2017	August 2016	648,000	Cape May Inlet Jetty to Perchard Ave; Yeaton Rd to Brooklyn Ave	00+44 to 30+00; 65+38 to 86+00	+6.7 ft-NAVD88	Varies	1V:10H within USCG Training Center; 1V:15H at City Beach	Offshore Areas K1-3	
September 2019	September 2018	340,000	Cape May Inlet Jetty to Perchard Ave; Yeaton Rd to Brooklyn Ave	00+45 to 30+03; 68+37 to 85+03	+6.72 ft-NAVD88	Varies	1V:10H within USCG Training Center; 1V:15H at City Beach	Offshore Areas K1-3	
December 2021	April 2021	645,000	Cape May Inlet Jetty to Perchard Ave; Yeaton Rd to Brooklyn Ave	00+94 to 30+03; 68+19 to 85+03	+6.72 ft-NAVD88	Varies	1V:10H within USCG Training Center; 1V:15H at City Beach	Offshore Areas KE 1 & 2	
December 2023	May 2023	519,700	Cape May Inlet Jetty to Perchard Ave; Yeaton Rd to Brooklyn Ave	01+09 to 30+30; 68+29 to 85+03	+6.72 ft-NAVD88	Varies	1V:10H within USCG Training Center; 1V:15H at City Beach	Offshore Areas K1-3 and KE 1 & 2	



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10199 SOUTHSIDE BOULEVARD
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CITY OF CAPE MAY BEACH NEEDS ASSESSMENT

FIGURE 2.3
BEACH PLACEMENT HISTORY

CAPE MAY CO., NEW JERSEY

PROJECT	C2023-109
DRAWN BY	PL
SHEET	1 OF 1
DATE	MAR 2025

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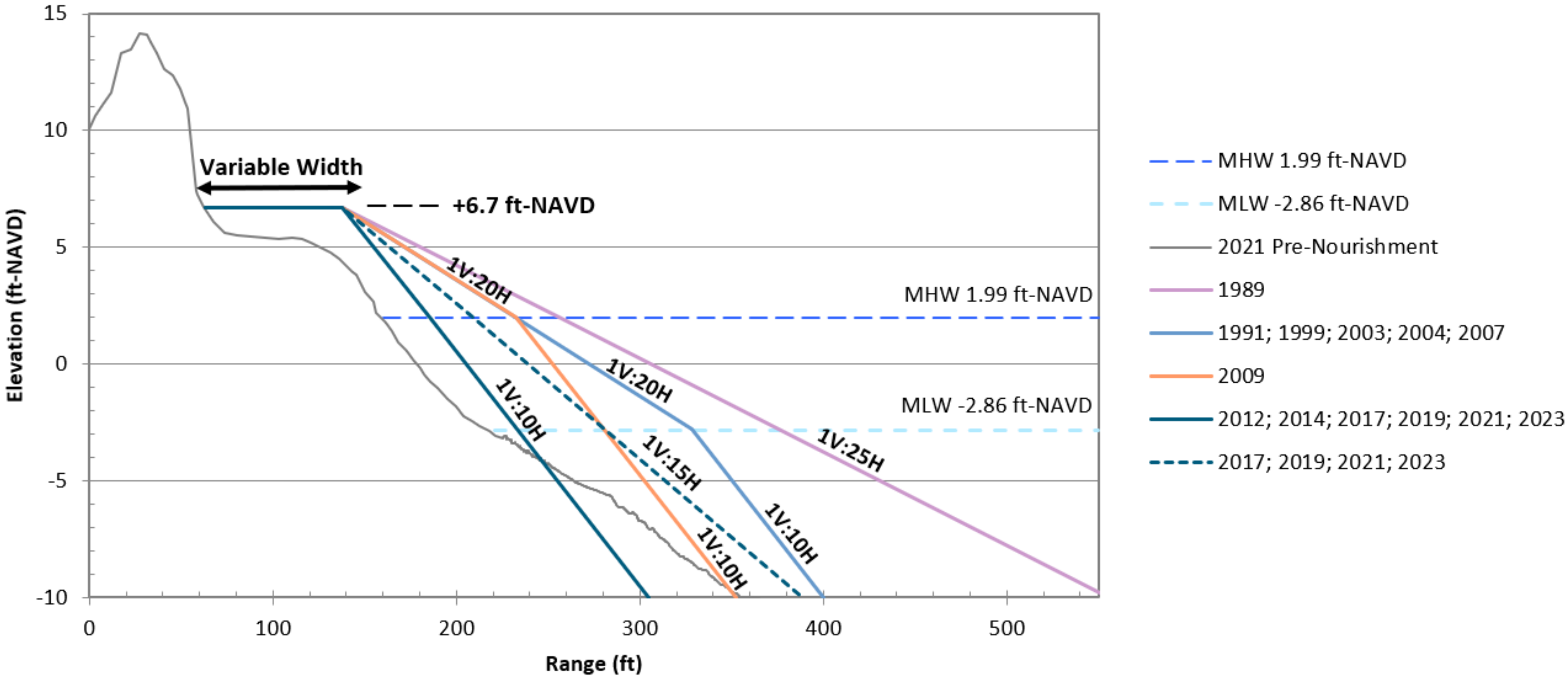

Figure 2.4 Beach Fill Template Variations

2.4 Beach Structure History

Project documentation indicates project partners have made multiple modifications to the Cape May beaches since the early 1900's. The first major modification in this area was the Cape May Inlet navigation project, which connected Cape May Harbor with the Atlantic Ocean. The USACE constructed the navigation project between 1908 and 1911 with a 25 ft (MLW) depth and 400 ft width. Following this construction, multiple channel maintenance projects occurred to reduce channel shoaling and USACE noted disruption to the littoral system (USACE, 1980). From the 1920's through the 1970's, the USACE and USCG constructed multiple timber, sheet pile, and rock groins to address coastal erosion and shoreline conditions; across this time period many of the structures required repair and/or replacement due to the conditions of the marine environment and degradation of materials. One especially active period of coastal project construction occurred following the "Ash Wednesday Storm" of 1962 with immediate post-storm projects and the construction of a seawall in the years after the storm. Many documents listed in Section 2.1 contain specific information about these structures; further investigation of these structures is important to fully understanding the beach's morphology and changes over time.

2.5 Water Level History and Sea Level Rise Projections

Coastal conditions directly affecting the project area and considered in this study include the past, present, and future mean sea levels and storm-induced water levels and waves. This section details each of these topics for the project area and discusses their impact.

2.5.1 Tidal Datums

Geodetic datums (e.g. NGVD29 and NAVD88) do not rely on temporally variable water levels and remain fixed throughout a project's lifetime. Given the long history of work in the project area, some documents reference NGVD29 and other documents reference the newer datum, NAVD88. The conversion between NGVD29 and NAVD88 is approximately -1.29 ft for the project area (NOAA, 2024a). Tidal datums vary temporally and usually change with updates to the National Tidal Datum Epoch (NTDE) over a project's lifetime. The National Oceanic and Atmospheric Administration (NOAA) tracks water levels and publishes the NTDE, a 19-year time period over which NOAA calculates tidal datum values, such as MHW or Mean Sea Level (MSL); these values are based on historically observed water levels. NOAA's tidal benchmark station 8536110 is located in Cape May, NJ, at the entry of the Cape May Canal from the Delaware Bay. Table 2.4 presents the current tidal datum data referenced in ft-NAVD88 for the Cape May, NJ, NOAA station 8536110 (NOAA, 2024c).

Table 2.4 NOAA Tidal Station 8536110 (Cape May, NJ) Tidal Datums

Tidal Datum	Elevation (ft-NAVD88)
Mean Higher High Water (MHHW)	2.43
Mean High Water (MHW)	1.99
Mean Sea Level (MSL)	-0.45
Mean Low Water (MLW)	-2.86
Mean Lower Low Water (MLLW)	-3.02
Tide Range (MHW-MLW)	4.85
Diurnal Tide Range (MHHW-MLLW)	5.45

2.5.2 Future Sea Level Rise Projections

SLR constitutes an important flood risk consideration for the City's beaches when investigating historic trends or preparing for the future. For this study, Taylor Engineering staff provide a comparison of the USACE and NOAA SLR projection curves, Figure 2.5. Due to federal, USACE, participation, the study team recommends the use of the USACE SLR projections.

Analysis of observed water level data from NOAA tide gauge 8536110 at Cape May, NJ indicates that the shoreline experienced approximately 0.7 feet of SLR from the first federal beach nourishment project in 1988 through 2022, a 34 year period. Figure 2.5 presents the USACE High, Intermediate (INT), and Low scenarios, the NOAA Intermediate (INT) and Intermediate-Low (INT Low) scenarios, and a linear SLR trend based on the last 40 years of MSL data extrapolated to the year 2100. Table 2.5 summarizes the historical and projected SLR estimates and their basis to both the year 2050 (28 years) and the year 2100 (78 years).

A comparison between NOAA, USACE, and the linear projections indicates the USACE Low curve provides the lowest projection, falling below both the NOAA Intermediate-Low curve and the 40-year linear extrapolation of observed data. Therefore, the USACE Low curve likely represents an unlikely low SLR scenario and the present study recommends excluding this curve from for future project planning.

Table 2.5 SLR Estimates for the City of Cape May's Beaches

Period	SLR (ft)	Basis
1988 – 2022	0.7	Observed SLR at the City of Cape May gauge
2022 – 2050	0.5	USACE Low (based on City of Cape May gauge)
2022 – 2050	0.8	USACE Intermediate (based on City of Cape May gauge)
2022 – 2050	1.5	USACE High (based on City of Cape May gauge)
2022 – 2100	1.6	USACE Low (based on City of Cape May gauge)
2022 – 2100	2.5	USACE Intermediate (based on City of Cape May gauge)
2022 – 2100	5.6	USACE High (based on City of Cape May gauge)

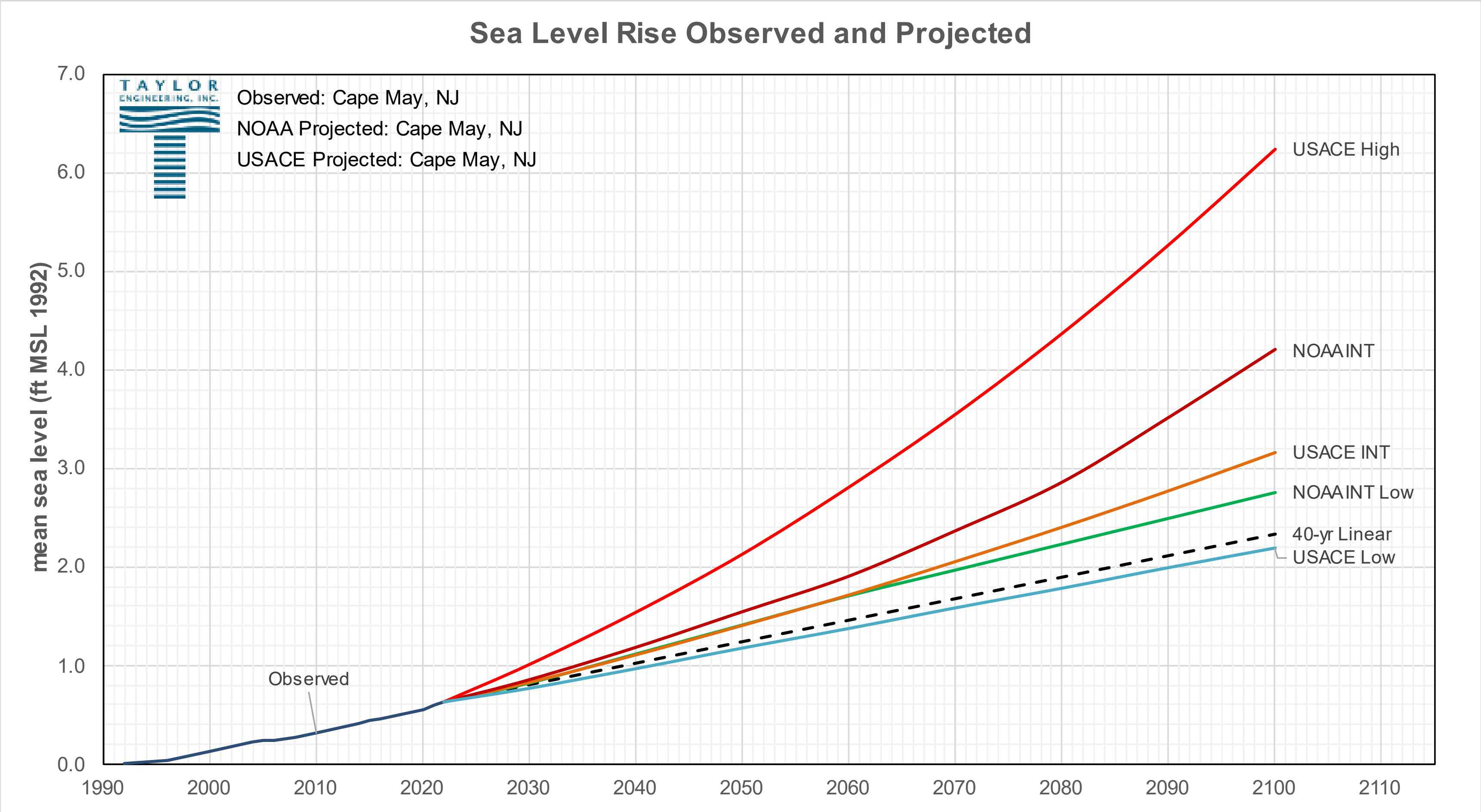

Figure 2.5 Comparison of NOAA, USACE, and Linear SLR Projections for Cape May, NJ

2.6 Historic Storm Events

Wave and water level history associated with major historic storm events is critical to understanding how the beach responds to high-energy events. Both tropical and extratropical storm events often induce erosion along the coast; tropical storm events feature elevated water levels and intense wave energy for a relatively short duration, while extratropical storms (such as nor'easters) typically feature moderately elevated water levels and wave energy sustained over multiple days. Over a timescale of decades, most erosion occurs during the winter months through extratropical storm activity that occurs every year. However, erosion resulting from a low frequency landfalling or locally bypassing tropical storm event can account for the majority of erosion associated with a particular year. The erosion induced by a storm event depends on wave parameters including wave height, period, and direction; water level, including both tide phase and storm surge components; duration of the storm; and the existing morphological condition of the dune, berm, and offshore bars.

To better understand the influences on historical shoreline evolution along the City's coastline, Taylor Engineering identified historical storm events with potentially significant impact. The study team referenced the NOAA Climate Data Center Storm Events Database (NOAA, 2024b) which documents and classifies notable storm parameters; the USACE Wave Information Study (WIS) (USACE, 2024a), which provides hindcasted wave parameter between 1980 and 2022; and the FEMA Coastal Flood Insurance Study Intermediate Data Submittal 2 (FEMA FIS) covering New York and New Jersey (FEMA, 2023).

Table 2.6 lists significant storm events since the early 1940s when modern aircraft reconnaissance allowed for reliable storm tracking, including nine tropical and four extra-tropical storms. Hindcasted USACE WIS wave heights are provided for all storms beginning with 1980. Tropical storm records include intensity category and maximum sustained wind speed.

Table 2.6 Significant Storm Events

Storm Name	Date[1]	Intensity[2]	Windspeed[3] (kts)	WIS H_S (ft)
Great Atlantic Hurricane	9/14/1944	H4	115	-
Hurricane Donna	9/12/1960	H4	115	-
Extra-tropical (Ash Wednesday Storm)	3/8/1962	-	-	-
Extra-tropical (December 1992 Nor'easter)	12/11/1992	-	-	13.5
Extra-tropical (Storm of the Century)	3/13/1993	-	-	13.8
Tropical Storm Bertha	7/13/1996	TS	45	14.1
Hurricane Floyd	9/16/1999	H2	90	13.8
Hurricane Isabel	9/18/2003	H5	145	14.4
Tropical Storm Ernesto	9/2/2006	TS	65	12.8
Extra-tropical (Nor'Ida)	11/13/2009	-	-	13.1
Hurricane Earl	9/3/2010	H2	95	12.8

Storm Name	Date[1]	Intensity[2]	Windspeed[3] (kts)	WIS H_S (ft)
Hurricane Irene	8/28/2011	H3	105	15.1
Hurricane Sandy	10/29/2012	H3	100	13.5

Storm data from NOAA, 2024b
[1] Date of maximum wave height/wind speed near Cape May
[2] Highest recorded intensity
[3] Highest recorded windspeed

3.0 HISTORIC PROJECT PERFORMANCE—BEACH MORPHOLOGY ANALYSIS

To better understand morphometric trends along the beach, Taylor Engineering evaluated the evolution of two common beach features—the MHW shoreline position and the berm evolution. Changes to the shoreline position track the beach's approximate seaward limit, meanwhile changes to the beach width and berm elevation provide insight on the beach's protective buffer and available recreation space. Figure 3.1 depicts these beach features. For the purpose of this study, the berm width is defined as the distance between the approximate seaward dune toe position and the MHW shoreline position. Engineers visually assessed the beach profile data along each transect to obtain the approximate dune toe position. The average berm elevation is calculated from the weighted average elevation along the berm width. A weighted average is similar to a mathematical mean, except that instead of each point being equally averaged, data points are valued based on a parameter, in this case, the distance between points.

Taylor Engineering evaluated changes to these evolution parameters at USACE survey monuments (Figure 2.2). Taylor Engineering analyzed five different surveys to compare the gross scale spatial and temporal evolution of the beach, including alongshore and cross-shore changes. Alongshore changes occur between transects, or parallel to the shoreline, and show broad trends, while cross-shore changes occur along the transects, or perpendicular to the shoreline, and present localized trends. Appendix A lists the U-monument locations and associated azimuths, or the angle at which the surveyor collects each profile. Appendix B presents the profile plots of the data for the selected surveys. Notably, for the surveys analyzed, data was not collected at U-2, U-17, U-21, and U-25, and thus, this report does not present data or conduct analyses at these U-monuments.

A weighted average procedure incorporates the alongshore (controlling) distance between monuments, included within Appendix A. This weighted average, applied to the shoreline position, beach width, and berm elevation analyses, establishes a comparative basis between alongshore segments of the beach. In general, a monument's controlling distance extends between the halfway points of adjacent monuments. Exceptions to this rule occur at either end of the study area and at monuments lacking data. At U-1 and U-30, or the study area's start/end points, the controlling distances extend to the adjacent groin or jetty rock structure. For monuments where there is a data gap, the controlling distance extends halfway between the nearest monuments containing data to the east and west.

This study's shoreline position, beach width, and berm elevation analyses compare the December 1994, November 2021 (pre-fill), December 2021 (post-fill), and September 2022 (one-year post-fill) USACE surveys to the November 2023 (two-year post-fill) USACE survey. Taylor Engineering selected these surveys as they span a nourishment cycle and allow for the analysis of fill evolution along the beach for short-term and long-term periods. Although these surveys only show a snapshot in time and represent a single nourishment event, analyzing the data through the span of a nourishment cycle allows for a better understanding of how the beach reacted following the 2021 placement event. As such, Taylor Engineering analyzed each of the following comparison periods:

- **December 1994 to November 2021**—this comparison demonstrates the long-term performance and evolution of the beach and all fill events since 1994 compared to the 2021 pre-fill condition of the beach;
- **November 2021 to December 2021**—this comparison shows the direct impacts of the 2021 nourishment event;
- **December 2021 to September 2022**—this comparison demonstrates the evolution of fill one year following construction;
- **September 2022 to November 2023**—this comparison documents the evolution of fill during the second year following construction and prior to the next fill event

Notably, the USACE 2021 nourishment event placed 645,000 cy, the third largest placement event in the project history, and included two placement locations—fill location one was approximately between the South Cape May Inlet Jetty and Perchard Ave (U-1 and U-4.5), and fill location two was approximately between Yeaton Rd and Brooklyn Ave (U-9 and U-11). The fill template placed the majority of the sand in the first placement area nearest to the inlet, with the berm reaching a maximum width of approximately 350 ft; meanwhile, at the second fill location, the template called for a maximum berm extension of approximately 50 ft.

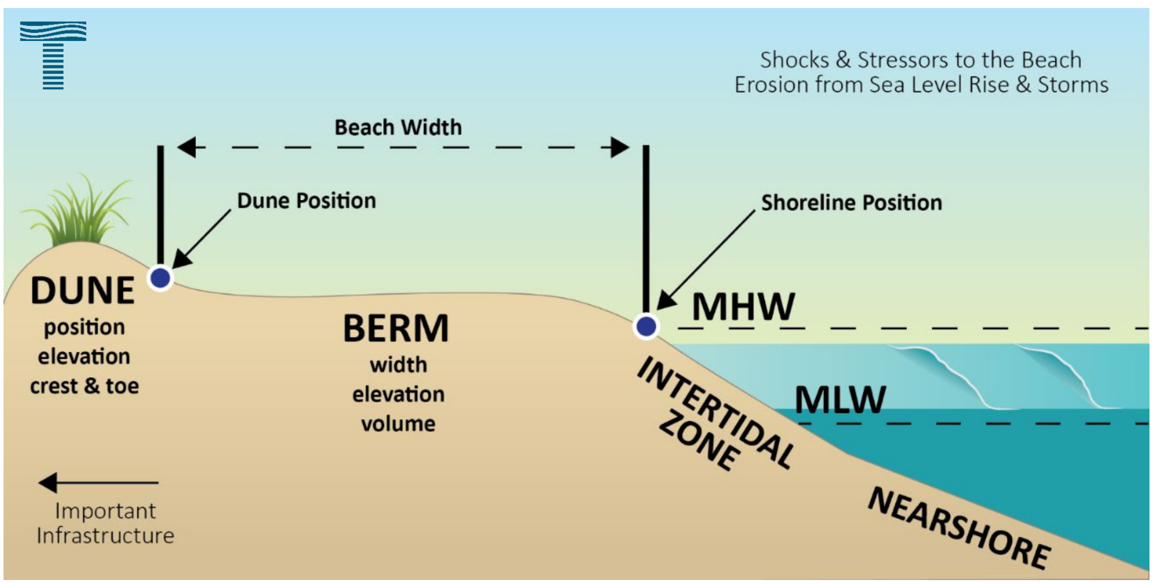

Figure 3.1 Common Beach Morphology Parameters

3.1 Shoreline Positions and Changes

For the purpose of this analysis, the shoreline position is defined by the MHW contour (+1.99 ft-NAVD88, Section 2.5.1). Changes in the MHW shoreline position demonstrate the alongshore and cross-shore evolution of the beach across the comparison periods. Table 3.1 presents the MHW shoreline positions as a function of distance from each monument location for the December 1994, November 2021, December 2021, September 2022, and November 2023 surveys; Figure 3.2 presents a visual comparison of the data in Table 3.1 and Figure 3.3 present the shoreline position for each analyzed period. Table 3.2, and Figure

3.3 present the shoreline position change for each of the comparison periods, where a positive value represents shoreline advance, or seaward movement, and negative values represent shoreline retreat, or landward movement.

The long-term shoreline position comparison, December 1994 to November 2021, indicates shoreline advance west of U-4 which is likely a direct result of the nine sand placement events that occurred during this comparison period. On average, 98 ft of shoreline advance occurs across the project area; in the USCG Training Center retreat occurred; meanwhile, significant advance occurred throughout the City's beaches, increasing with westward movement. Notably, the largest variation in MHW shoreline positions occurs directly adjacent to the inlet and the federal navigation channel at U-1, Figure 3.2; this is expected, as the beaches adjacent to an inlet are the most dynamic, experiencing direct influences from the inlet's channel and shoals.

The November to December 2021 comparison demonstrates the direct impact of the 2021 fill event, shifting the shoreline seaward an average of 195 ft at the monuments within the USCG Training Center. Outside of the two placement areas, this comparison yields minor mixed shoreline advance and retreat; this is anticipated due to the short timescale.

In the first year following construction, December 2021 to September 2022, shoreline retreat occurs within both placement areas as the fill disperses. Shoreline advance is evident at the monuments adjacent to the fill areas, suggesting expected alongshore dispersion of fill.

In the second year following construction, September 2022 to November 2023, shoreline retreat is evident throughout the limits of the USCG Training Center, averaging 40 ft. Summation of the year one and year two changes at U-1 suggest that significant sediment movement occurred and the shoreline position at the monument is nearing its pre-fill condition; this is confirmed by the profile plots in Appendix B.

Table 3.1 MHW Shoreline Position Location

Transect		MHW Shoreline Position (ft, from monument)				
		December 1994	November 2021	December 2021	September 2022	November 2023
Cape May Inlet Jetty	U-1	904	739	1,312	1,056	820
USCG Training Center	U-3	653	550	935	751	590
USCG Training Center	U-4	475	522	699	693	547
USCG Training Center	U-5	543	614	649	741	621
USCG Training Center	U-6	763	808	800	905	812
USCG Training Center	U-7	942	976	975	1,055	982
USCG Training Center	U-8	1,072	1,112	1,105	1,160	1,107
Yeaton Rd	U-9	369	426	431	458	432
Yeaton Rd & Wilmington Ave	U-10	334	400	484	418	415
Wilmington Ave	U-11	97	159	250	189	192
Brooklyn Ave	U-12	198	306	290	316	325
Pittsburg Ave & Trenton Ave	U-13	313	440	415	446	423
Reading Ave	U-14	400	444	424	450	431
Philadelphia Ave	U-15	256	402	368	393	400
Philadelphia Ave & Madison Ave	U-16	228	356	347	371	382
Madison Ave & Queen St	U-18	287	422	411	435	438
Queen St & Jefferson St	U-19	147	339	313	317	327
Jefferson St & Howard St	U-20	175	318	323	329	334
Ocean St	U-22	251	434	425	427	436
Decatur St	U-23	318	501	497	505	514
Perry St	U-24	264	439	447	447	455
Grant St	U-26	164	377	304	300	305
Grant St & Patterson Ave	U-27	112	252	263	267	286
Patterson Ave & South Broadway	U-28	140	355	373	313	310
1st Ave	U-29	102	416	435	417	411
2nd Ave	U-30	192	495	497	482	522
WEIGHTED AVERAGE						
Project Area		385	483	539	532	493
USCG Training Center (U-1 through U-8)		728	716	911	880	743
City of Cape May (U-9 through U-30)		242	386	384	388	388

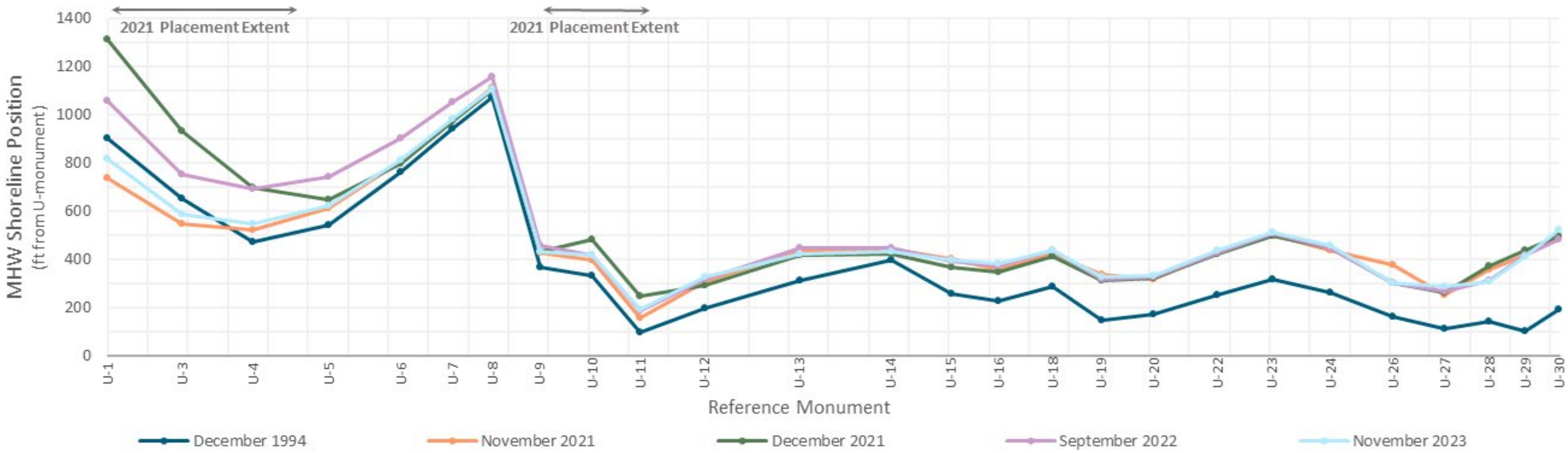

Figure 3.2 MHW Shoreline Positions

Table 3.2 MHW Shoreline Position Change

Transect		MHW Shoreline Position Change (ft)			
		December 1994 - November 2021	December 1994 - November 2021	December 1994 - November 2021	December 1994 - November 2021
Cape May Inlet Jetty	U-1	-165	574	-256	-236
USCG Training Center	U-3	-103	385	-184	-161
USCG Training Center	U-4	47	177	-6	-145
USCG Training Center	U-5	71	35	92	-120
USCG Training Center	U-6	45	-8	105	-93
USCG Training Center	U-7	35	-2	80	-72
USCG Training Center	U-8	40	-6	55	-53
Yeaton Rd	U-9	58	5	27	-26
Yeaton Rd & Wilmington Ave	U-10	66	84	-66	-3
Wilmington Ave	U-11	62	91	-60	3
Brooklyn Ave	U-12	108	-16	27	9
Pittsburg Ave & Trenton Ave	U-13	127	-25	31	-24
Reading Ave	U-14	44	-19	25	-19
Philadelphia Ave	U-15	146	-34	25	7
Philadelphia Ave & Madison Ave	U-16	127	-9	24	12
Madison Ave & Queen St	U-18	136	-11	25	2
Queen St & Jefferson St	U-19	192	-26	4	10
Jefferson St & Howard St	U-20	143	5	6	5
Ocean St	U-22	182	-9	2	9
Decatur St	U-23	182	-4	8	9
Perry St	U-24	175	8	0	8
Grant St	U-26	213	-72	-4	4
Grant St & Patterson Ave	U-27	140	11	3	20
Patterson Ave & South Broadway	U-28	215	18	-60	-3
1st Ave	U-29	314	19	-18	-6
2nd Ave	U-30	303	2	-15	40
WEIGHTED AVERAGE					
Project Area		98	56	-7	-40
USCG Training Center (U-1 through U-8)		-12	195	-32	-137
City of Cape May (U-9 through U-30)		144	-2	4	1

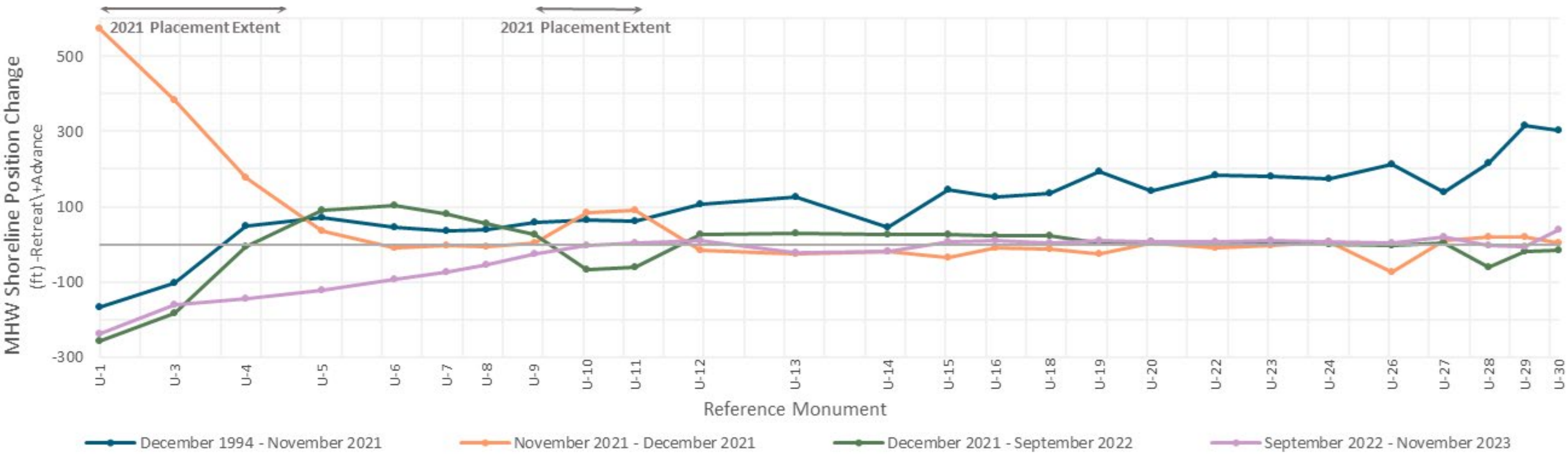

Figure 3.3 MHW Shoreline Position Change

3.2 Beach Width and Changes

The approximate beach width is an important beach feature to assess, as it not only provides a protectional buffer during storm events, but it is also recreational space and habitat for many beach species. This study defines the beach width as the distance between the approximate seaward dune toe and the MHW shoreline position. Changes in the beach width indicate the alongshore and cross-shore evolution of the subaerial (dry), recreational section of the beach. Often, increases in beach width are assumed to indicate a healthy beach; however, because the distance between the seaward dune toe and shoreline position define the beach width, increases in beach width may also be a result of retreat of the dune toe. Therefore, changes to the beach width must undergo careful analysis, as an increase in beach width may reflect a setback in the dune toe position. Table 3.3 and Figure 3.4 present the calculated beach width for each analysis period.

Due to its close relation with the MHW shoreline position, the beach width trends follow closely to the shoreline position. The long-term comparison demonstrates a positive impact of fill placement throughout the City's beaches, while also depicting the dynamic nature of the beach area within the USCG Training Center. Table 3.4 and Figure 3.5 present the changes in beach width for each comparison period. Table 3.4 depicts differences in average beach width trends for the 1994 dataset at U-6 through U-8 and west of U-18. Without further data investigation the cause of the increase in beach width of the 1994 data at U-6 through U-8 is not known, although it is possible that the difference is due to the large fill placement event that occurred in 1991. The increase in beach width west of U-15 is likely due to the impacts of numerous fill events.

Following construction in 2021, the average width within the USCG Training Center and the project area decreases with time as the placed fill dissipates. Two years following construction, the width decreased by 124 ft within the USCG Training Center, suggesting that an average of 59 ft of added berm width remains as a result of the nourishment (Table 3.4). On average the City of Cape May beaches maintain a relatively stable width, increasing slightly with time following the 2021 nourishment event.

Table 3.3 Beach Width

Transect		Beach Width (ft)				
		December 1994	December 1994	December 1994	December 1994	December 1994
Cape May Inlet Jetty	U-1	53	53	53	53	820
USCG Training Center	U-3	102	102	102	102	590
USCG Training Center	U-4	193	193	193	193	547
USCG Training Center	U-5	137	137	137	137	621
USCG Training Center	U-6	339	339	339	339	812
USCG Training Center	U-7	421	421	421	421	982
USCG Training Center	U-8	414	414	414	414	1,107
Yeaton Rd	U-9	216	216	216	216	432
Yeaton Rd & Wilmington Ave	U-10	210	210	210	210	415
Wilmington Ave	U-11	29	29	29	29	192
Brooklyn Ave	U-12	57	57	57	57	325
Pittsburg Ave & Trenton Ave	U-13	246	246	246	246	423
Reading Ave	U-14	277	277	277	277	431
Philadelphia Ave	U-15	149	149	149	149	400
Philadelphia Ave & Madison Ave	U-16	200	200	200	200	382
Madison Ave & Queen St	U-18	183	183	183	183	438
Queen St & Jefferson St	U-19	109	109	109	109	327
Jefferson St & Howard St	U-20	125	125	125	125	334
Ocean St	U-22	133	133	133	133	436
Decatur St	U-23	157	157	157	157	514
Perry St	U-24	130	130	130	130	455
Grant St	U-26	99	99	99	99	305
Grant St & Patterson Ave	U-27	56	56	56	56	286
Patterson Ave & South Broadway	U-28	99	99	99	99	310
1st Ave	U-29	74	74	74	74	411
2nd Ave	U-30	118	118	118	118	522
WEIGHTED AVERAGE						
Project Area		166	193	249	243	208
USCG Training Center (U-1 through U-8)		205	79	262	232	108
City of Cape May (U-9 through U-30)		149	240	244	248	250

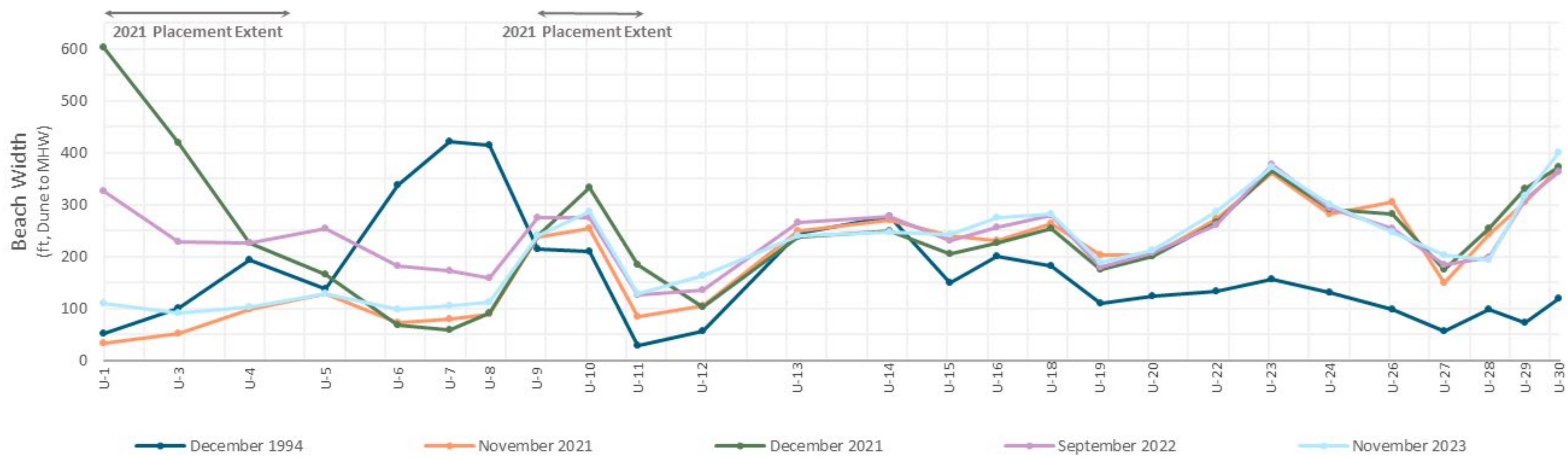

Figure 3.4 Beach Width

Table 3.4 Beach Width Change

Transect		Beach Width Change (ft)			
		December 1994 - November 2021	December 1994 - November 2021	December 1994 - November 2021	December 1994 - November 2021
Cape May Inlet Jetty	U-1	-18	568	-276	-216
USCG Training Center	U-3	-50	367	-189	-137
USCG Training Center	U-4	-95	128	1	-122
USCG Training Center	U-5	-8	37	87	-125
USCG Training Center	U-6	-267	-2	112	-83
USCG Training Center	U-7	-340	-22	114	-67
USCG Training Center	U-8	-325	3	68	-46
Yeaton Rd	U-9	22	3	34	-33
Yeaton Rd & Wilmington Ave	U-10	45	79	-60	11
Wilmington Ave	U-11	57	100	-60	4
Brooklyn Ave	U-12	49	-2	33	28
Pittsburg Ave & Trenton Ave	U-13	5	-13	27	-25
Reading Ave	U-14	-6	-22	28	-30
Philadelphia Ave	U-15	93	-35	24	12
Philadelphia Ave & Madison Ave	U-16	32	-6	32	19
Madison Ave & Queen St	U-18	81	-10	26	1
Queen St & Jefferson St	U-19	95	-28	4	9
Jefferson St & Howard St	U-20	79	-3	7	5
Ocean St	U-22	141	-9	-4	25
Decatur St	U-23	204	5	10	-3
Perry St	U-24	152	9	1	8
Grant St	U-26	206	-23	-28	-7
Grant St & Patterson Ave	U-27	93	25	9	19
Patterson Ave & South Broadway	U-28	145	11	-56	-3
1st Ave	U-29	230	26	-19	6
2nd Ave	U-30	251	4	-9	35
WEIGHTED AVERAGE					
Project Area		27	56	-6	-35
USCG Training Center (U-1 through U-8)		-126	183	-30	-124
City of Cape May (U-9 through U-30)		91	3	4	2

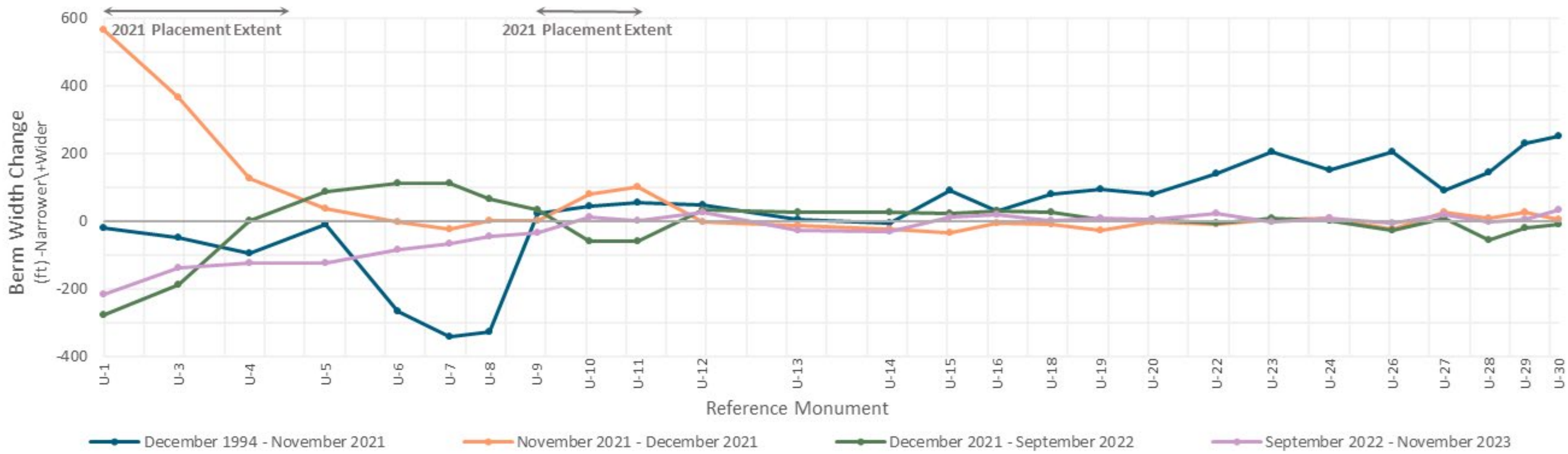

Figure 3.5 Beach Width Change

3.3 Average Berm Elevation and Changes

The final parameter Taylor Engineering analyzed for this analysis is the average berm elevation. For this analysis, the average berm elevation is defined as the weighted average elevation across the beach width. Although the shape of the beach berm varies throughout the City (i.e., flat, sloped, a combination of flat and sloped), the profile plots depict significant changes in the berm elevation temporally and the average elevation captures trends along the beach.

When examining the average berm elevation across the project area over time, it is evident that the elevation is increasing; this is clearly depicted in both the USCG Training Center and City of Cape May sub-areas following the 2021 nourishment.

The profile plots in Appendix B clearly depict this increase; Figure 3.6, representing profile U-14, shows the average increase in elevation as sand is becoming "stacked" along the edge of the berm. Specifically, the November 2023 survey recorded the highest berm elevations among all periods and at nearly every monument. Additionally, this profile also depicts a slight steepening of the nearshore slope as the profile moves in and up. This behavior could be tied to multiple parameters, including sediment grain size, SLR, or surging wave breaking regimes. Further investigation is recommended to evaluate the potential relationship between increased berm elevation and the steepness of the foreshore profile. Table 3.5 and Figure 3.7 present the average berm elevation for each monument for each analyzed survey. Table 3.6 and Figure 3.8 present the changes in the berm elevation for each comparison period.

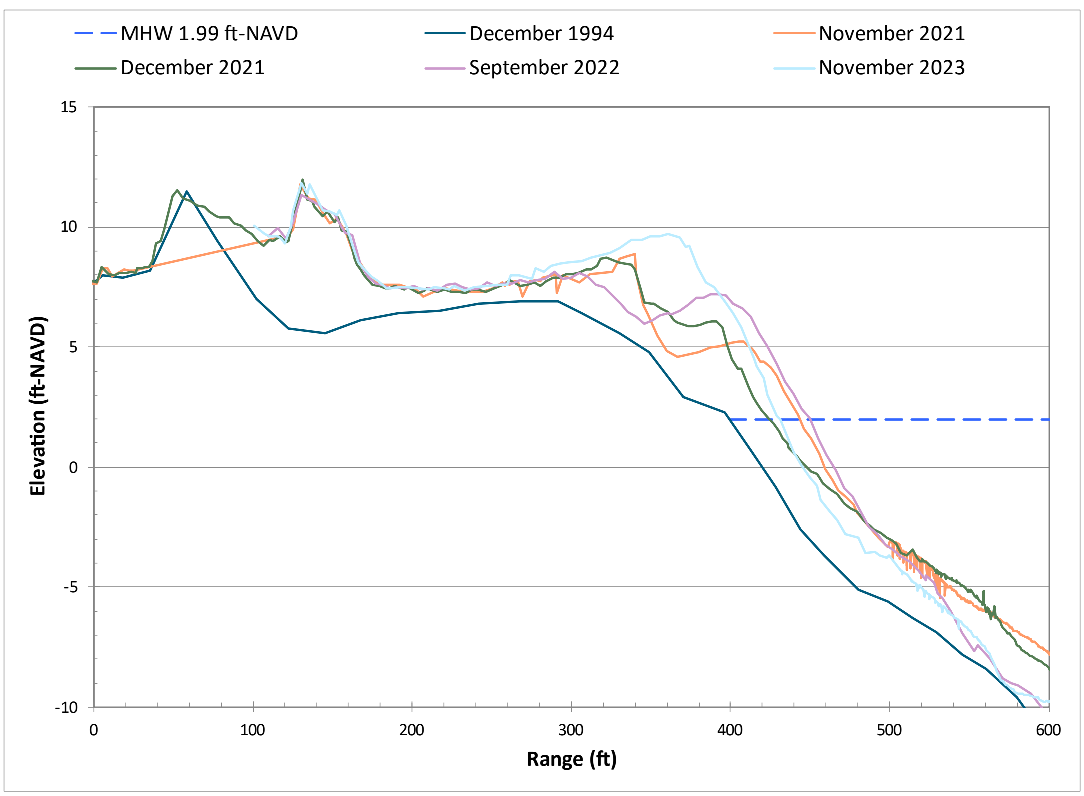

Figure 3.6 Increase in Berm Elevation at U-14

Table 3.5 Average Berm Elevation

Transect		Average Berm Elevation (ft-NAVD88)				
		December 1994	November 2021	December 2021	September 2022	November 2023
Cape May Inlet Jetty	U-1	3.9	3.4	6.8	6.6	7.2
USCG Training Center	U-3	6.6	4.7	6.7	6.5	7.2
USCG Training Center	U-4	6.8	5.6	6.1	6.8	7.0
USCG Training Center	U-5	5.9	6.9	6.2	7.3	8.2
USCG Training Center	U-6	7.7	4.5	5.2	7.1	8.5
USCG Training Center	U-7	8.2	5.2	4.3	7.1	8.8
USCG Training Center	U-8	7.9	4.3	5.2	7.1	8.6
Yeaton Rd	U-9	6.9	7.9	8.0	8.2	9.5
Yeaton Rd & Wilmington Ave	U-10	7.0	7.7	7.7	8.1	9.0
Wilmington Ave	U-11	3.4	4.8	6.2	6.3	7.8
Brooklyn Ave	U-12	4.2	4.7	5.5	6.1	7.5
Pittsburg Ave & Trenton Ave	U-13	6.7	6.9	7.6	7.3	8.3
Reading Ave	U-14	5.7	6.6	6.9	6.8	7.7
Philadelphia Ave	U-15	5.7	6.5	6.9	6.7	7.8
Philadelphia Ave & Madison Ave	U-16	6.0	6.6	7.7	7.5	8.2
Madison Ave & Queen St	U-18	5.0	6.8	7.3	6.9	7.5
Queen St & Jefferson St	U-19	5.8	6.0	7.1	6.9	7.8
Jefferson St & Howard St	U-20	5.5	6.6	7.3	7.2	7.8
Ocean St	U-22	5.1	6.7	7.4	7.9	7.8
Decatur St	U-23	5.2	7.6	8.1	8.3	8.5
Perry St	U-24	4.8	7.4	7.9	8.1	8.2
Grant St	U-26	4.5	6.3	7.0	6.8	7.0
Grant St & Patterson Ave	U-27	4.0	7.0	7.5	8.6	8.7
Patterson Ave & South Broadway	U-28	4.4	7.5	7.4	8.4	8.1
1st Ave	U-29	5.0	8.2	8.4	8.7	8.9
2nd Ave	U-30	4.7	7.9	8.1	8.4	8.3
WEIGHTED AVERAGE						
Project Area		5.7	6.2	6.9	7.3	8.0
USCG Training Center (U-1 through U-8)		6.5	5.0	6.0	6.9	7.8
City of Cape May (U-9 through U-30)		5.3	6.7	7.3	7.5	8.1

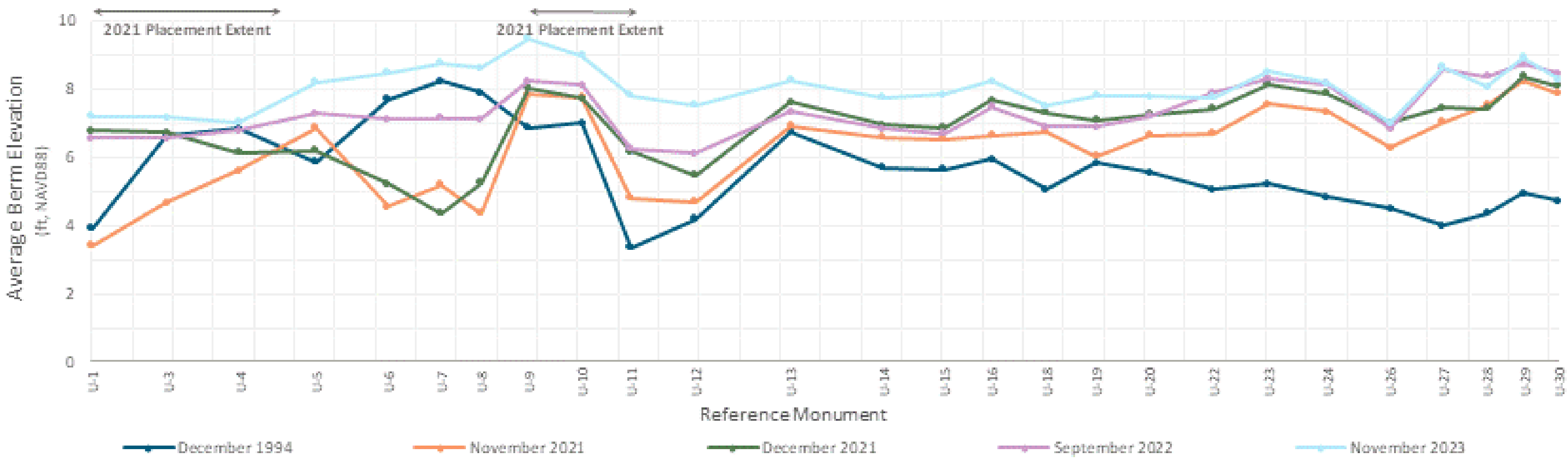

Figure 3.7 Average Berm Elevation

Table 3.6 Berm Elevation Change

Transect		Beach Width Change (ft)			
		December 1994 - November 2021	December 1994 - November 2021	December 1994 - November 2021	December 1994 - November 2021
Cape May Inlet Jetty	U-1	-0.5	3.4	-0.2	0.7
USCG Training Center	U-3	-2.0	2.0	-0.2	0.6
USCG Training Center	U-4	-1.2	0.5	0.6	0.3
USCG Training Center	U-5	1.0	-0.7	1.1	0.9
USCG Training Center	U-6	-3.1	0.7	1.9	1.4
USCG Training Center	U-7	-3.1	-0.8	2.8	1.6
USCG Training Center	U-8	-3.5	0.9	1.9	1.5
Yeaton Rd	U-9	1.0	0.2	0.2	1.2
Yeaton Rd & Wilmington Ave	U-10	0.7	0.0	0.4	0.8
Wilmington Ave	U-11	1.4	1.4	0.1	1.6
Brooklyn Ave	U-12	0.5	0.8	0.6	1.4
Pittsburg Ave & Trenton Ave	U-13	0.2	0.7	-0.3	0.9
Reading Ave	U-14	0.9	0.4	-0.1	0.9
Philadelphia Ave	U-15	0.9	0.3	-0.2	1.1
Philadelphia Ave & Madison Ave	U-16	0.7	1.0	-0.2	0.7
Madison Ave & Queen St	U-18	1.7	0.6	-0.4	0.6
Queen St & Jefferson St	U-19	0.2	1.1	-0.2	0.9
Jefferson St & Howard St	U-20	1.1	0.6	-0.1	0.6
Ocean St	U-22	1.6	0.7	0.5	-0.1
Decatur St	U-23	2.3	0.6	0.2	0.2
Perry St	U-24	2.5	0.5	0.3	0.0
Grant St	U-26	1.8	0.7	-0.2	0.2
Grant St & Patterson Ave	U-27	3.0	0.4	1.1	0.1
Patterson Ave & South Broadway	U-28	3.2	-0.1	0.9	-0.3
1st Ave	U-29	3.3	0.1	0.4	0.2
2nd Ave	U-30	3.2	0.2	0.4	-0.2
WEIGHTED AVERAGE					
Project Area		0.6	0.7	0.4	0.7
USCG Training Center (U-1 through U-8)		-1.5	1.0	0.9	0.9
City of Cape May (U-9 through U-30)		1.4	0.6	0.1	0.6

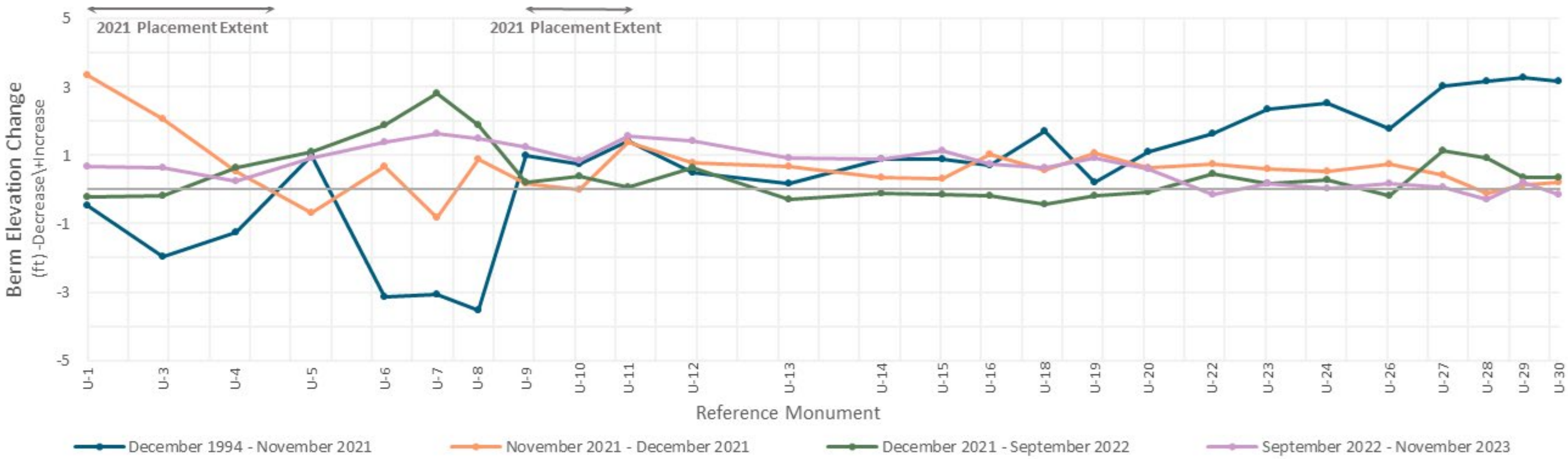

Figure 3.8 Berm Elevation Change

4.0 SUMMARY AND RECOMMENDATIONS

On behalf of the City of Cape May, Taylor Engineering, as a subconsultant to ACT Engineers, compiled and analyzed historical data and information related to beach management. The compilation of data included within this assessment acts as a foundation for future studies to support the City's efforts to better understand, manage, and balance the complex nature of the beach's ecosystem, storm hazard protection, and recreational functions.

As a part of this assessment, Taylor Engineering analyzed beach trends following the 2021 nourishment. It is evident that within the first two years following the nourishment event, the placed sand moves significantly in both the alongshore and cross-shore directions. Although not specifically analyzed due to this initial assessment focusing on the comparison of a few profiles, the profile plots do suggest that the nearshore slope is steep and has changed over time. The USACE design template for fill events has steepened, however the USACE has limited recent nourishments to only within the USCG Training Center and from Yeaton Road to Brooklyn Avenue (Section 2.3). The increase in berm elevation following construction suggests that coastal processes, specifically the wave action, may influence the shape of the beach as increased uprush of waves along the foreshore slope steepen and move sediment onto the edge of the berm.

To better understand these processes and further understand the beach, our team suggests consideration of the following actions in no specific order:

- Engage with project partners (USACE and NJDEP) and discuss the evolution of the beach fill template and if changes could be made that would be in the City's best interest, this may lead to the need for additional actions or studies;
- Investigate the sediment history, compile historic sediment information for the beach and borrow area sites, and analyze how grain size distribution may impact profile shape and performance;
- Collect and compile historic (and future) permitting documents, plans, and specifications to provide the City with critical background information and better outline the management history to understand beach and structure interactions;
- Analyze the foreshore beach slope for historic changes and compare the historic slopes to the nourishment templates to better understand how the beach morphology is changing following a nourishment event and over the long-term;
- Assemble and create a digital catalog of beach incident reports, the catalog should include location information (georeferenced and/or linked to transect locations) to understand the severity and distribution of injury concerns;
- Conduct multi-year post-project monitoring of the beach to understand the evolution of fill and the areas in need of further action within the project area;
- Conduct a modeling analysis to better understand the interactions between the local hydrodynamics, beach nourishment projects, and coastal structures to determine sediment transport pathways and optimize fill placement events.

Notably, some actions apply existing data or reports and could move forward relatively quickly—this includes investigating the sediment history, compiling historic permit documents, creating an incident catalog and an analysis of the foreshore beach slope. Other actions, such as the modeling analysis and post-project monitoring, could provide useful information but require additional data or model development and application, which take time. Talking with local partners is another way to obtain and evaluate information and could occur as coordination and scheduling allows.

Based on the City's desired goals and outcomes, Taylor Engineering encourages continued project engagement with all project partners. Prior to studying any of the above recommendations, stakeholder input is necessary to ensure the City is on the appropriate path forward and that project partners will support the recommended actions. It is possible that USACE will consider a modification of the beach template to enhance user experience, address safety concerns, and continue to protect the upland infrastructure. Understanding the morphology of fill and the evolution of the beach template is a multidimensional challenge; numerous factors influence this ongoing transformation— including local hydrodynamics, sea level change, dredging impacts, sediment grain size, storm events, seasonal variations, and interaction of structures. Given the complexity of these interrelated influences, there is no single, immediate solution. The beach functions as a dynamic system, continuously shaped by both environmental processes and human activities. However, with a comprehensive understanding of these factors, it is possible to make informed improvements that align with project goals and effectively balance the stakeholder interests.

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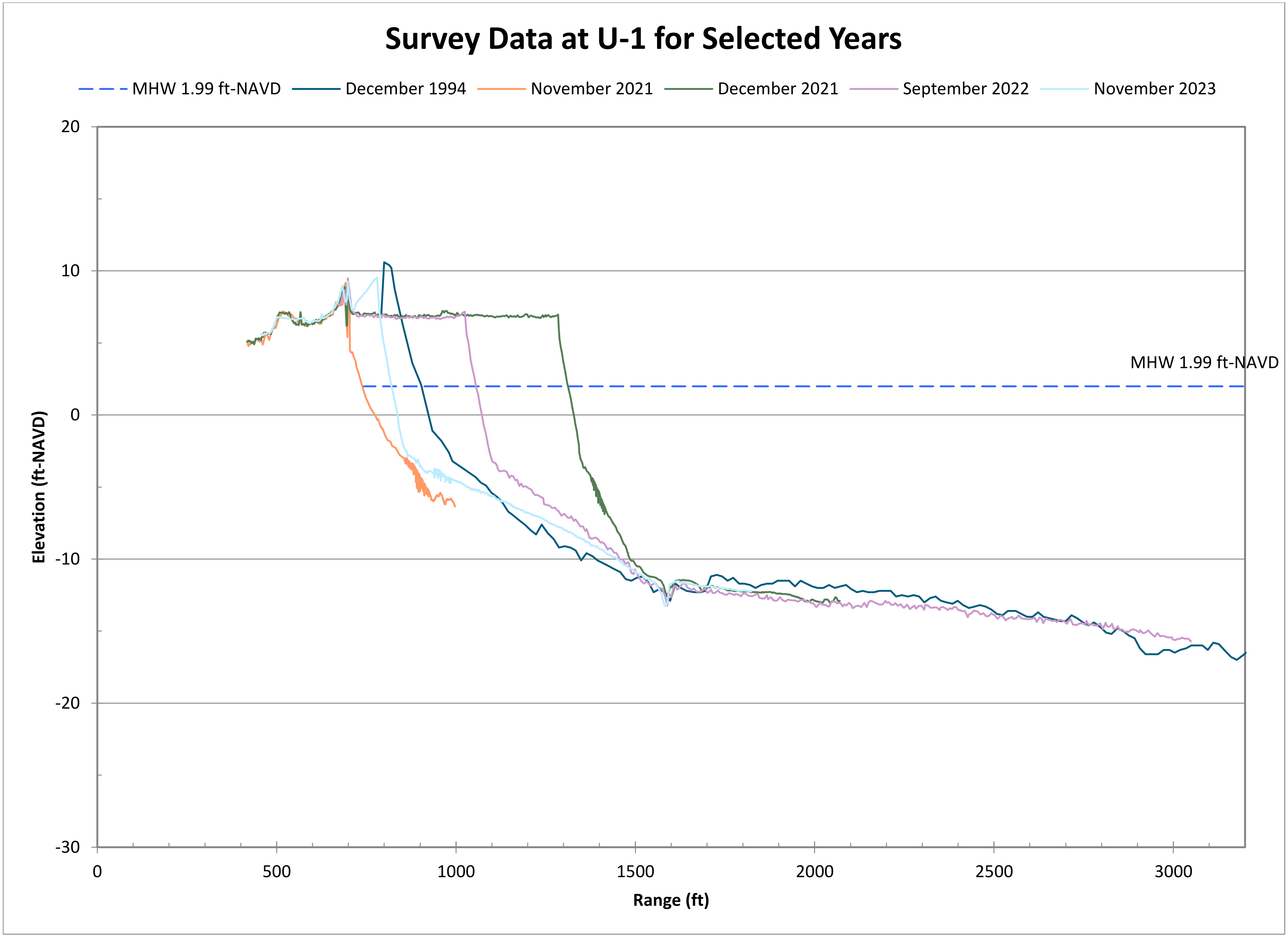
APPENDIX A
Transect Locations and Azimuths

Reference Monument Information for the City of Cape May				
Reference Monument	Easting (NJ SPF NAD83)	Northing (NJ SPF NAD83)	Azimuth (°, clockwise from North)	Controlling Distance (feet)
U-1	385,531.45	41,162.08	150.4386	968
U-2	385,183.42	40,964.69	150.4431	*
U-3	384,815.79	40,814.41	165.1847	890
U-4	384,042.43	40,609.87	165.1847	891
U-5	383,084.71	40,320.50	163.1858	991
U-6	382,127.74	40,031.39	163.2892	800
U-7	381,553.78	39,859.07	163.2892	500
U-8	381,170.69	39,744.06	163.2892	497
U-9	380,846.76	38,740.69	162.9919	677
U-10	380,189.66	38,284.25	162.9999	640
U-11	379,797.10	37,788.22	162.6114	560
U-12	379,224.55	37,608.92	162.6114	1035
U-13	377,825.82	37,071.02	157.2503	1335
U-14	376,719.31	36,606.30	157.1631	950
U-15	376,074.05	36,335.11	157.1631	550
U-16	375,705.33	36,180.14	157.1631	625
U-17	375,336.53	36,025.14	157.1631	*
U-18	374,945.31	35,945.20	168.8419	725
U-19	374,356.90	35,827.91	168.8419	500
U-20	373,965.24	35,746.02	168.8419	815
U-21	373,671.63	35,684.55	168.8419	*
U-22	372,776.71	35,602.98	177.1719	765
U-23	372,477.54	35,588.20	177.1719	601
U-24	371,578.13	35,547.32	177.9506	852
U-25	371,178.43	35,533.30	177.9506	*
U-26	370,778.84	35,519.28	177.9506	700
U-27	370,179.07	35,498.24	177.9506	600
U-28	369,579.44	35,477.21	177.9506	500
U-29	369,179.69	35,463.19	177.9506	400
U-30	368,779.96	35,449.17	177.9506	460

* Survey Data not available for monuments. Controlling distance is included in the adjacent monuments.

APPENDIX B
Beach Profiles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September 2022
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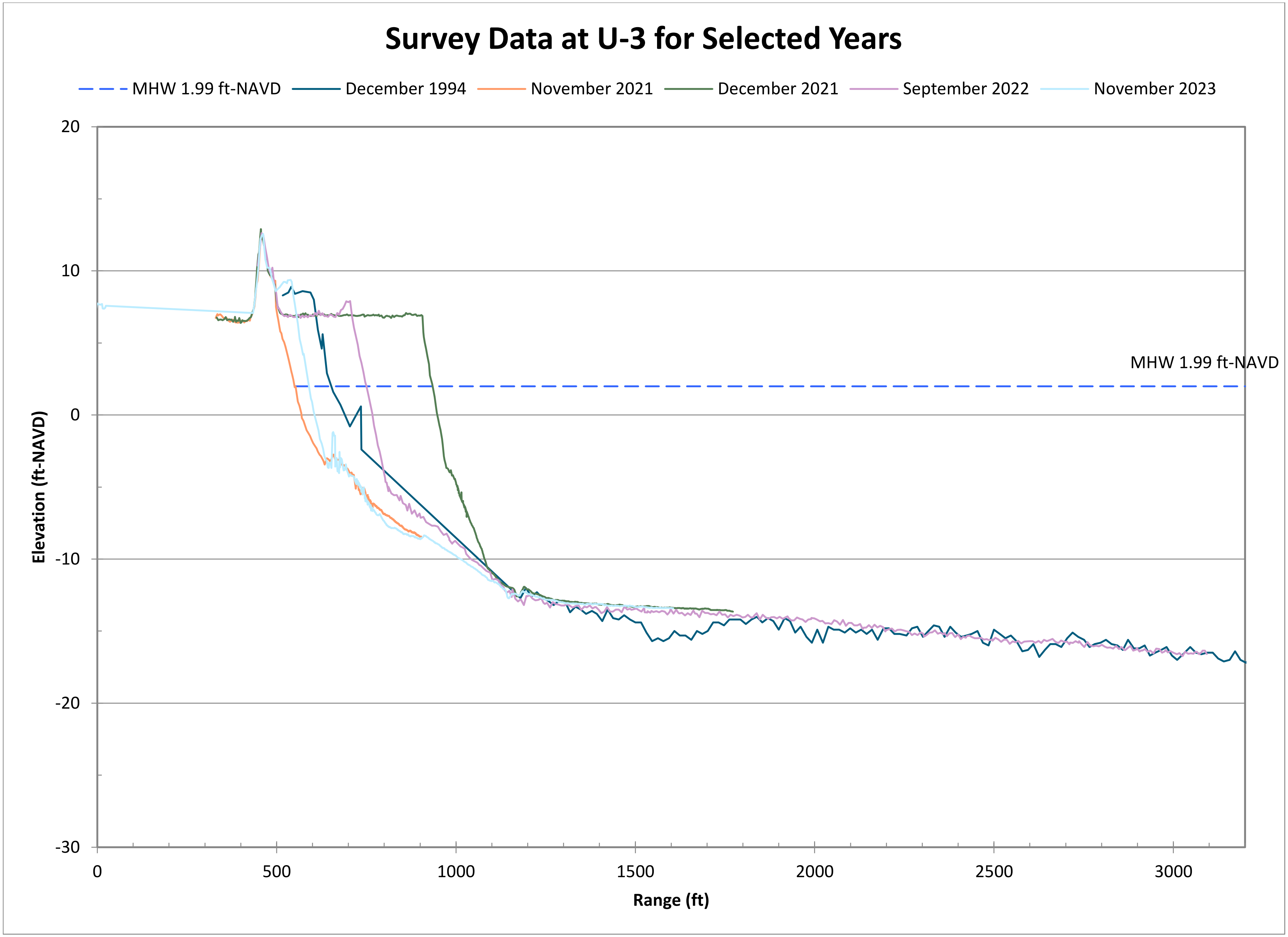
Range (ft)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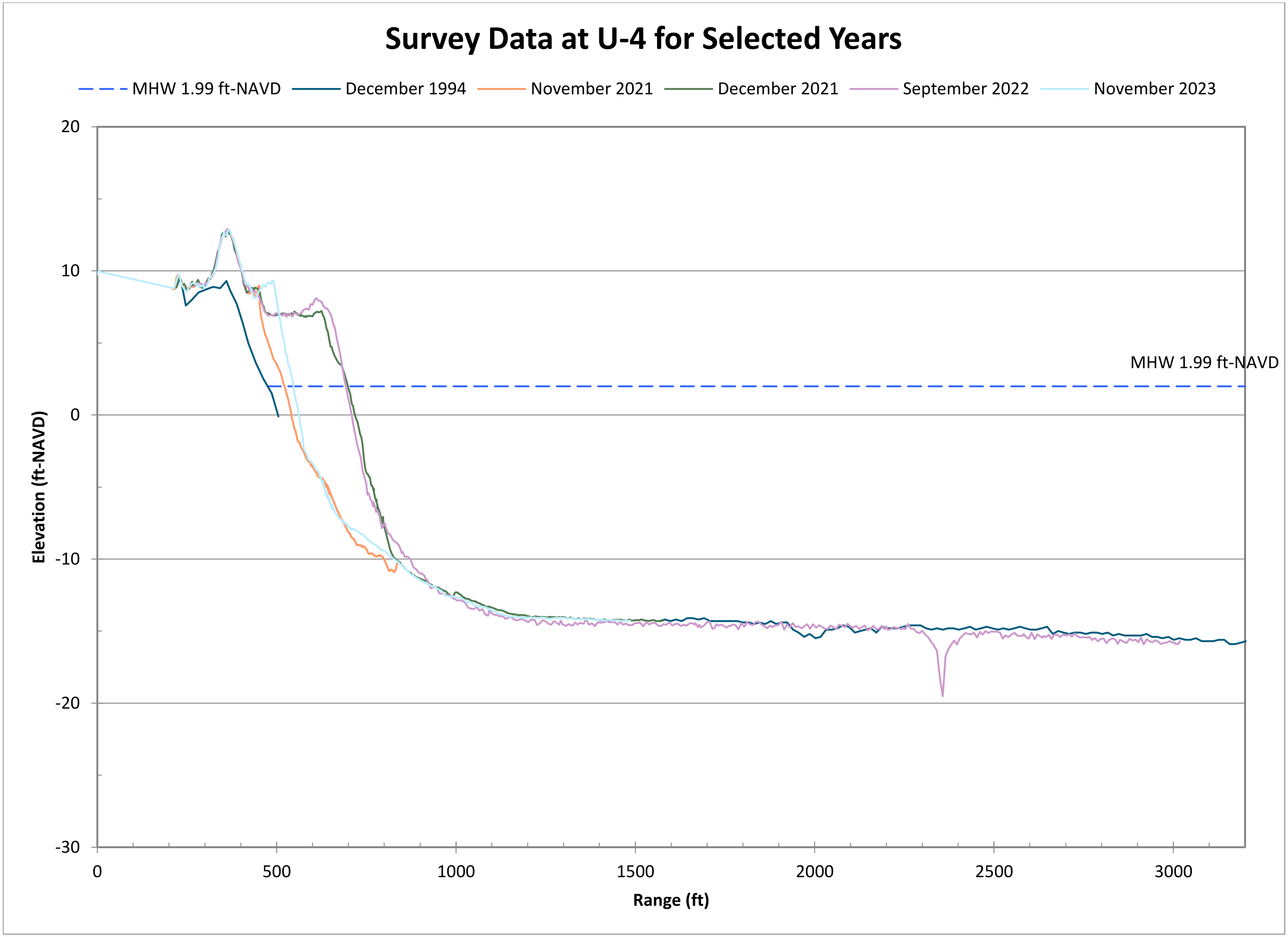
Range (ft)



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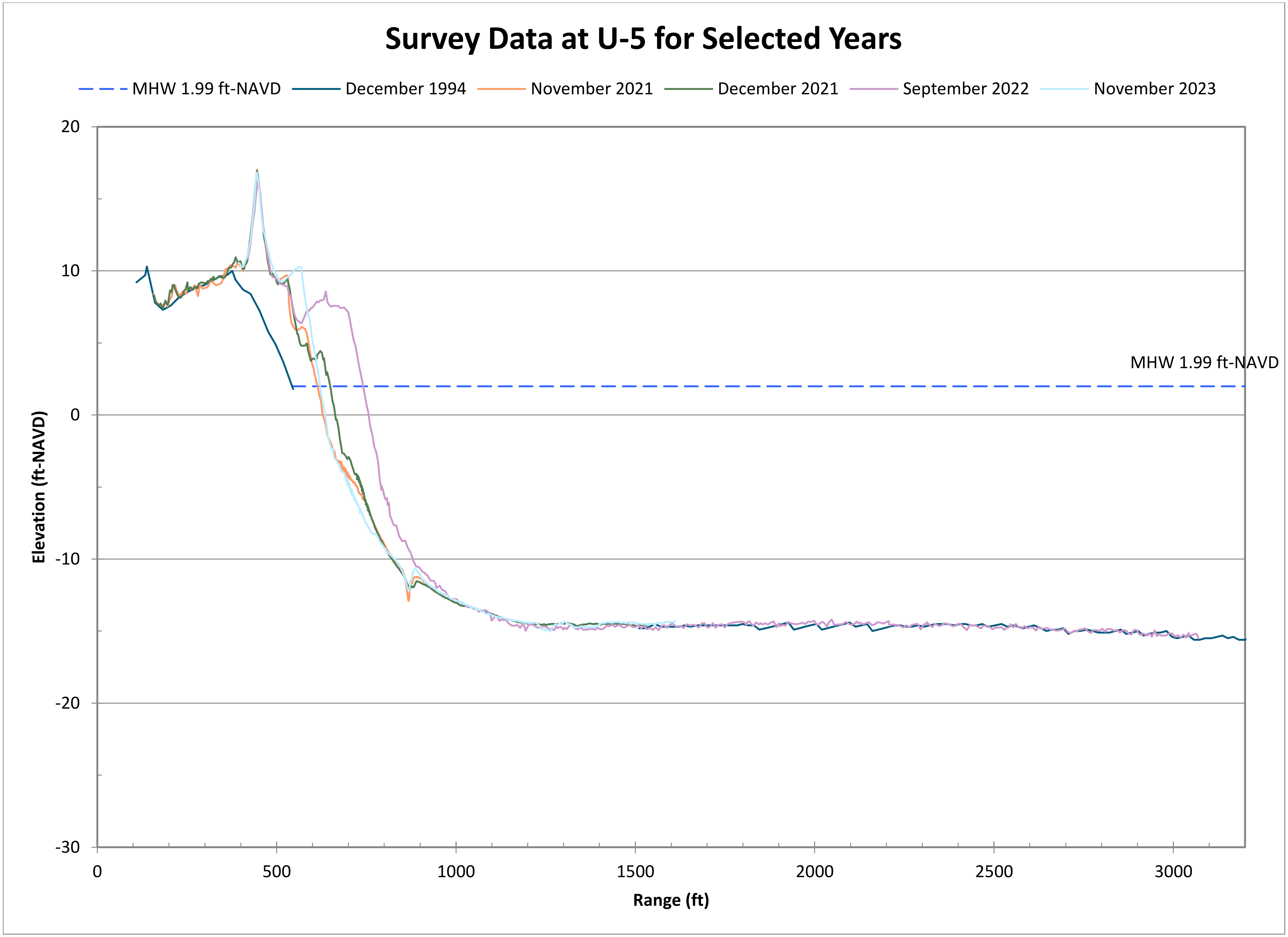
Range (ft)



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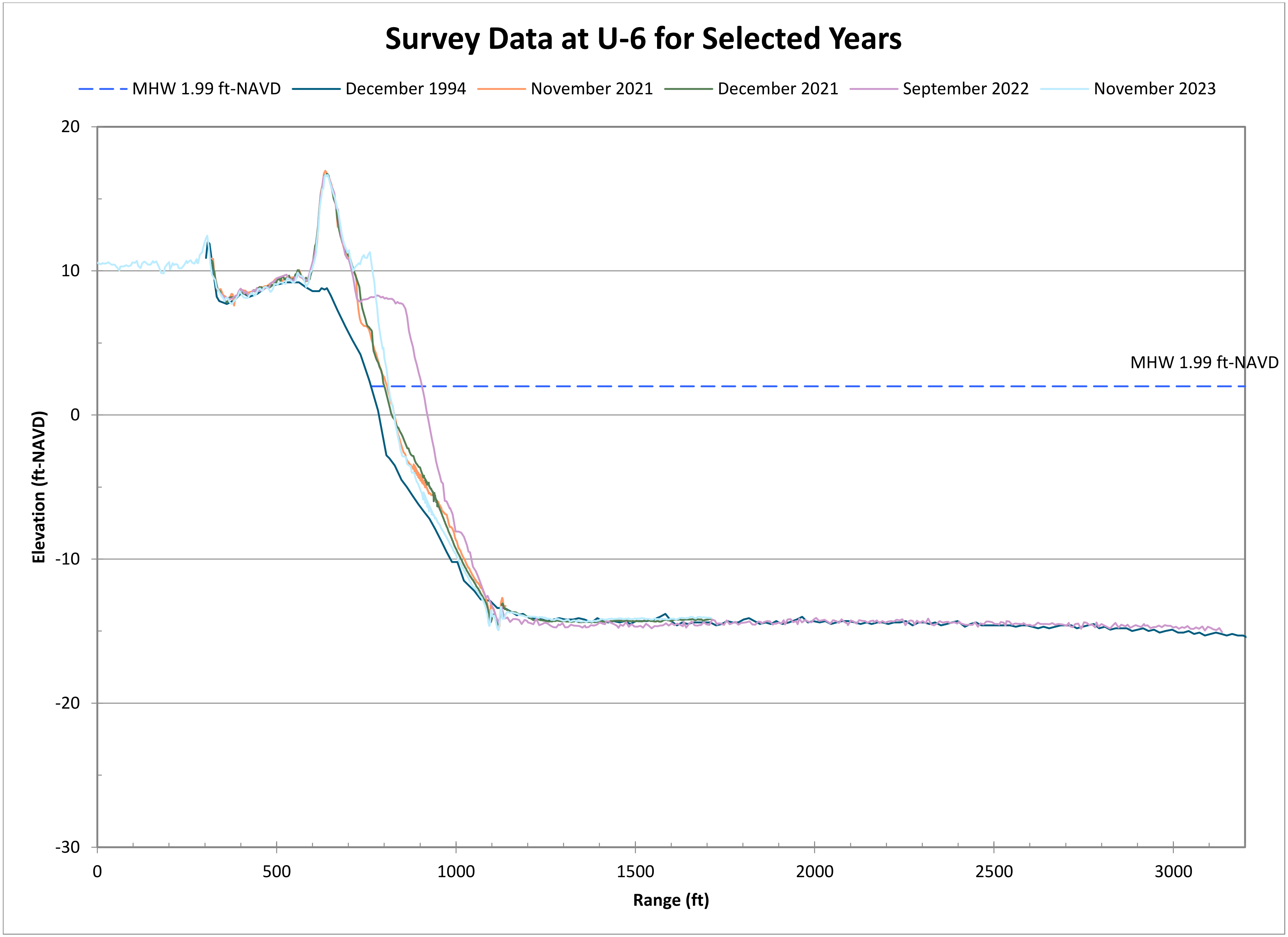

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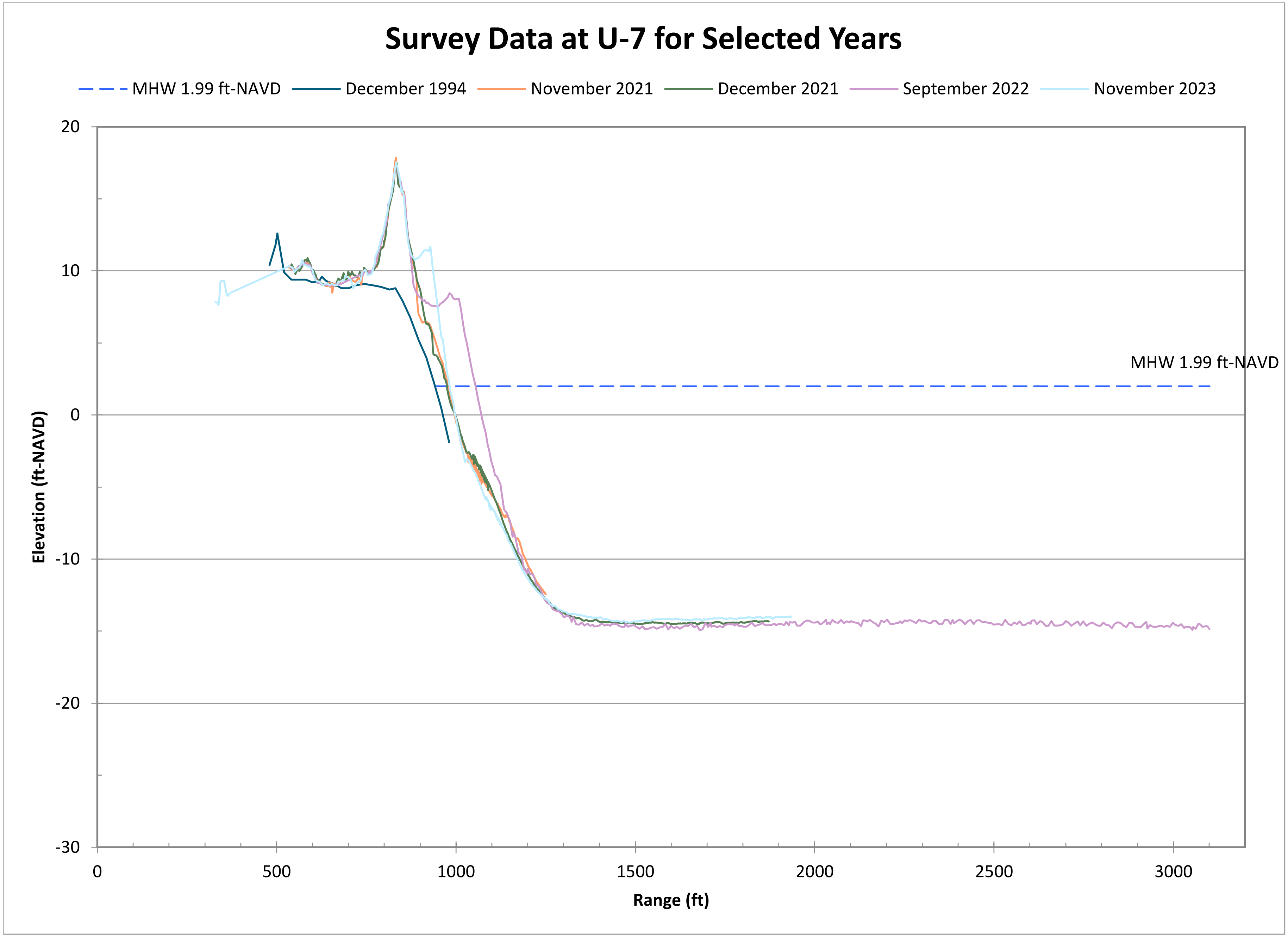
Range (ft)



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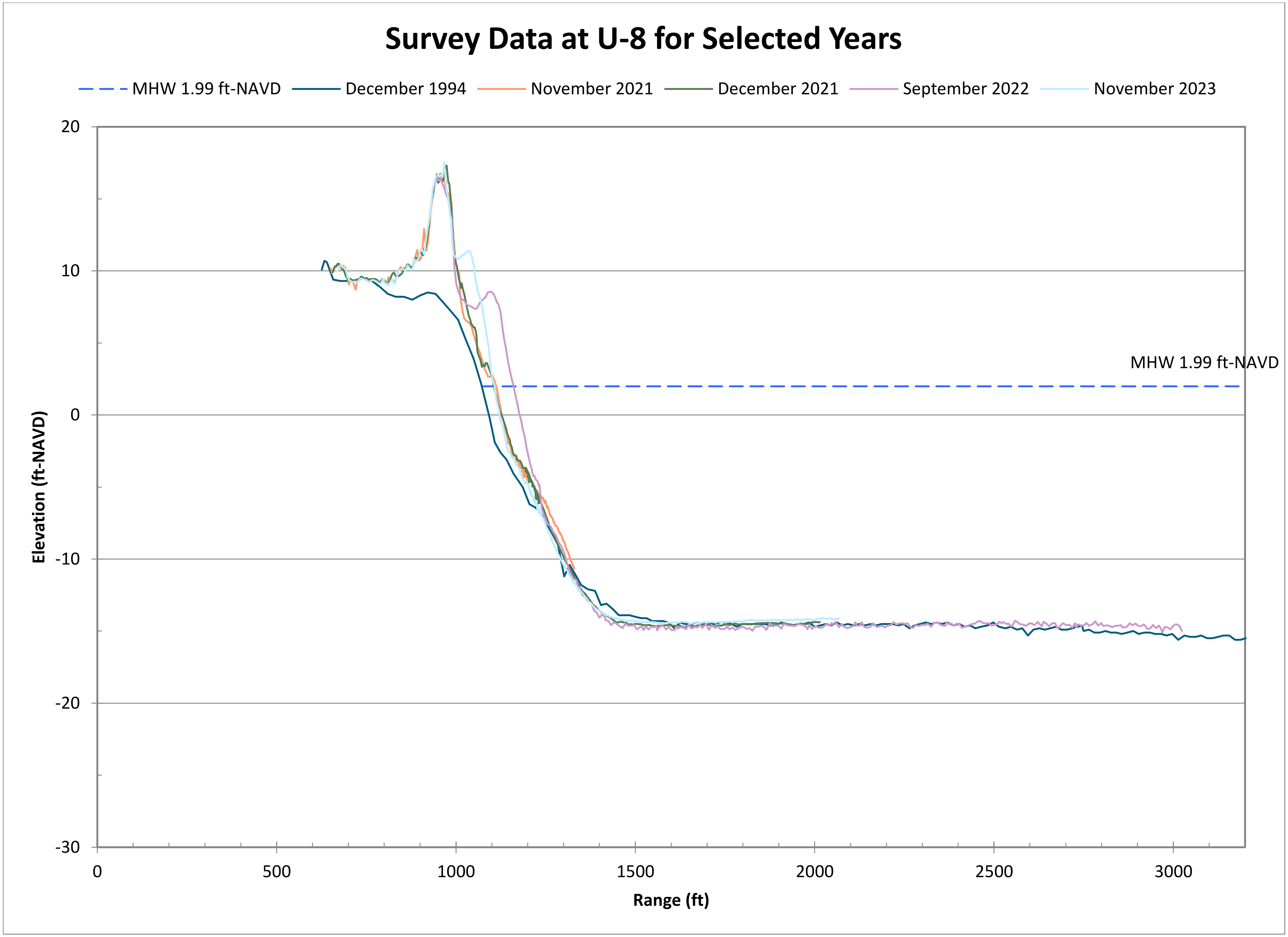
Range (ft)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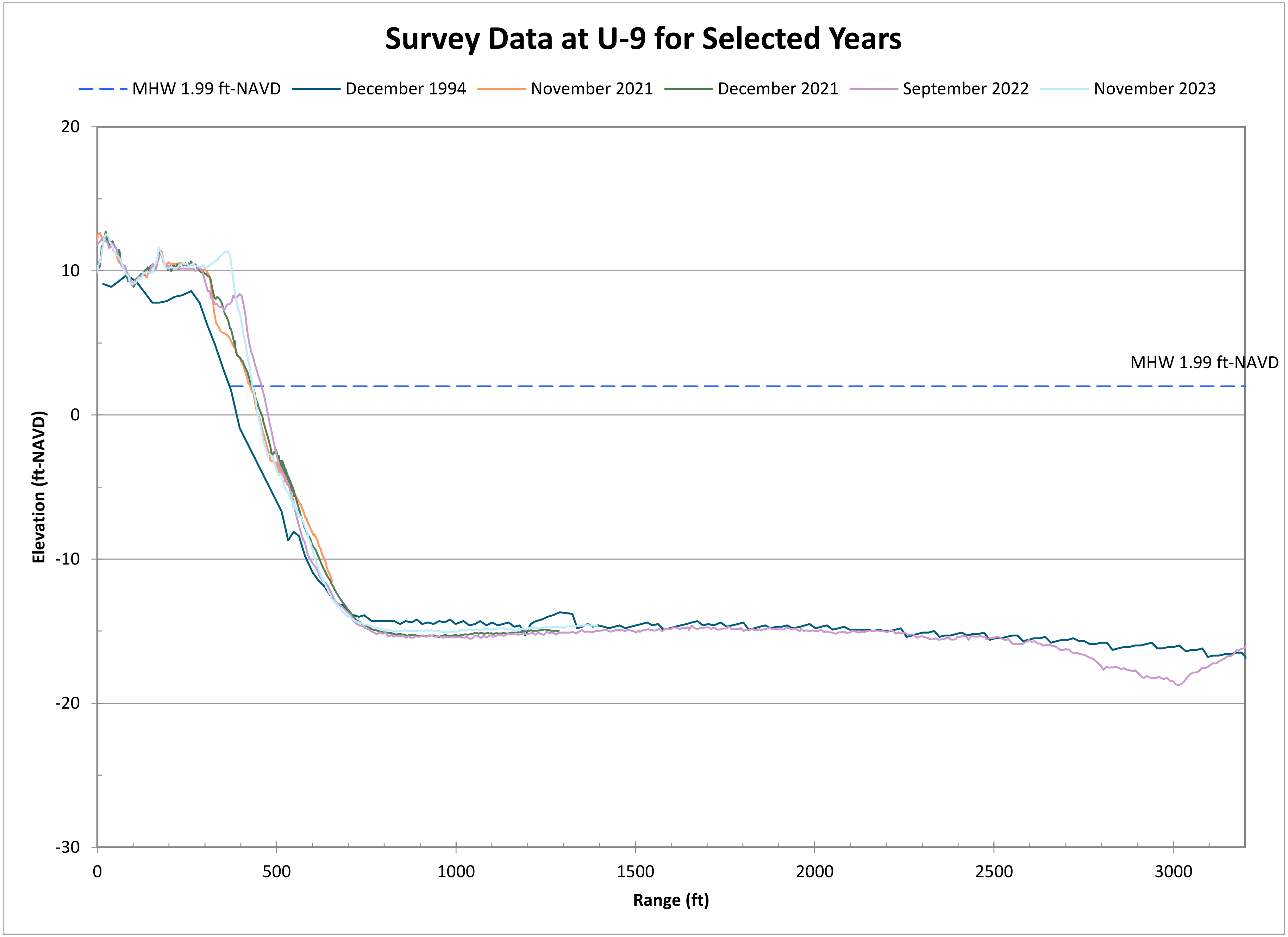
Range (ft)



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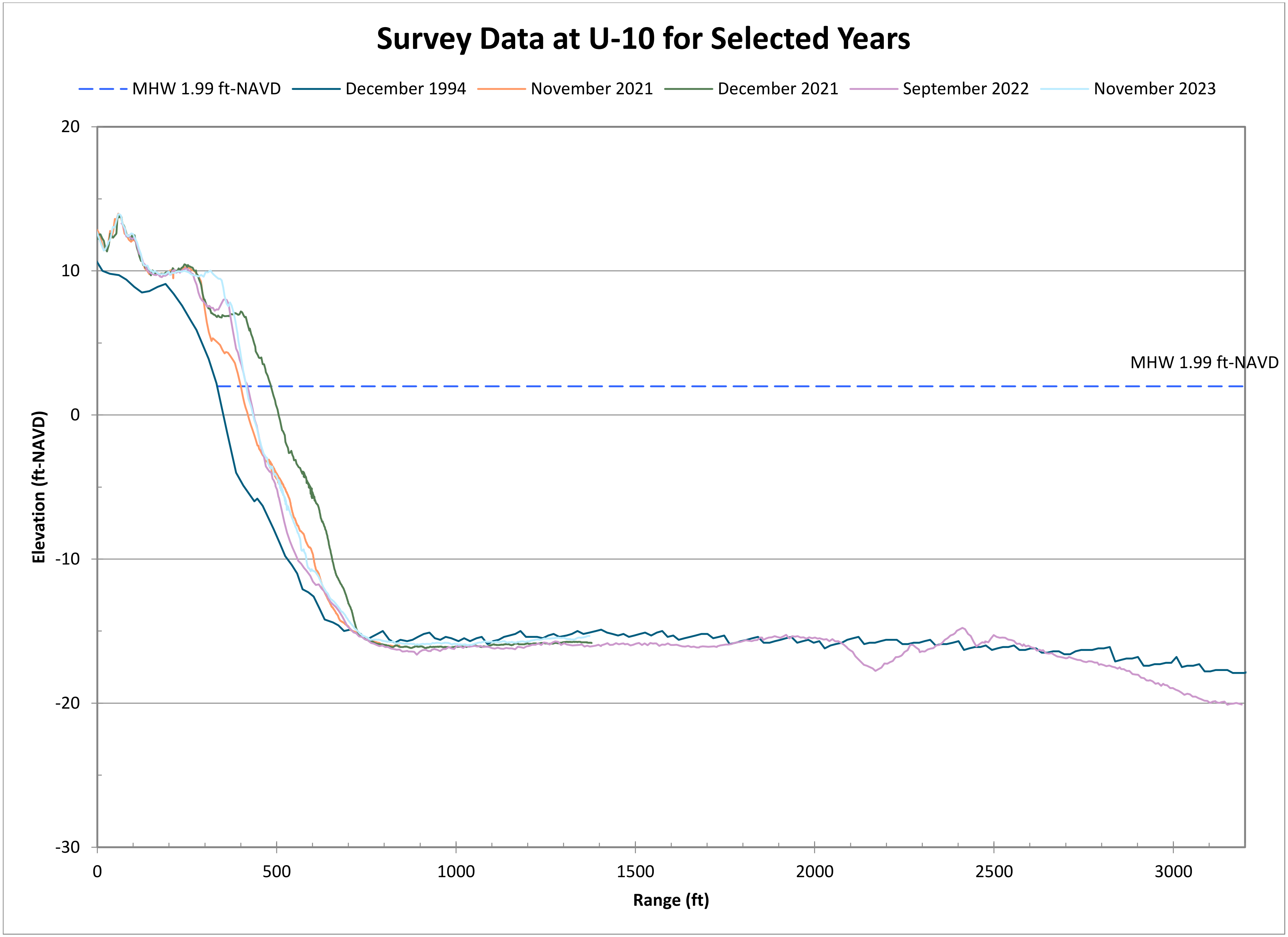
Range (ft)



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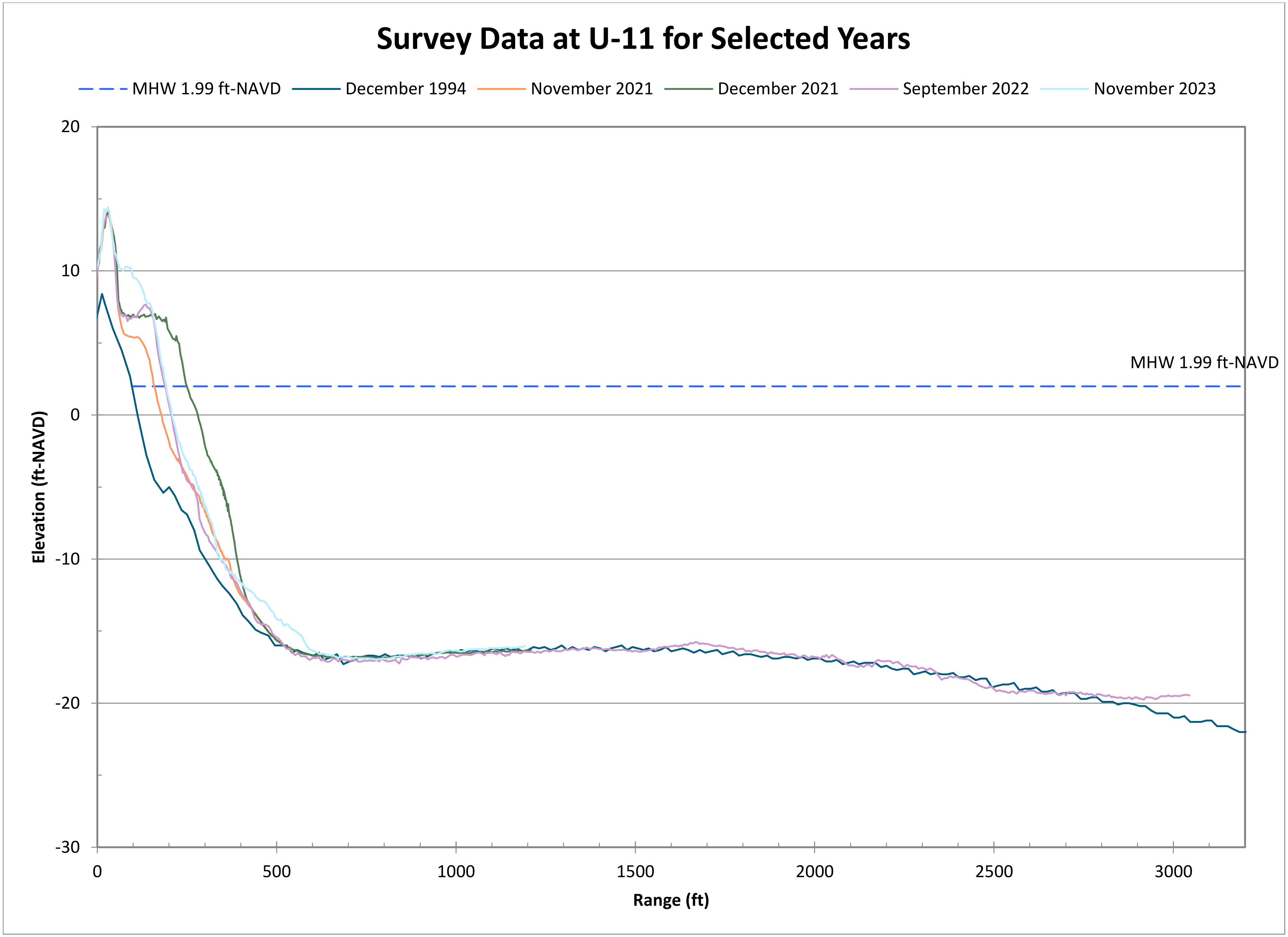
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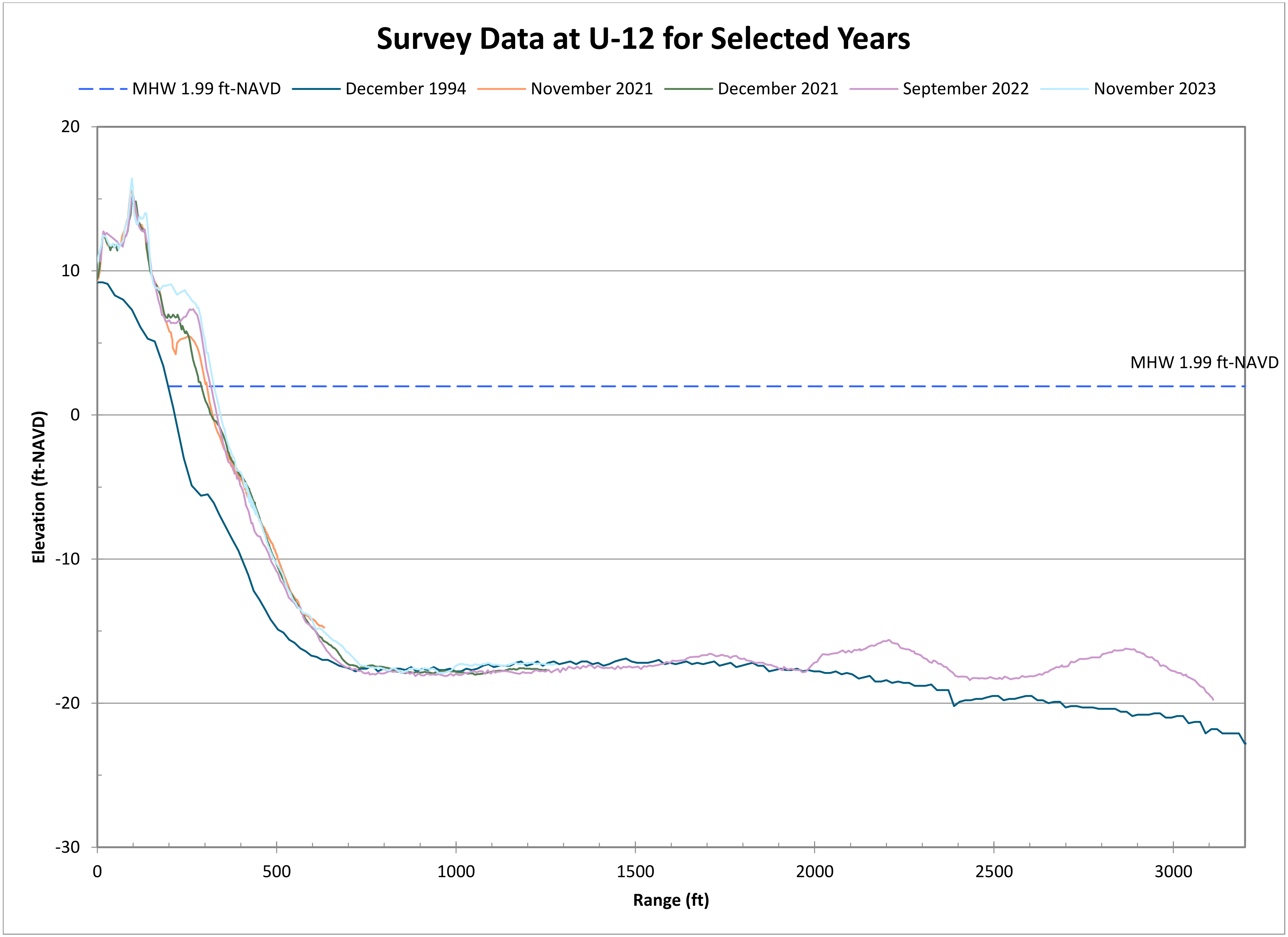
Range (ft)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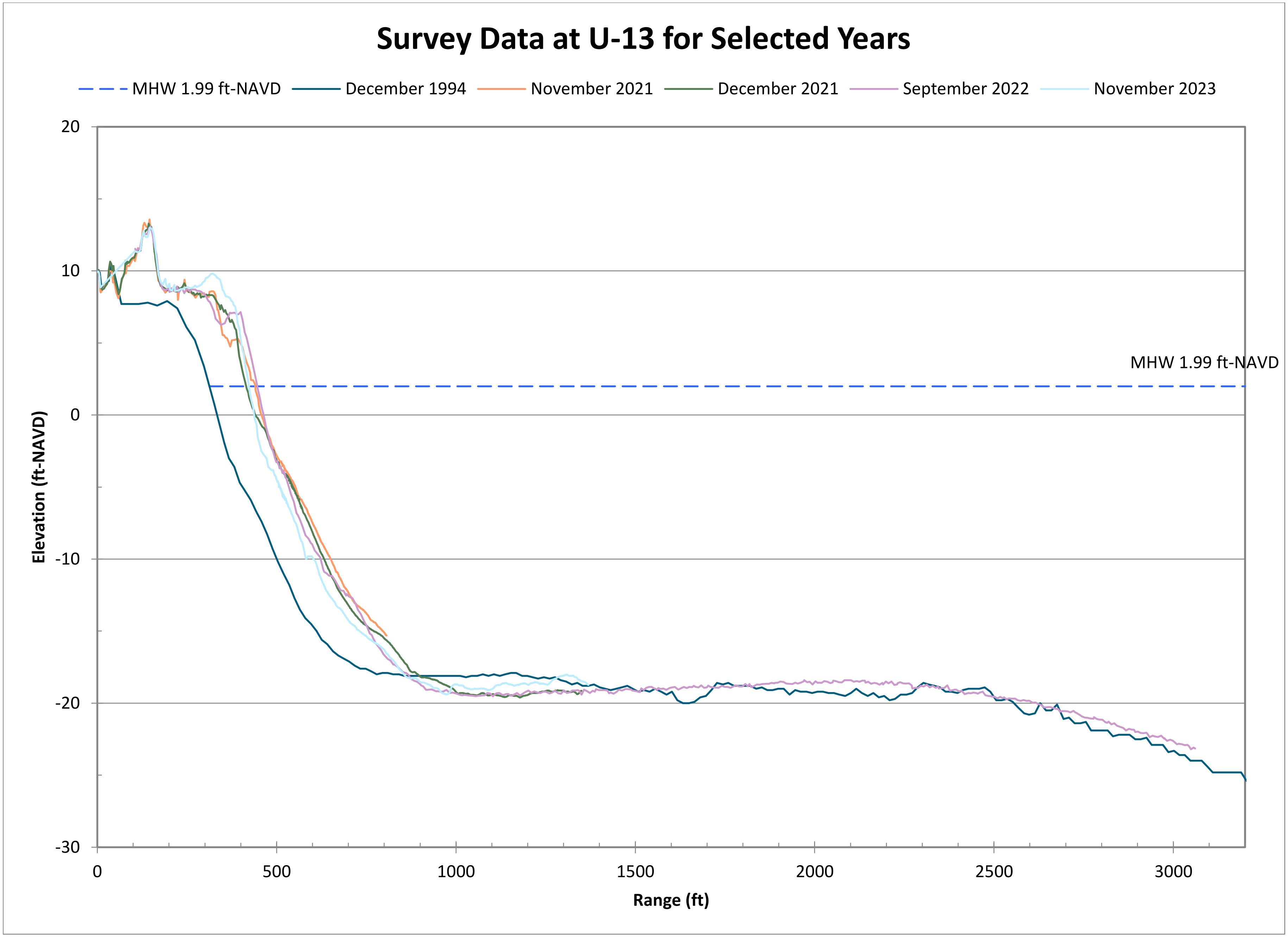
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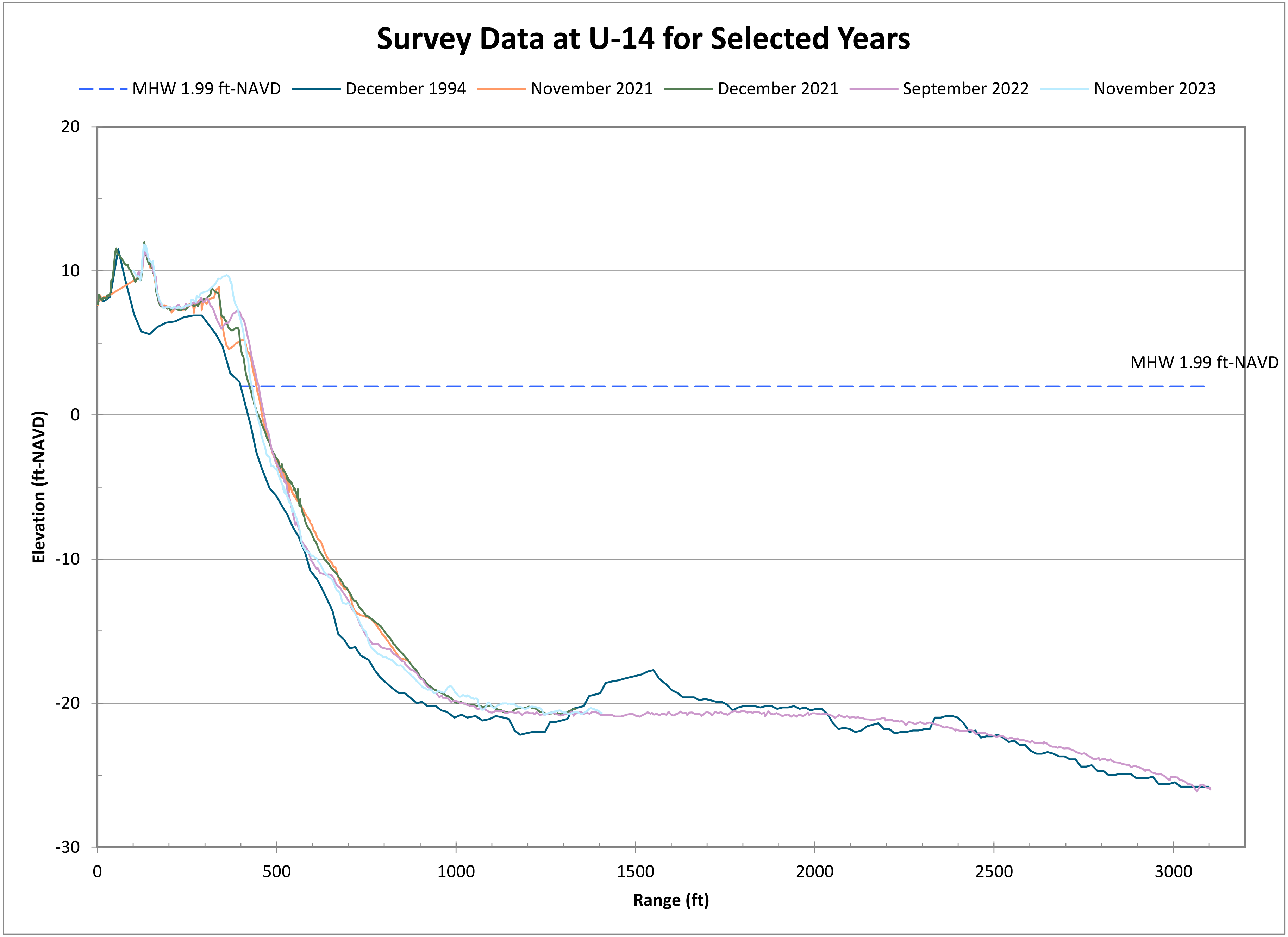
Range (ft)



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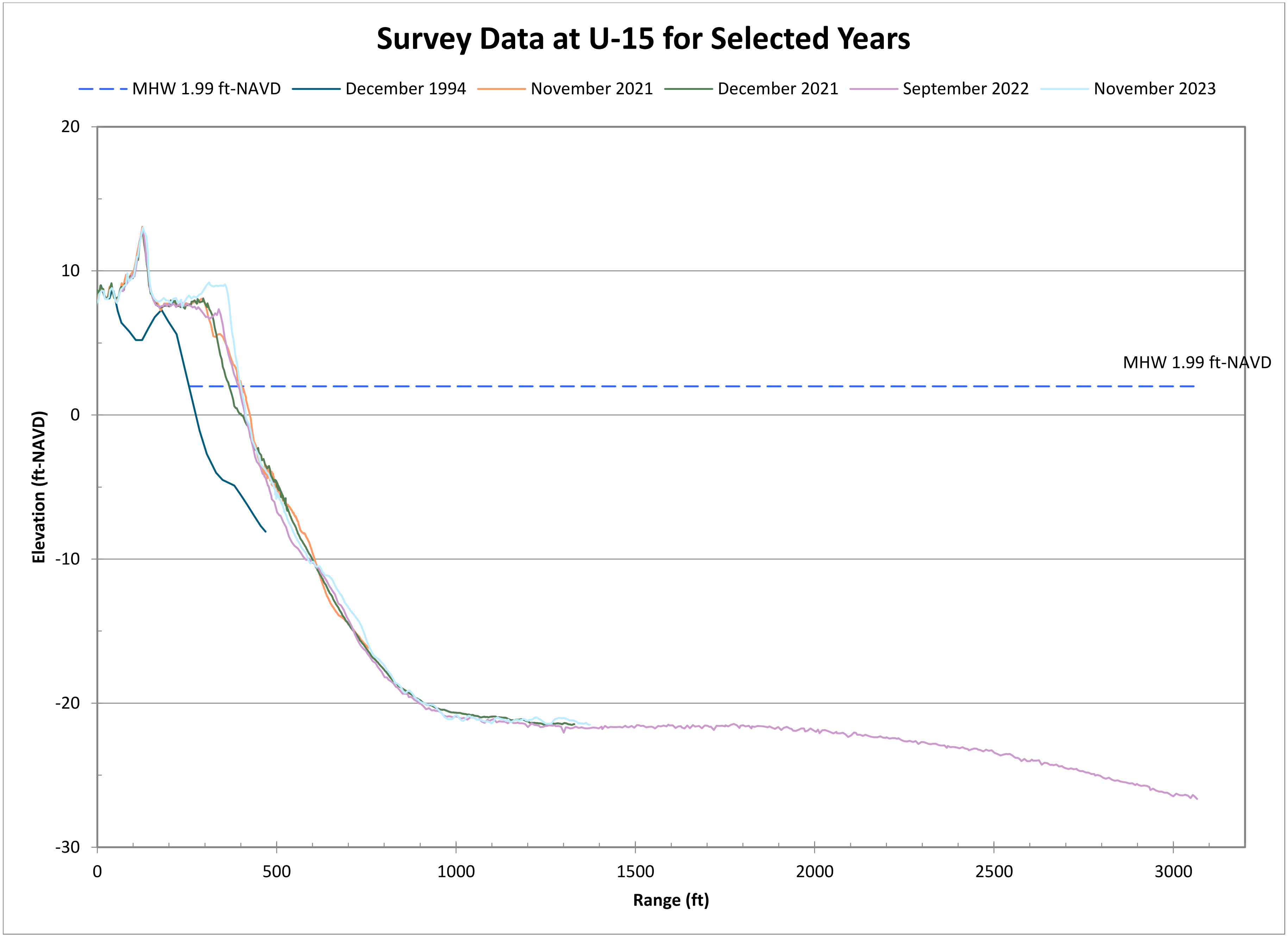
Range (ft)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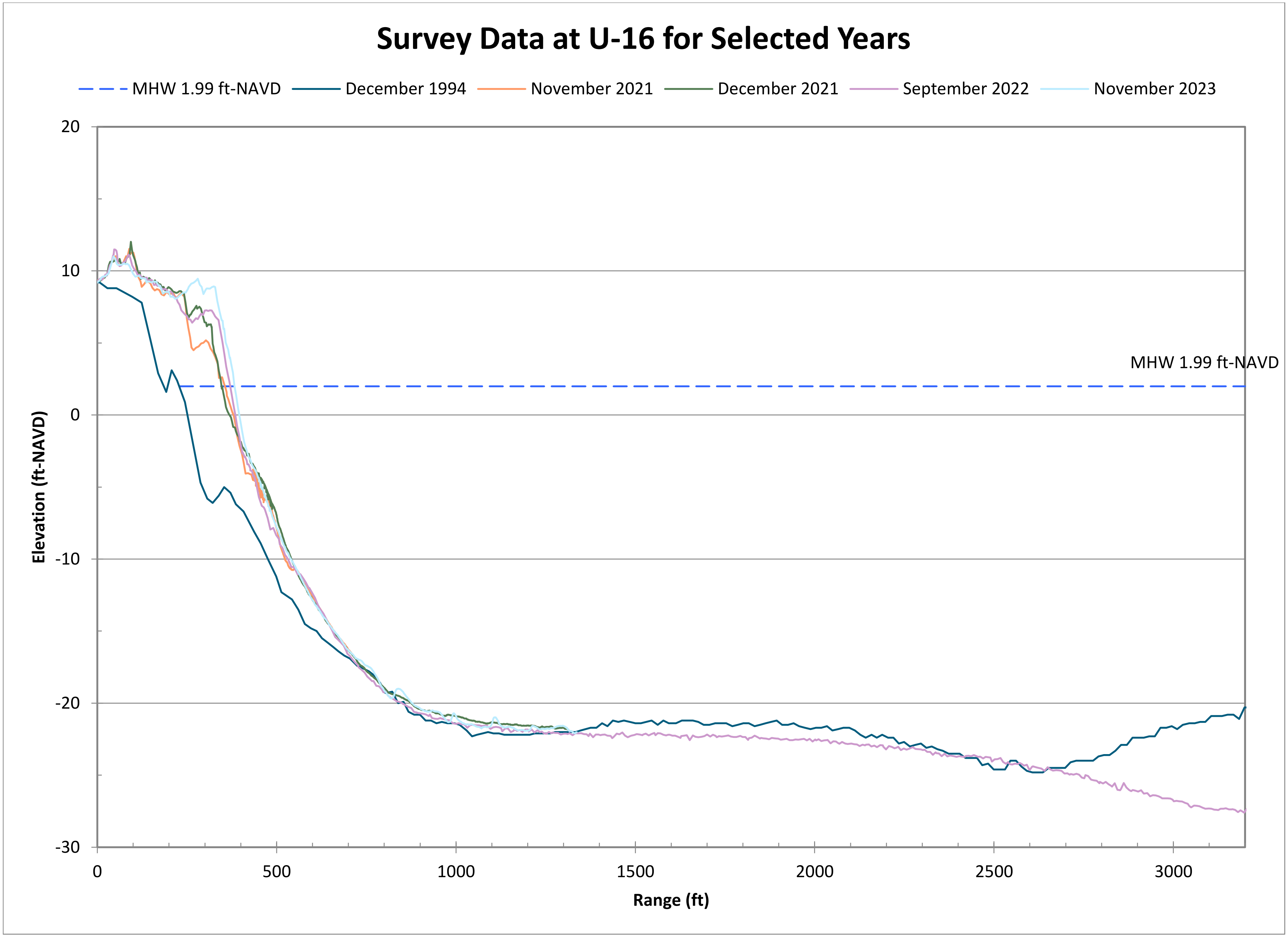

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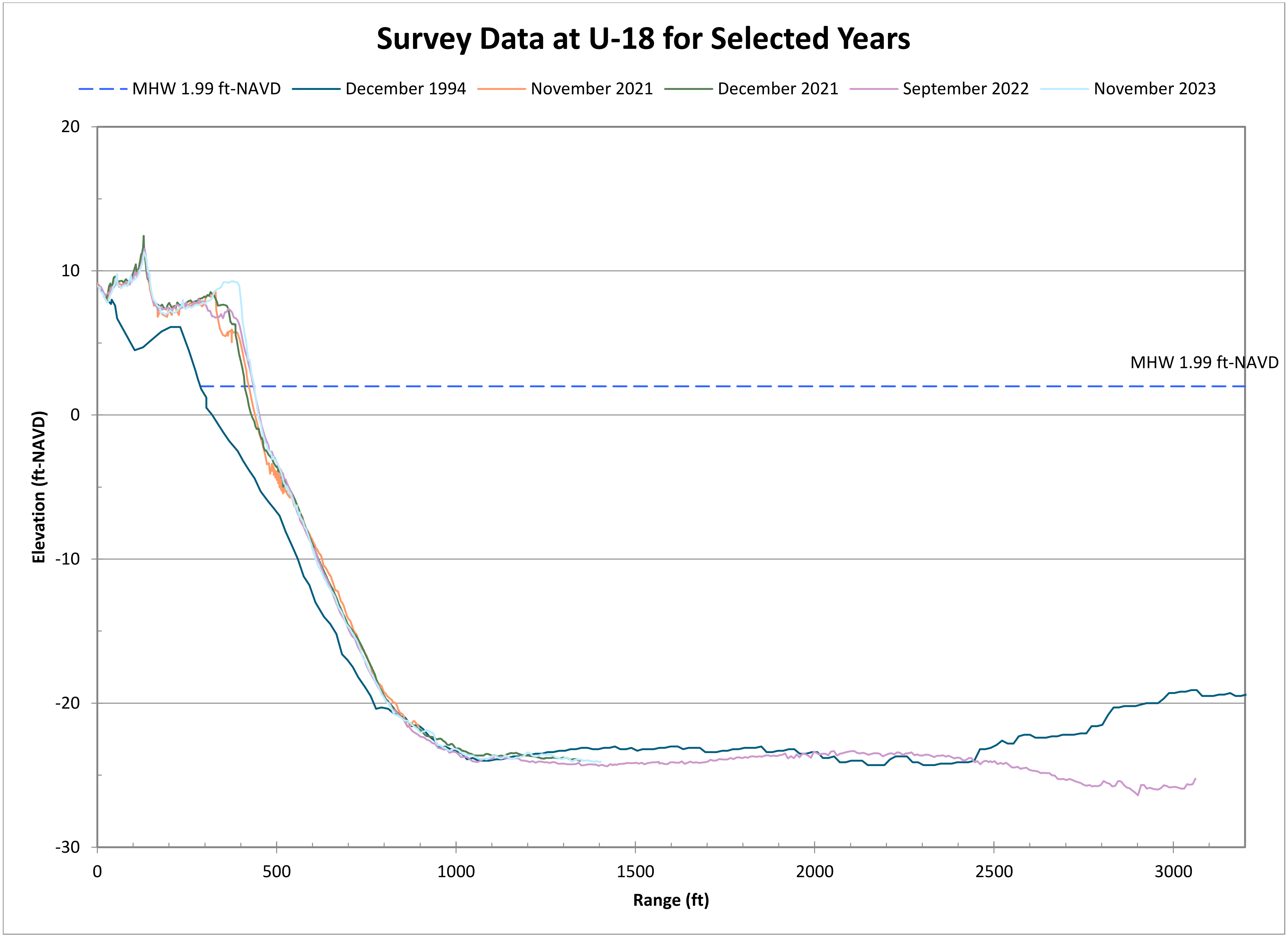
Range (ft)



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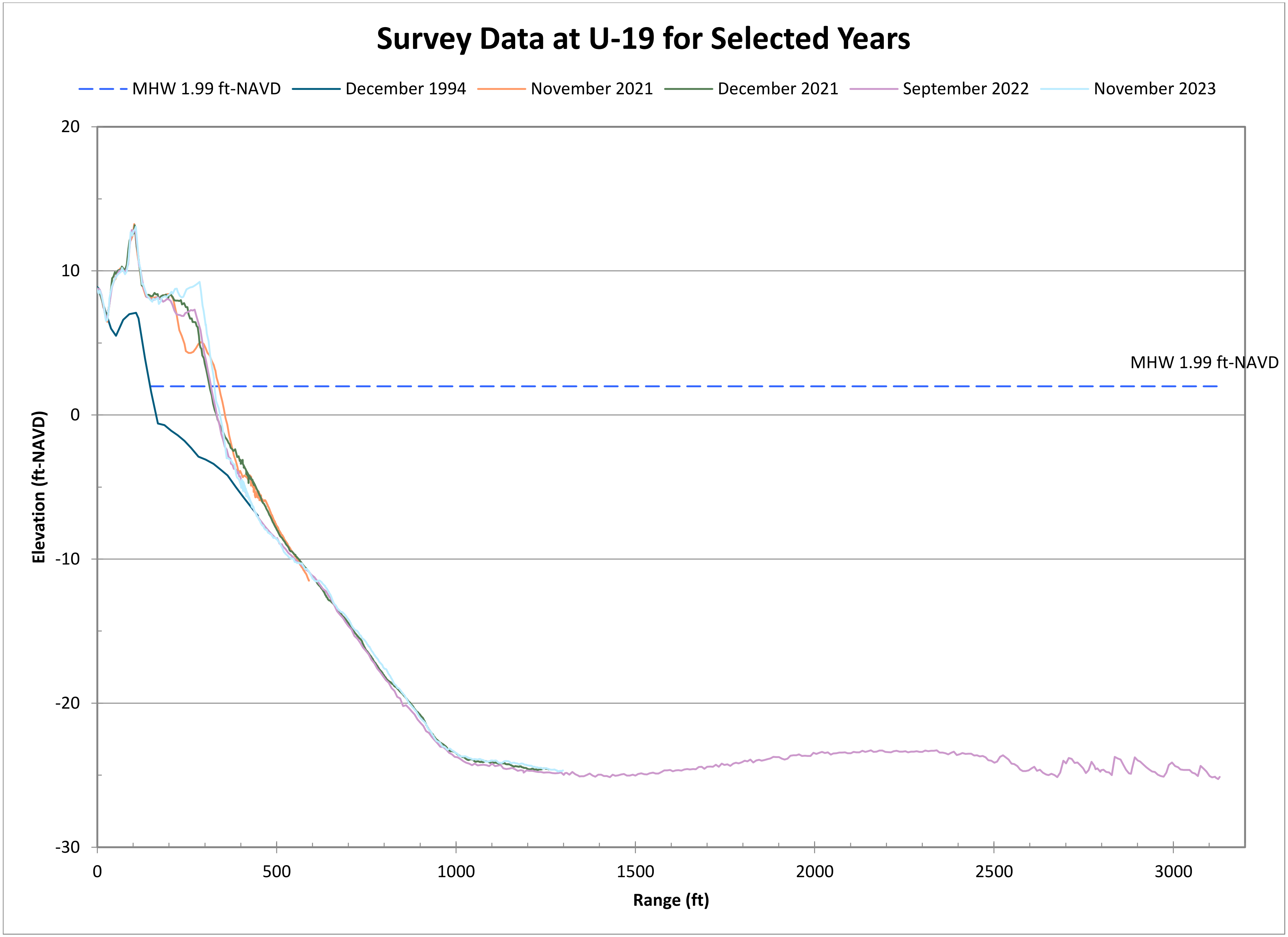

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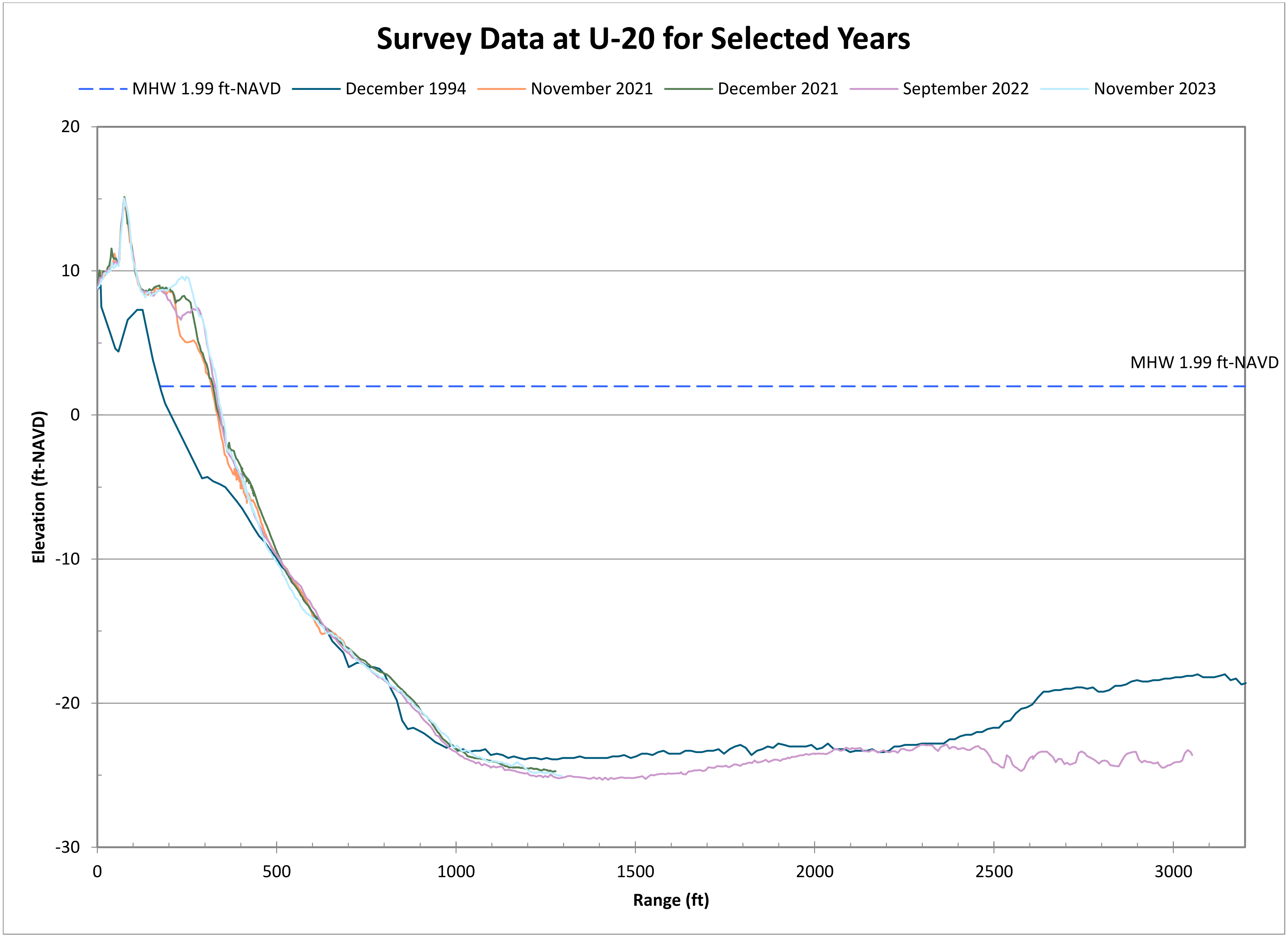
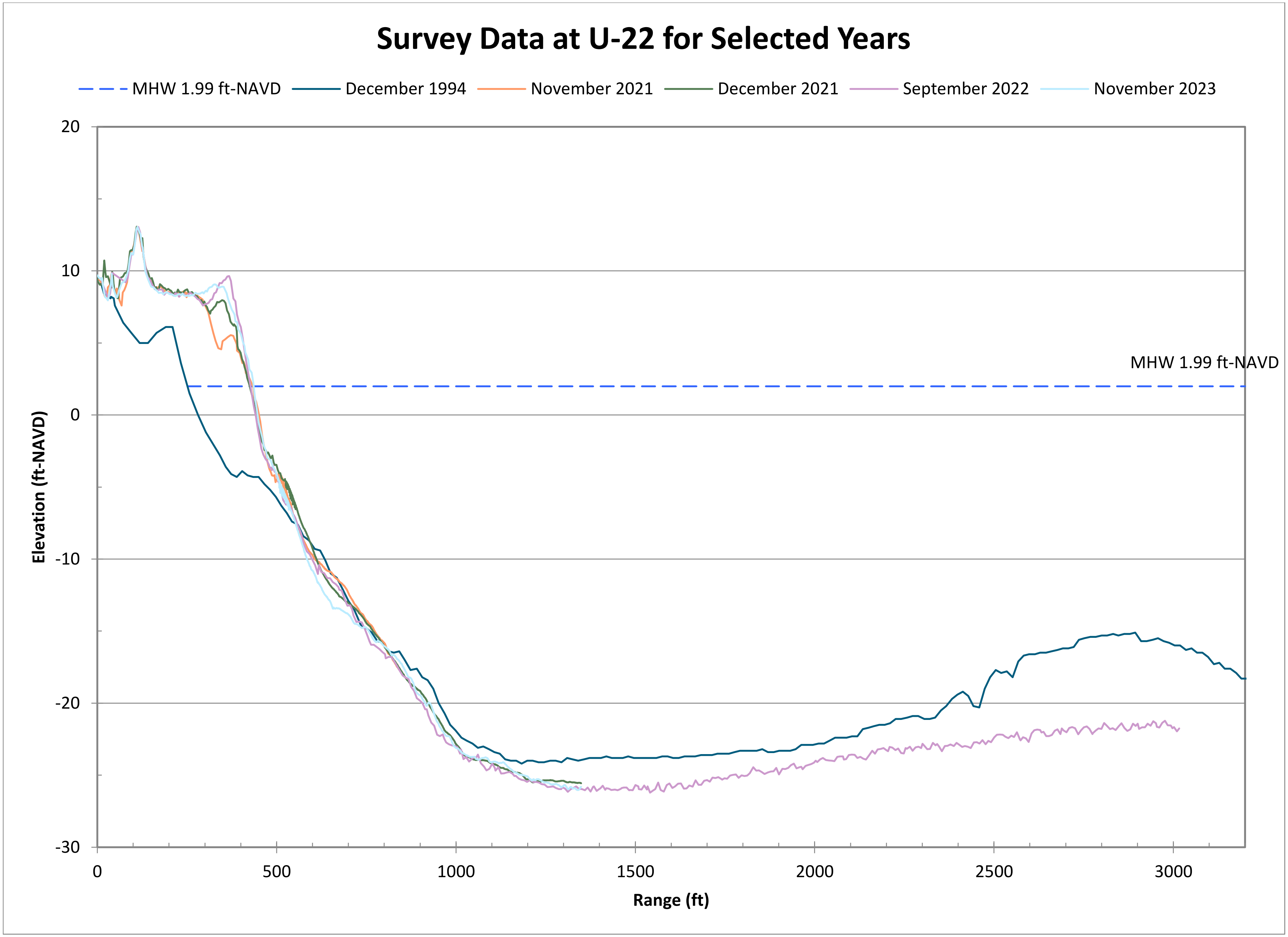
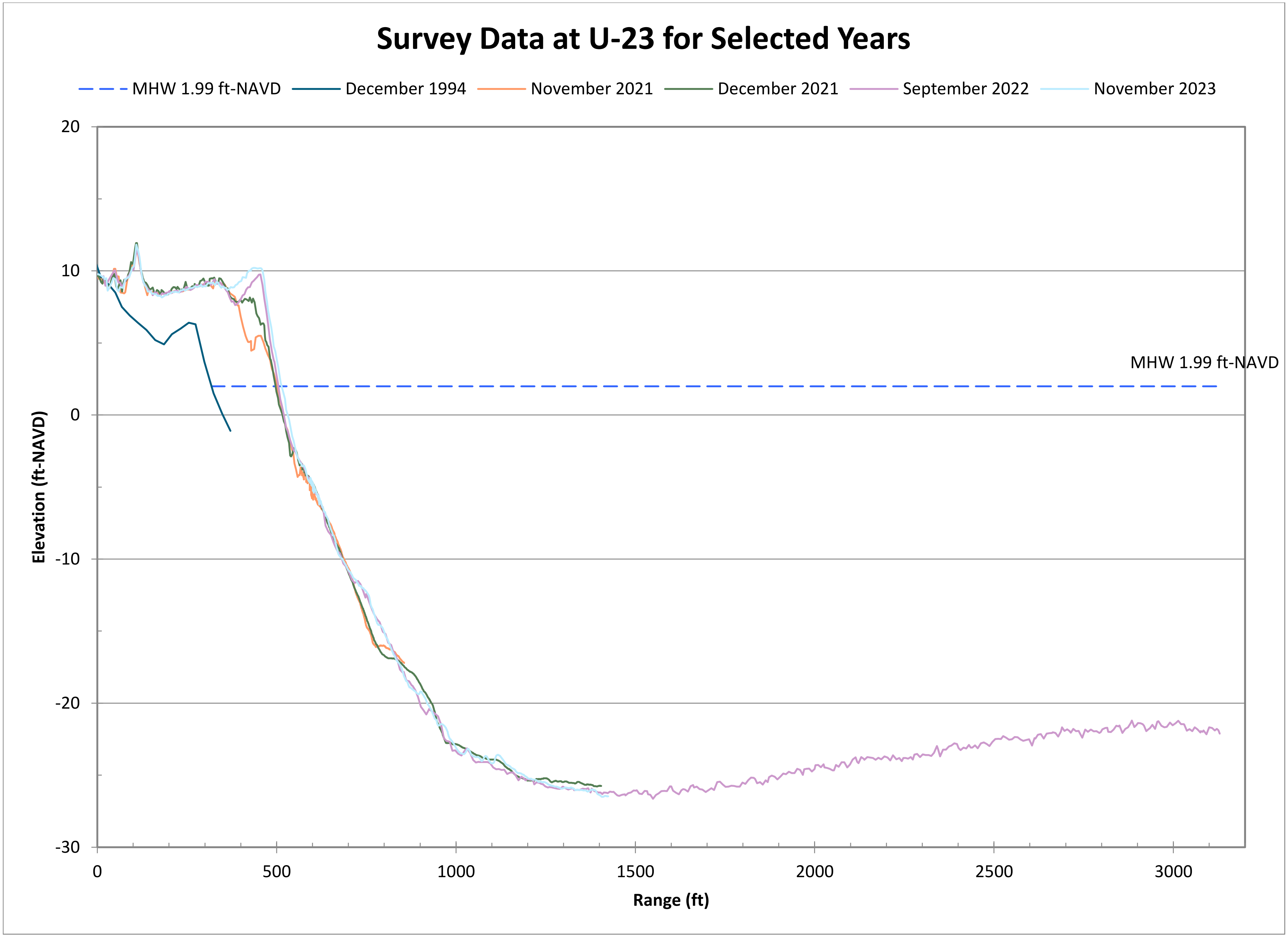
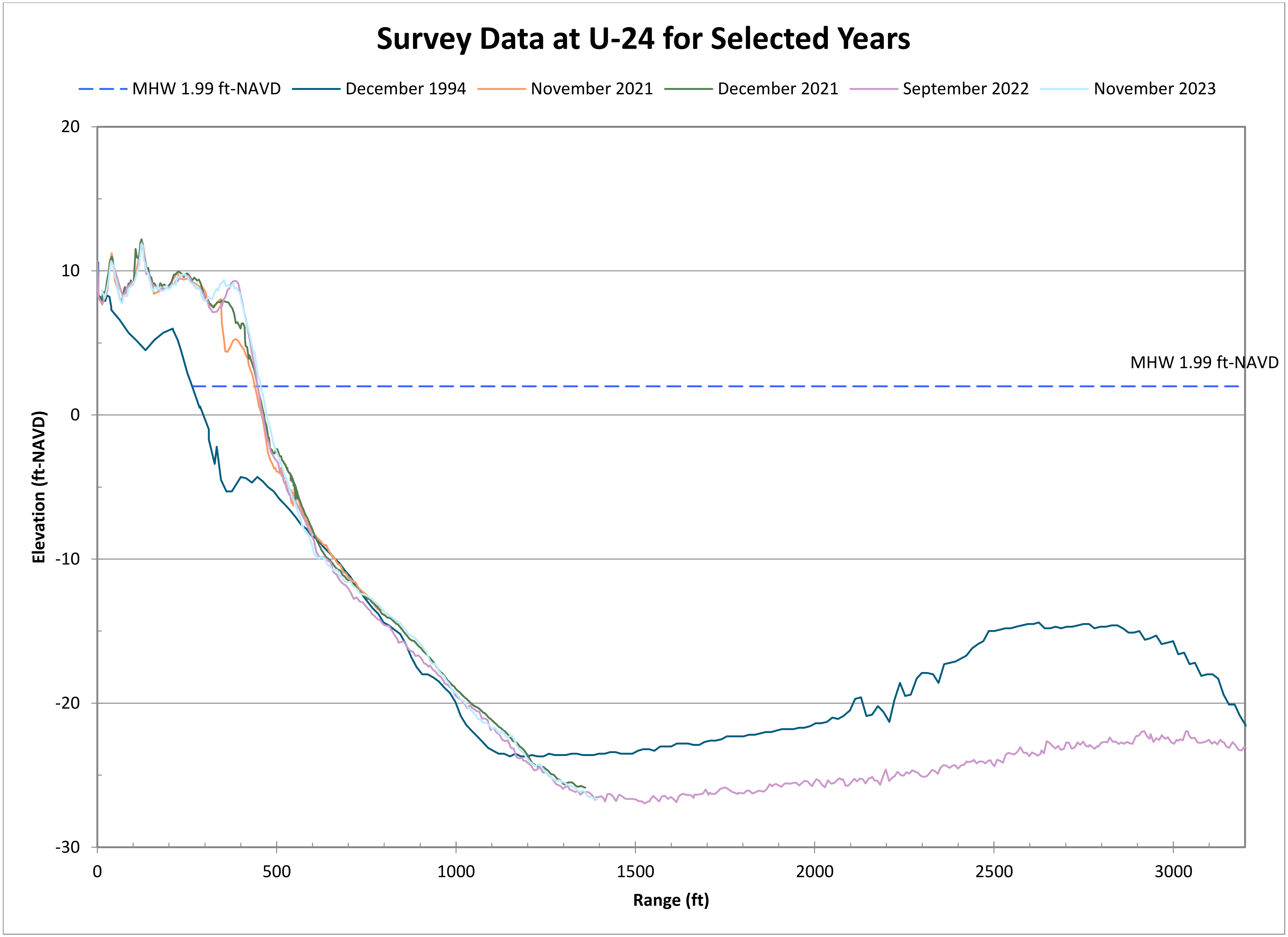
Range (ft)



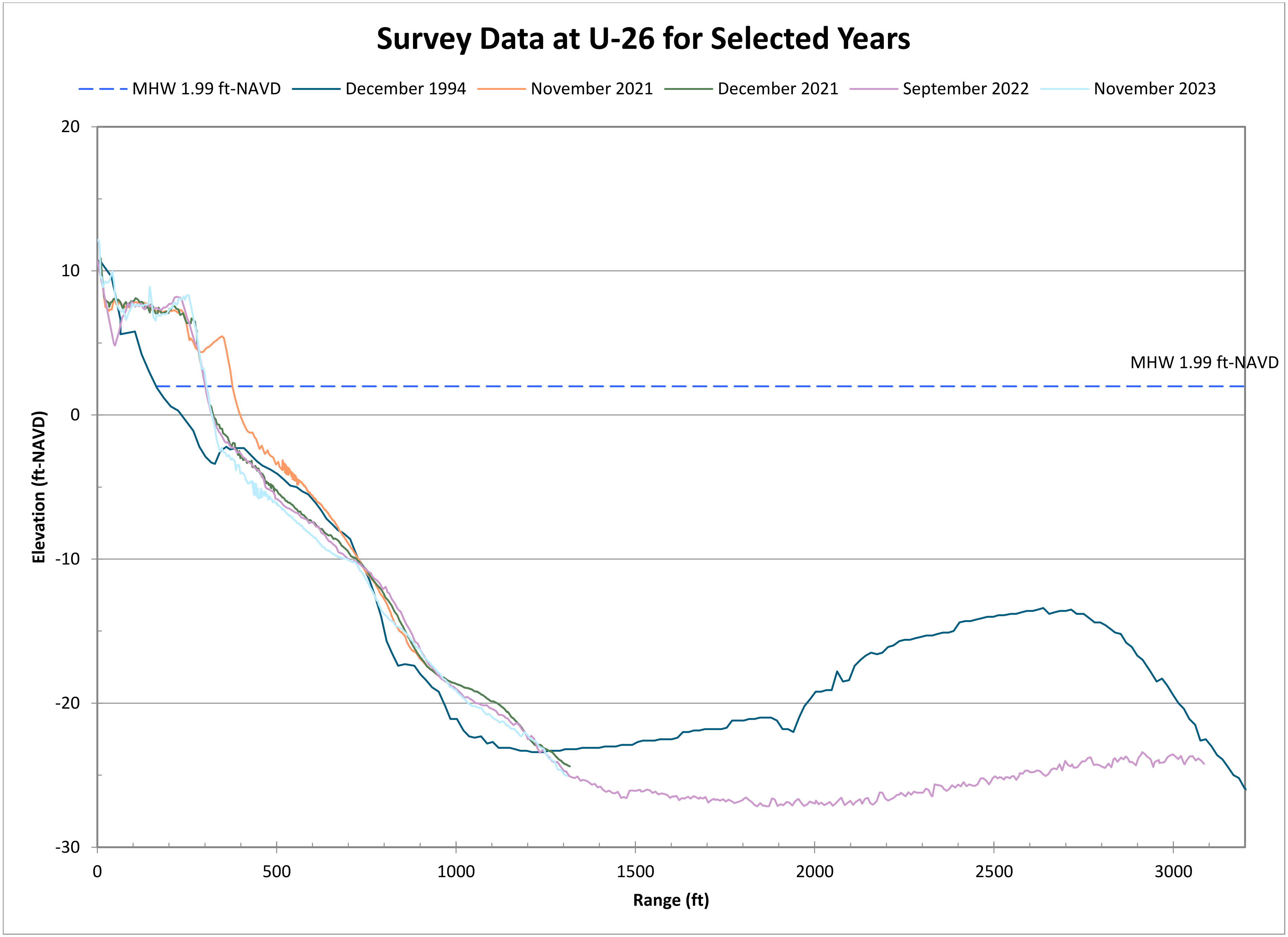
Survey Data at U-20 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
MHW 1.99 ft-NAVD
Elevation (ft-NAVD)
20
10
0
-10
-20
-30
0
500
1000
1500
2000
2500
3000
Range (ft)

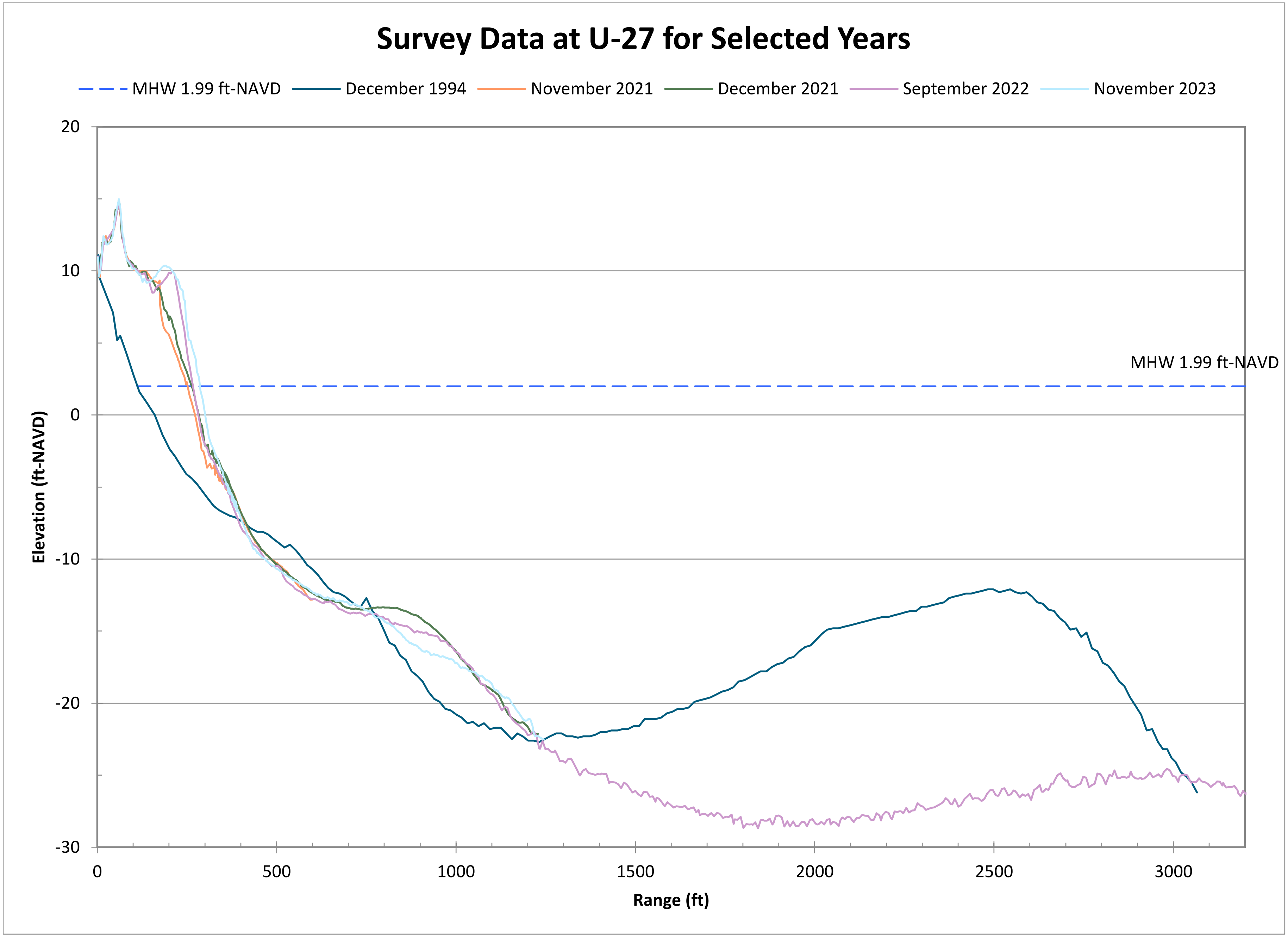

Survey Data at U-22 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
-30
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
0
500
1000
1500
2000
2500
3000
Range (ft)


Survey Data at U-23 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
MHW 1.99 ft-NAVD
Elevation (ft-NAVD)
Range (ft)
20
10
0
-10
-20
-30
0
500
1000
1500
2000
2500
3000

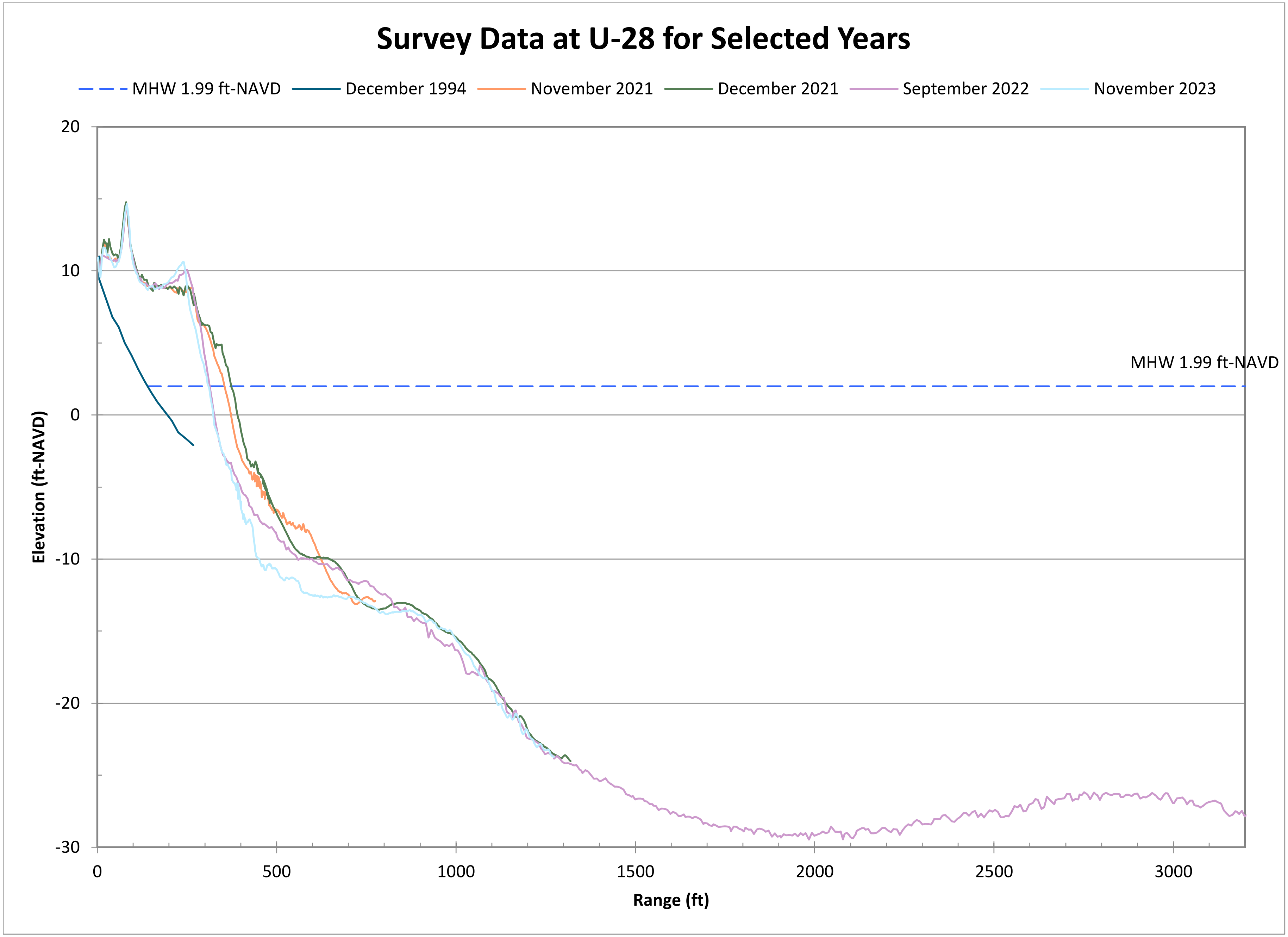


Survey Data at U-24 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
Elevation (ft-NAVD)
20
10
0
-10
-20
-30
MHW 1.99 ft-NAVD
0
500
1000
1500
2000
2500
3000
Range (ft)

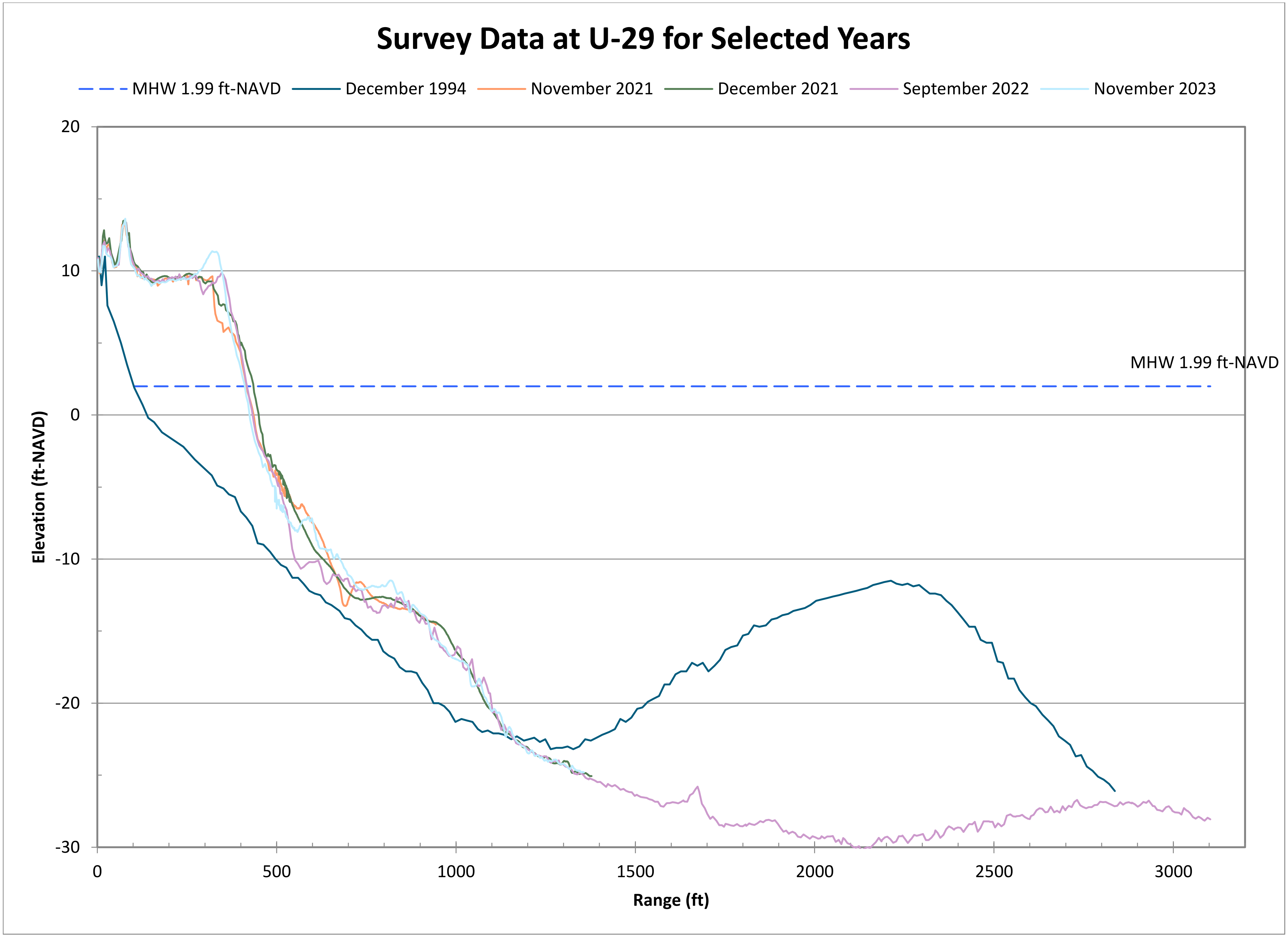

Survey Data at U-26 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
MHW 1.99 ft-NAVD
Elevation (ft-NAVD)
20
10
0
-10
-20
-30
0
500
1000
1500
2000
2500
3000
Range (ft)



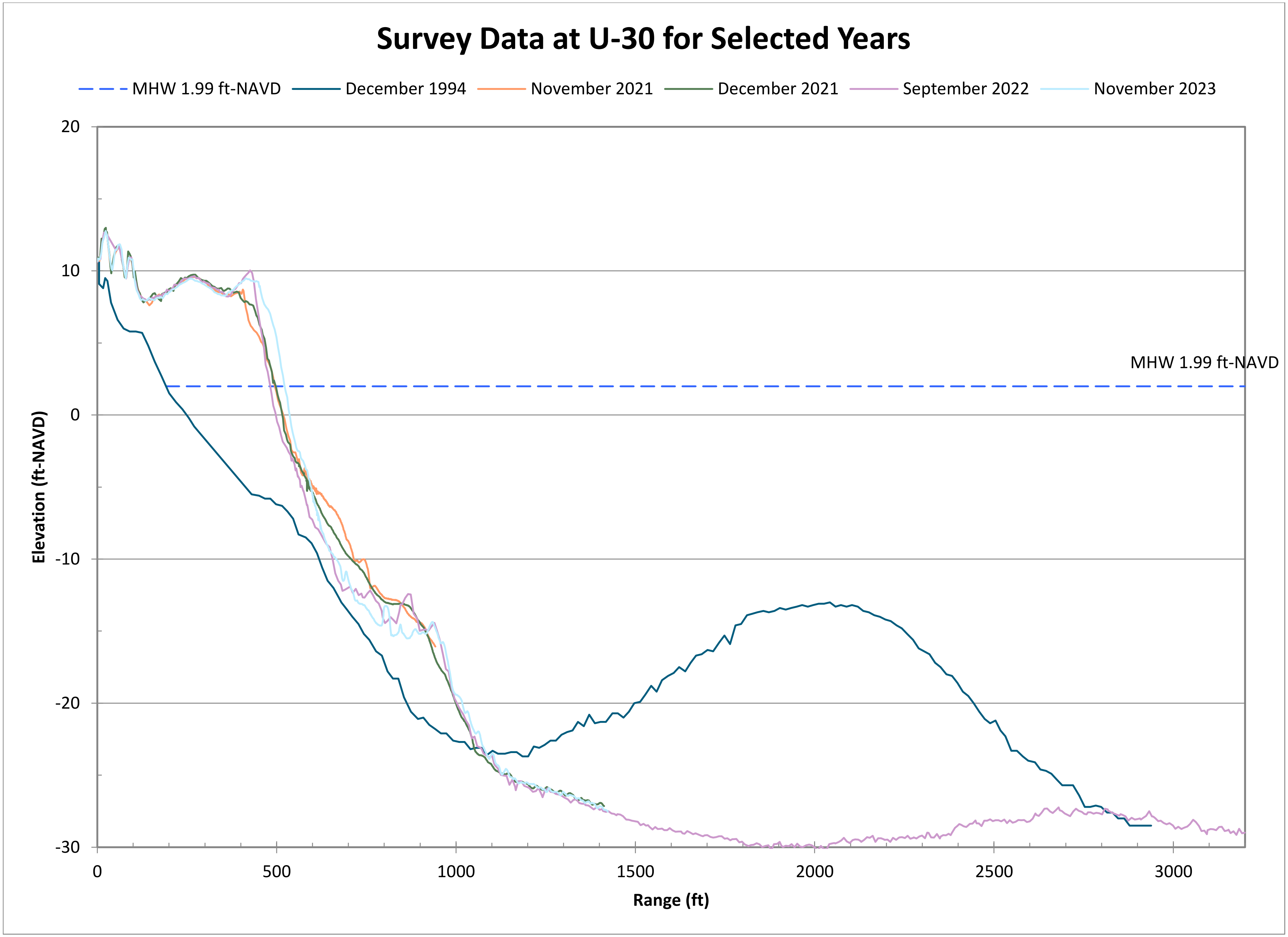
Survey Data at U-27 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
MHW 1.99 ft-NAVD
Elevation (ft-NAVD)
Range (ft)
20
10
0
-10
-20
-30
0
500
1000
1500
2000
2500
3000



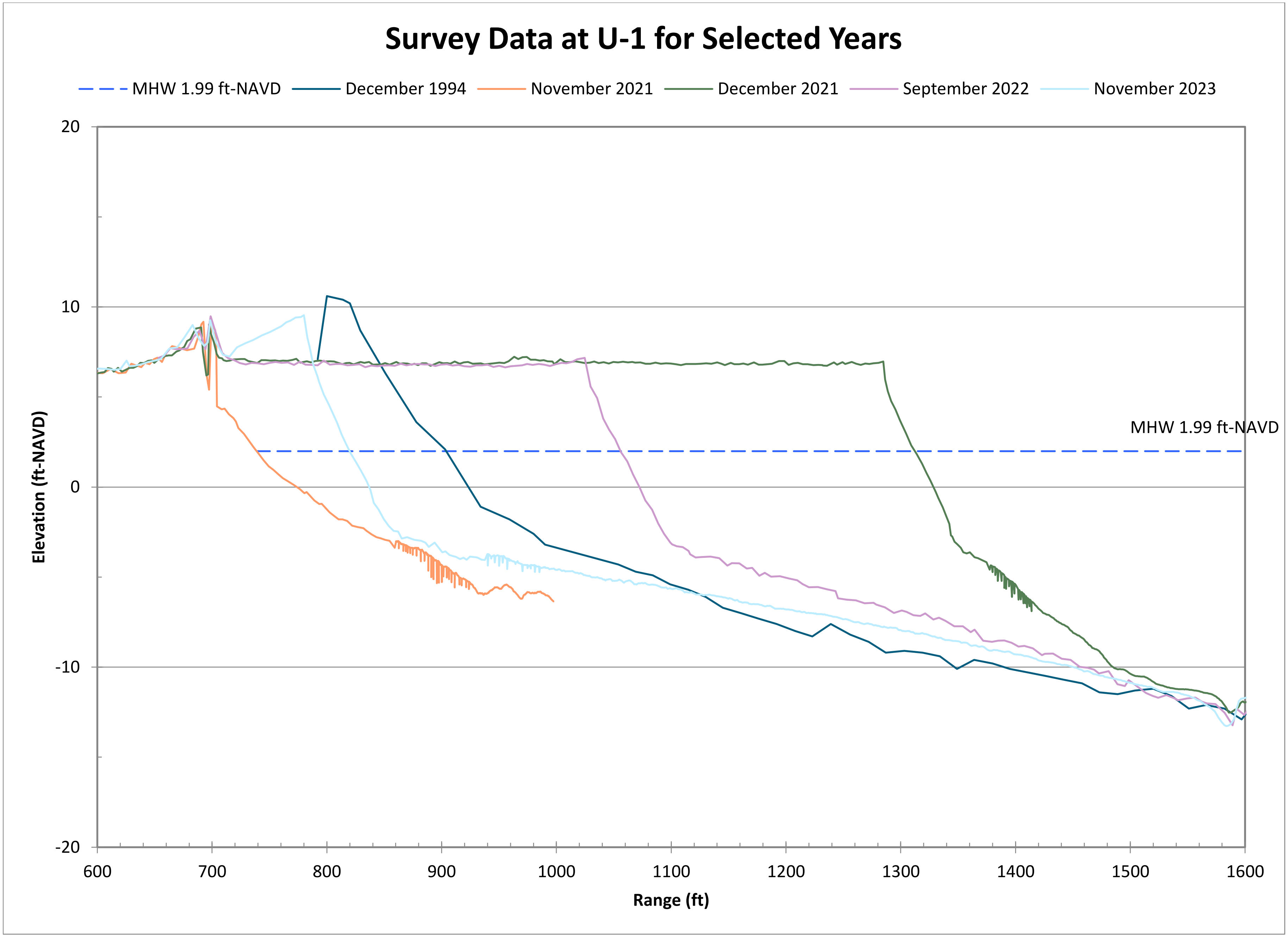
Survey Data at U-28 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
MHW 1.99 ft-NAVD
Elevation (ft-NAVD)
20
10
0
-10
-20
-30
0
500
1000
1500
2000
2500
3000
Range (ft)

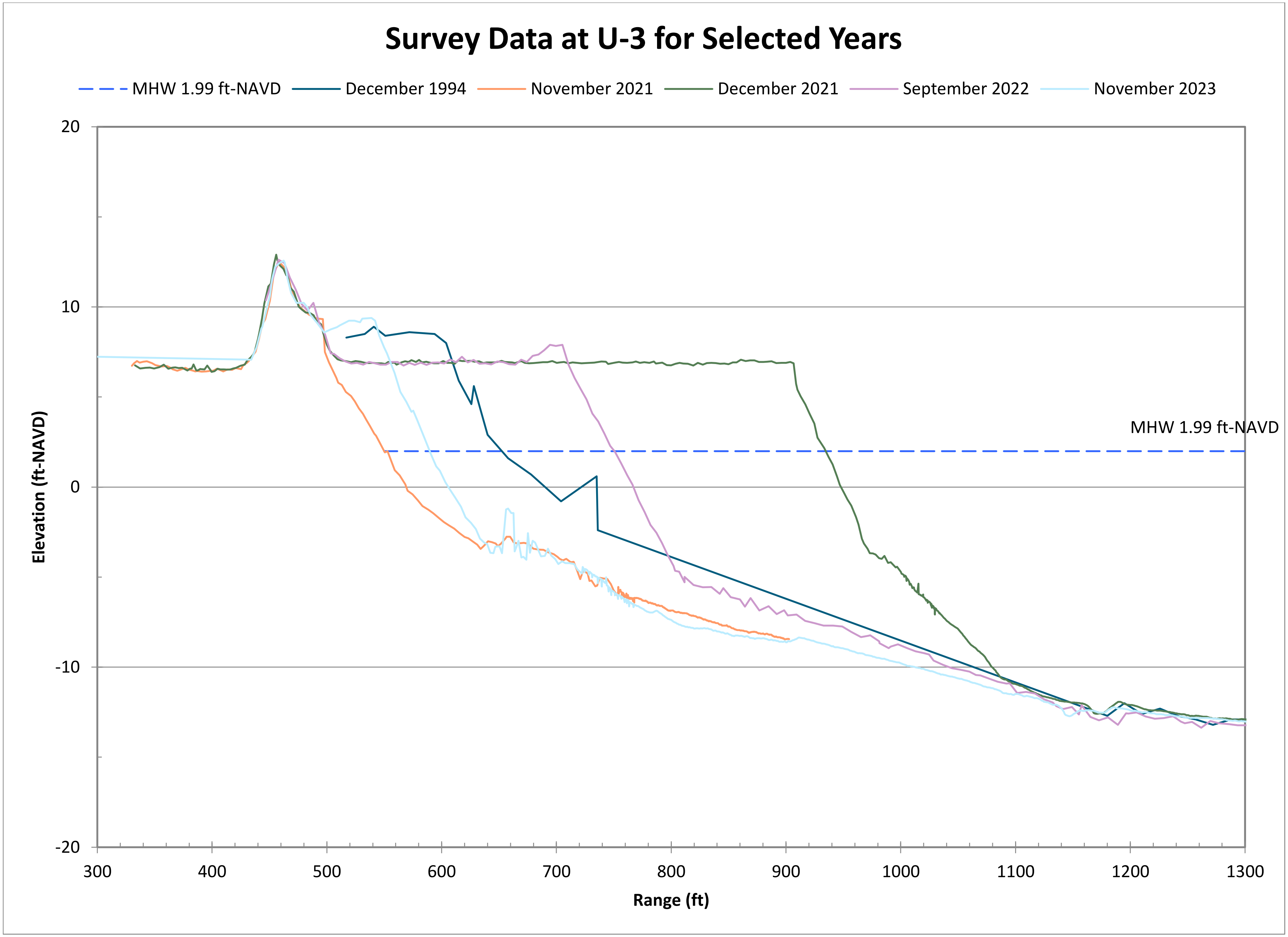


Survey Data at U-29 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
-30
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
0
500
1000
1500
2000
2500
3000
Range (ft)

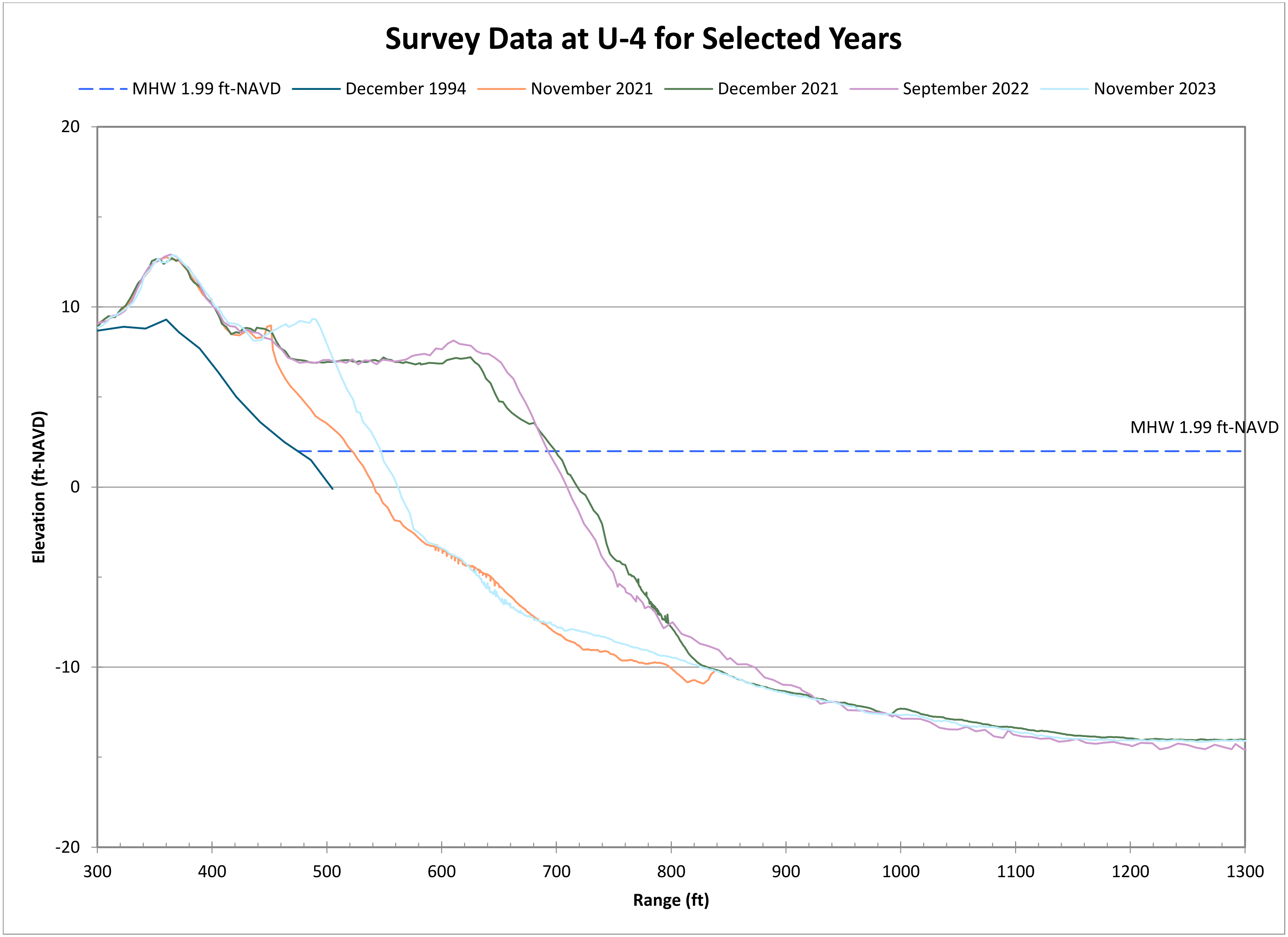


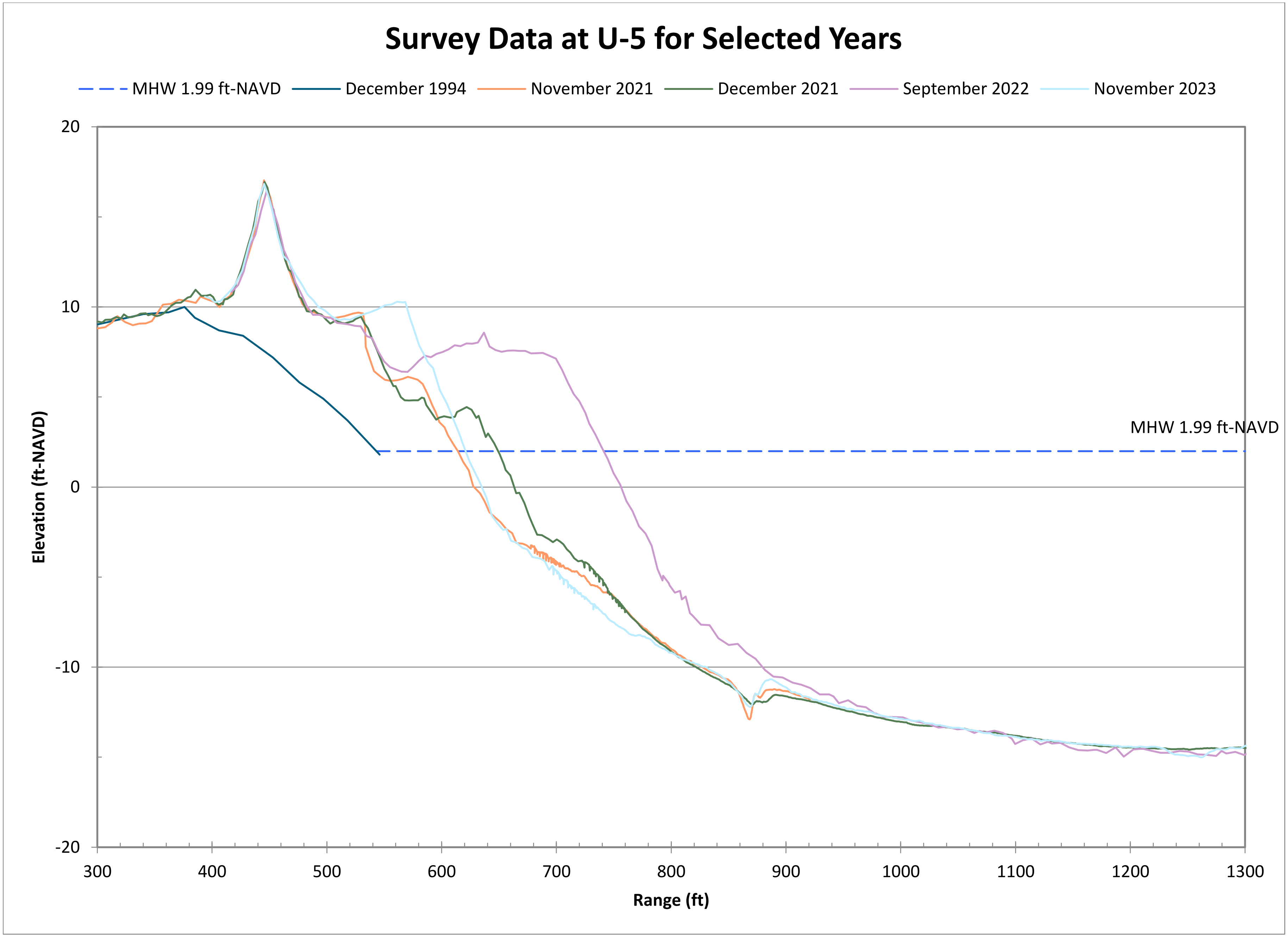
Survey Data at U-30 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
-30
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
0
500
1000
1500
2000
2500
3000
Range (ft)


Survey Data at U-1 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
Range (ft)

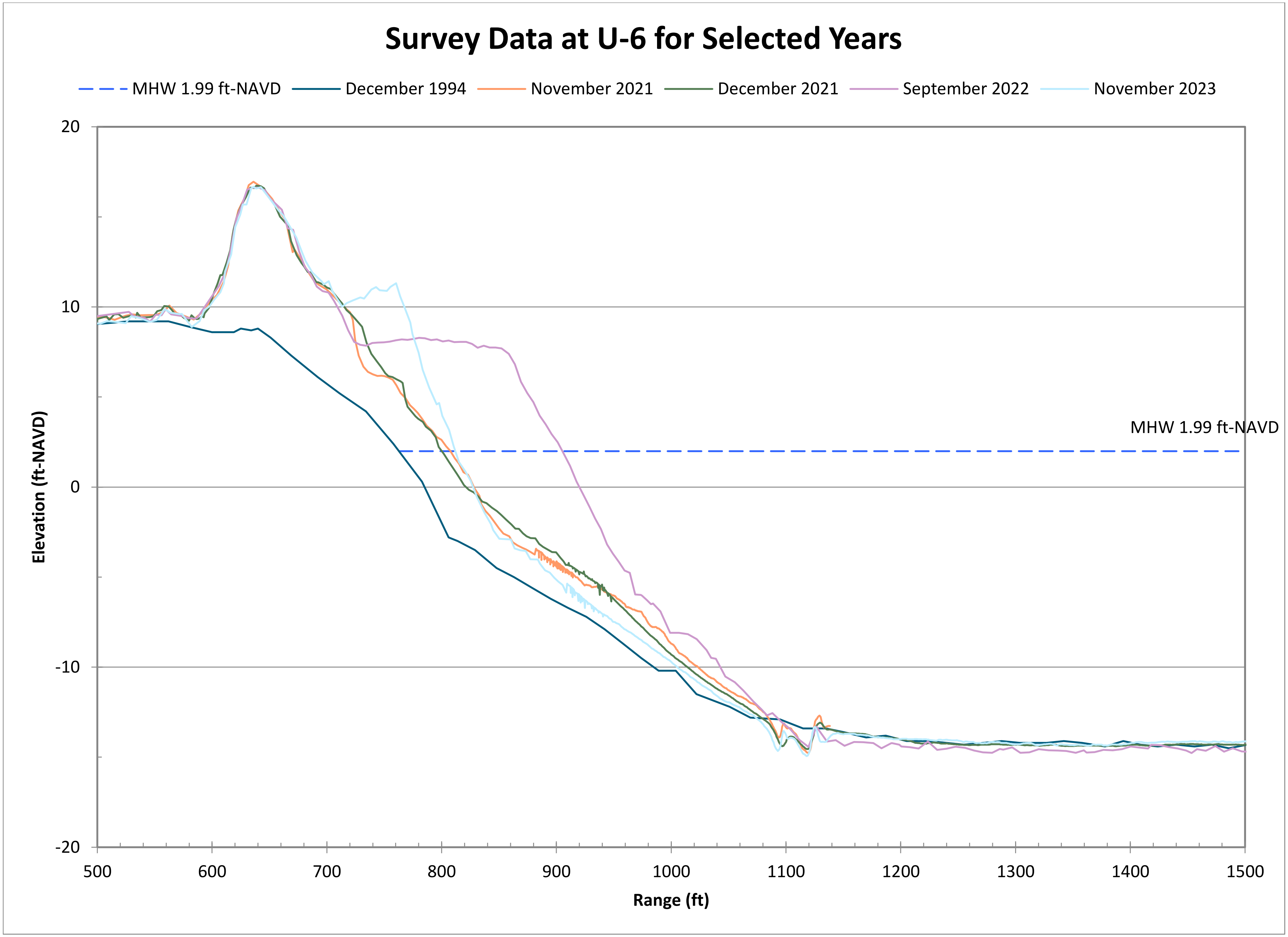


Survey Data at U-3 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
300
400
500
600
700
800
900
1000
1100
1200
1300
Range (ft)

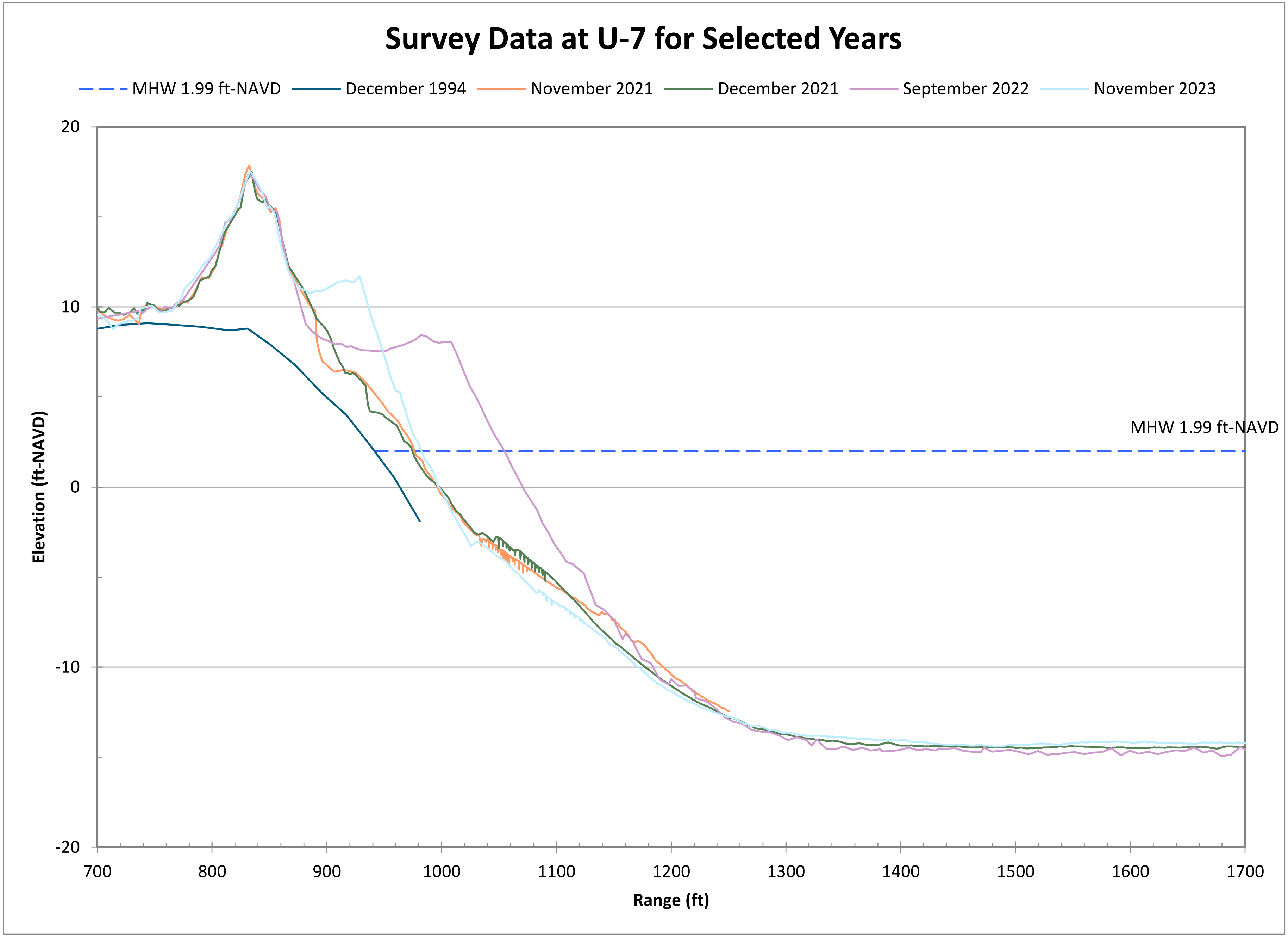

Survey Data at U-4 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
Elevation (ft-NAVD)
20
10
0
-10
-20
MHW 1.99 ft-NAVD
300
400
500
600
700
800
900
1000
1100
1200
1300
Range (ft)



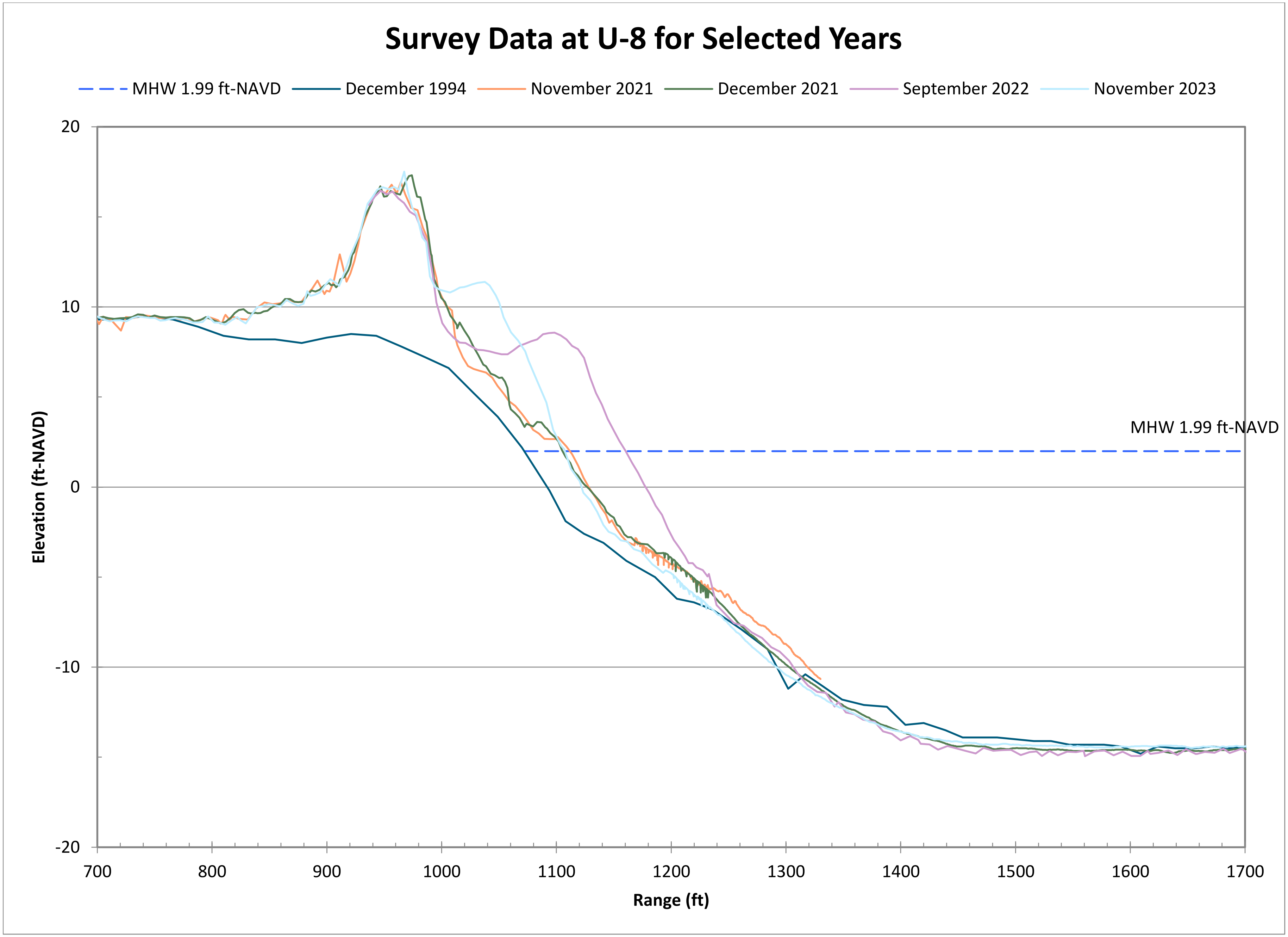
Survey Data at U-5 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
300
400
500
600
700
800
900
1000
1100
1200
1300
Range (ft)

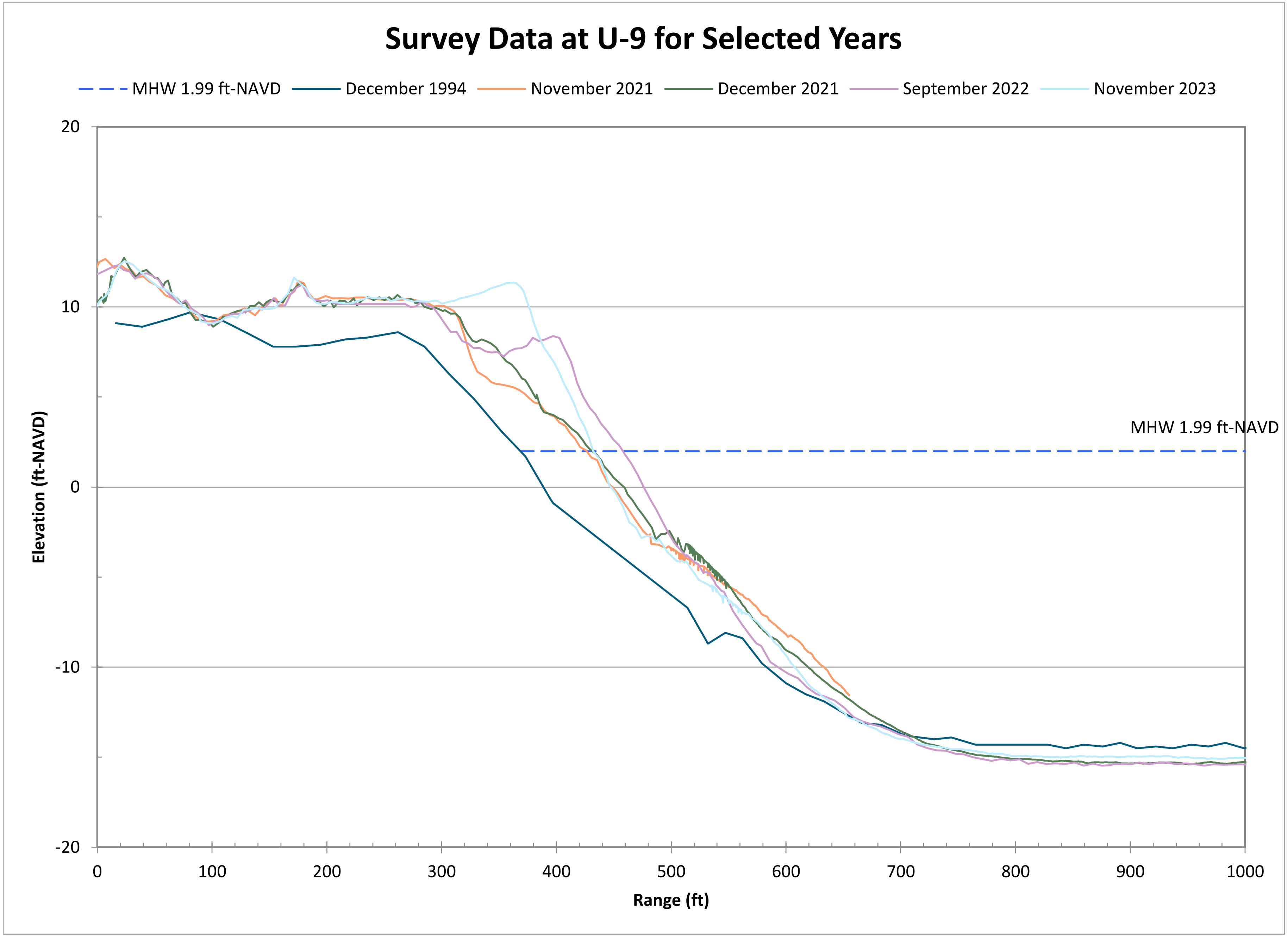


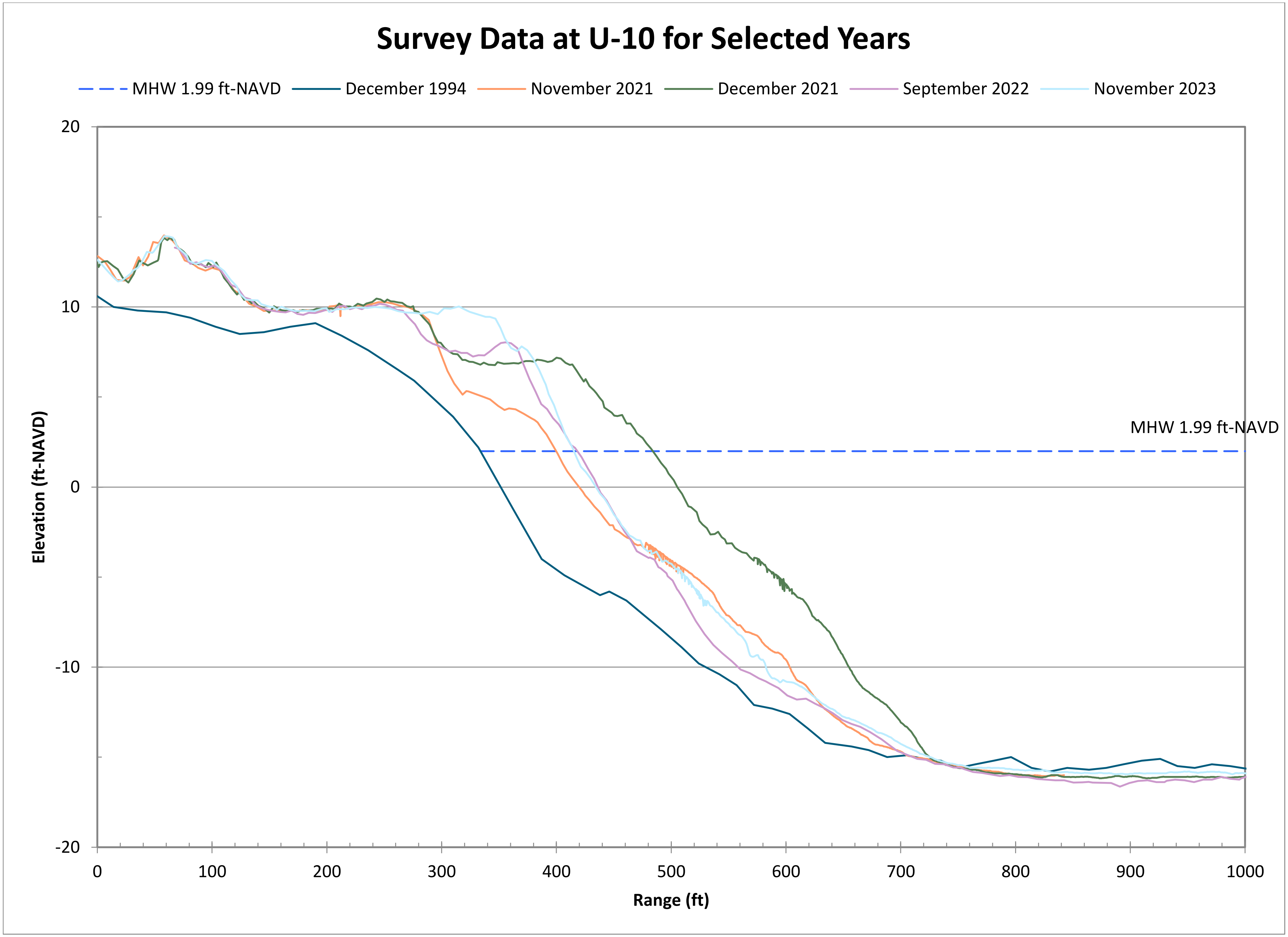
Survey Data at U-6 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
500
600
700
800
900
1000
1100
1200
1300
1400
1500
Range (ft)



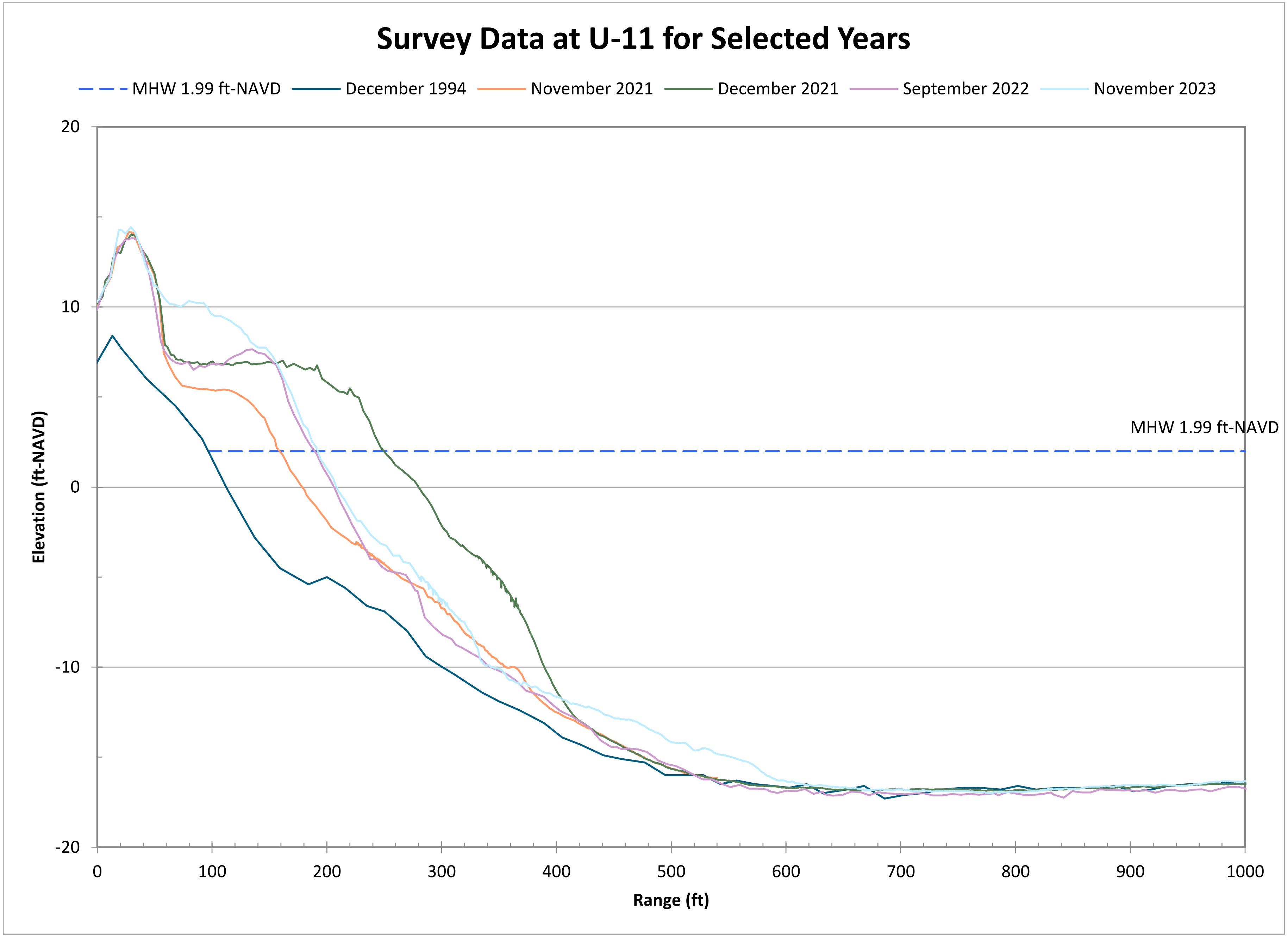
Survey Data at U-7 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
Range (ft)

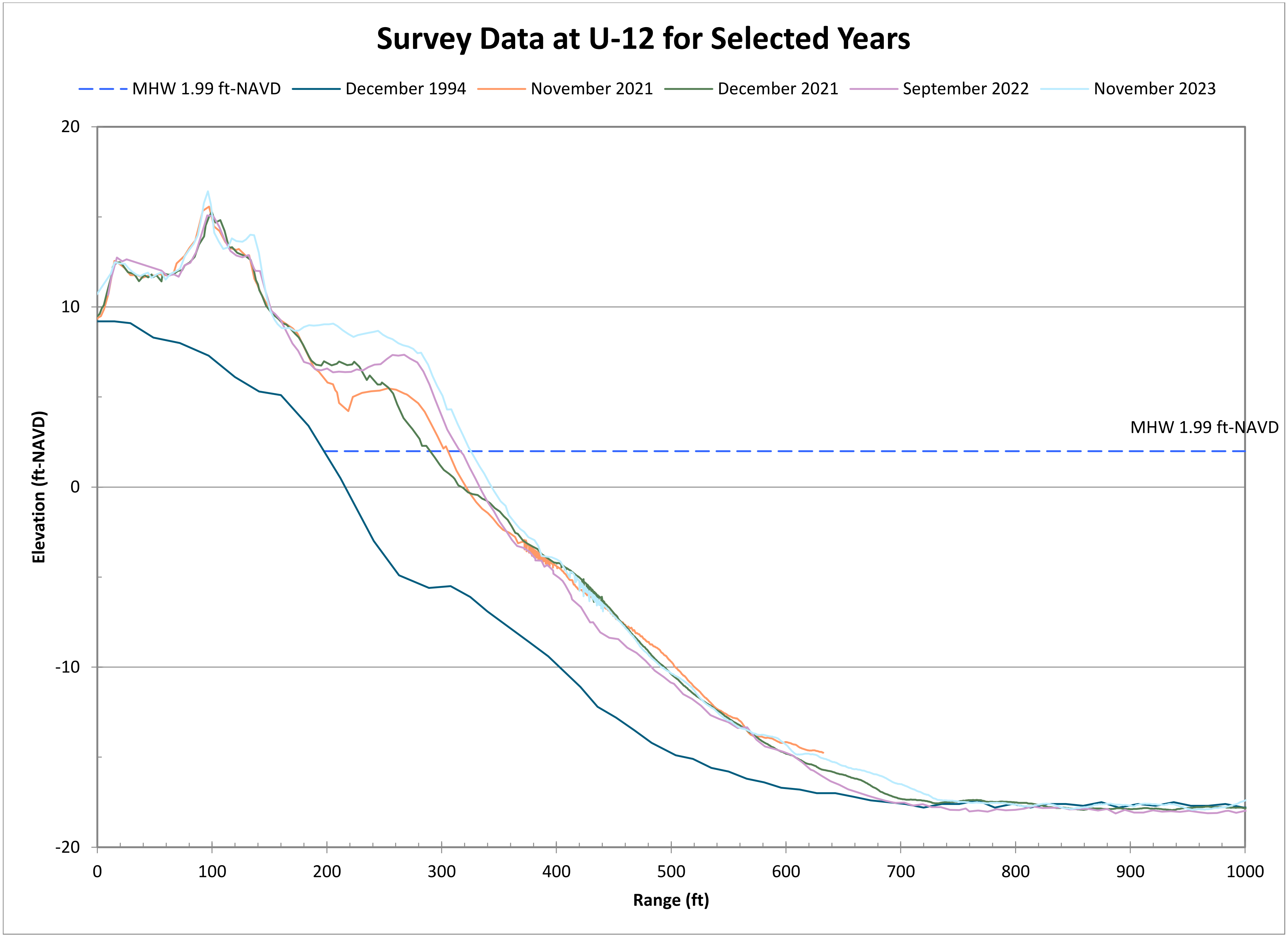

Survey Data at U-8 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
Range (ft)
MHW 1.99 ft-NAVD


Survey Data at U-9 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)

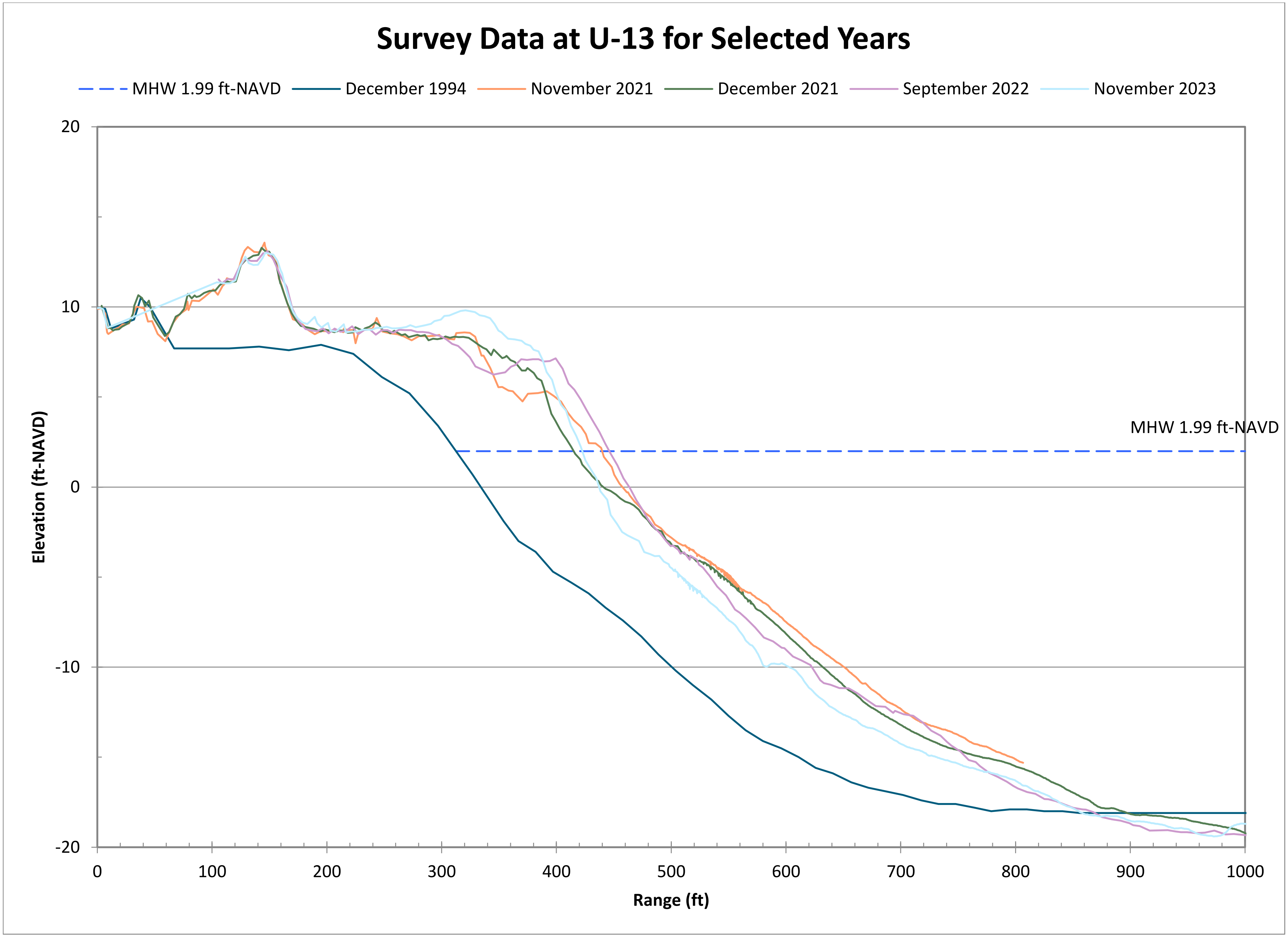


Survey Data at U-10 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)
MHW 1.99 ft-NAVD

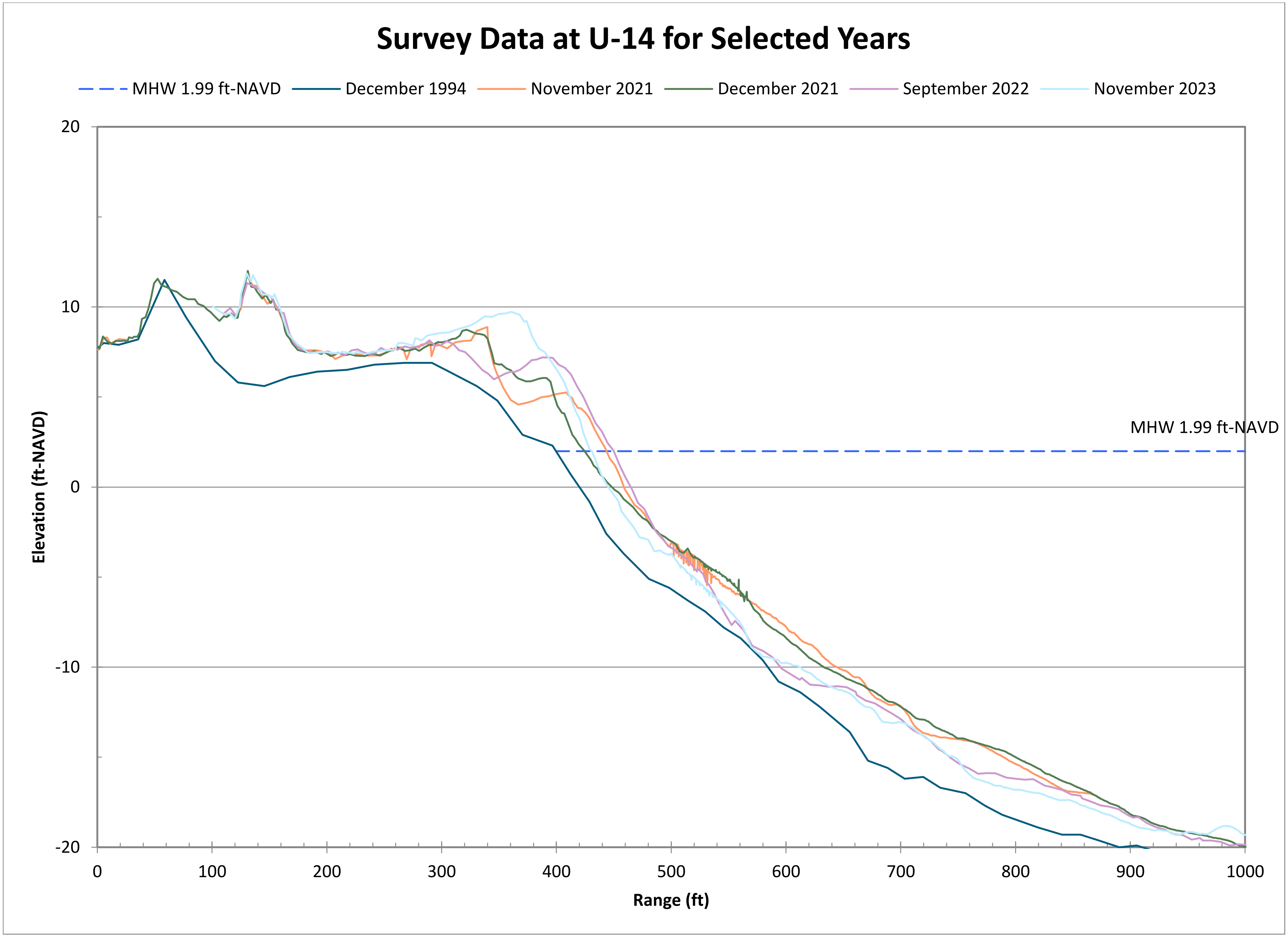

Survey Data at U-11 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
Elevation (ft-NAVD)
20
10
0
-10
-20
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)

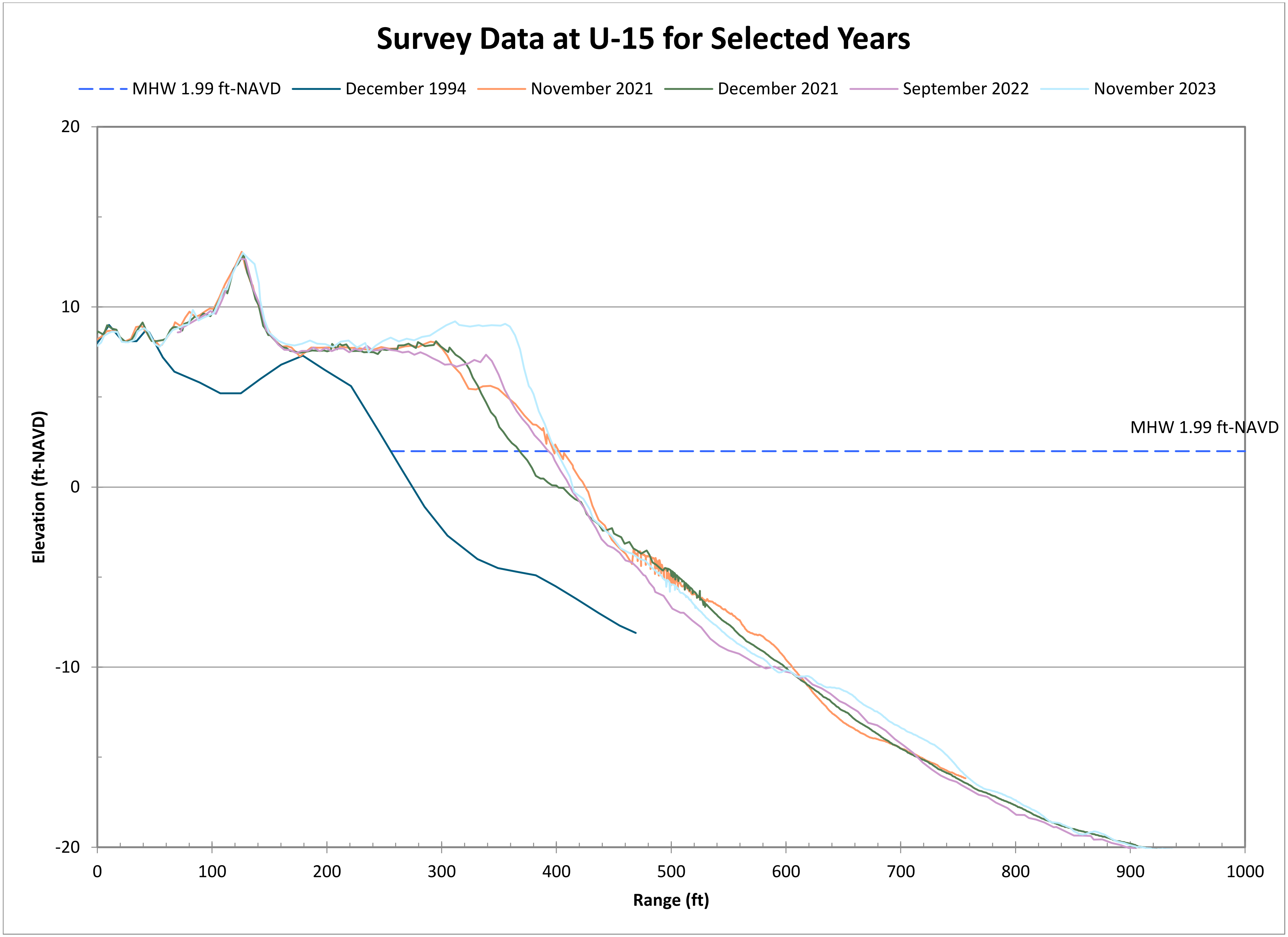


Survey Data at U-12 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)

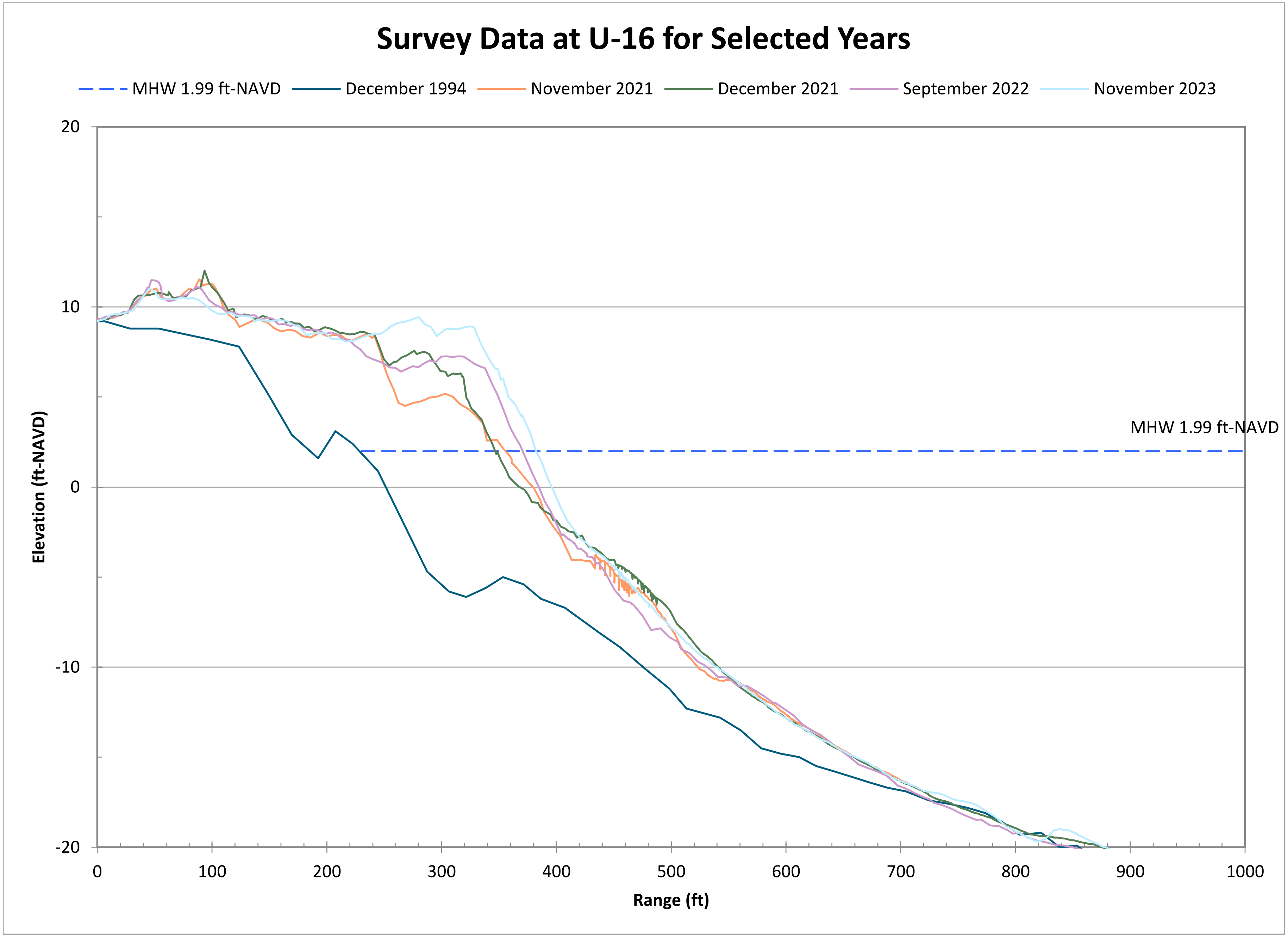


Survey Data at U-13 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
Elevation (ft-NAVD)
Range (ft)
MHW 1.99 ft-NAVD
20
10
0
-10
-20
0
100
200
300
400
500
600
700
800
900
1000

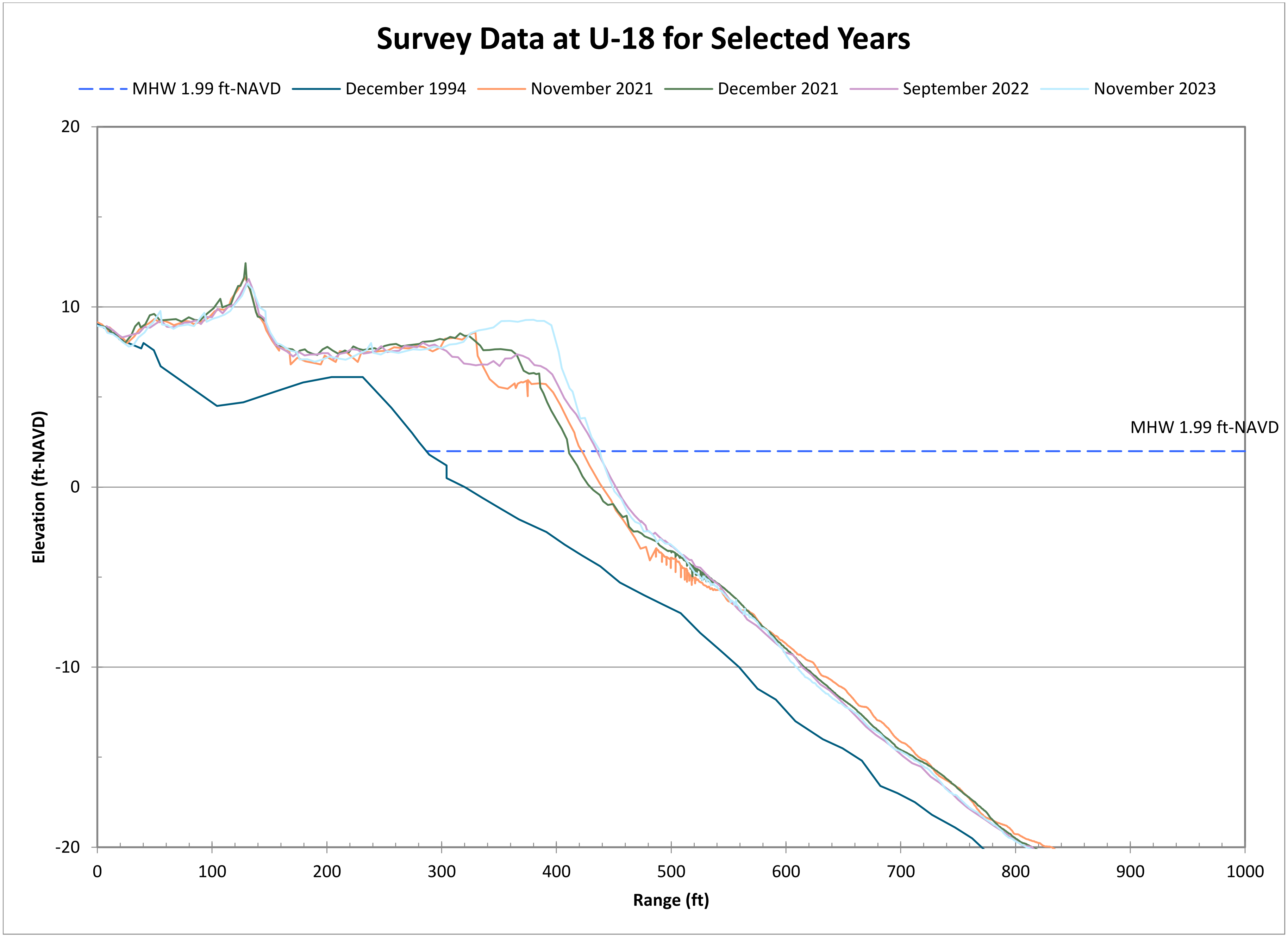

Survey Data at U-14 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
Elevation (ft-NAVD)
20
10
0
-10
-20
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)



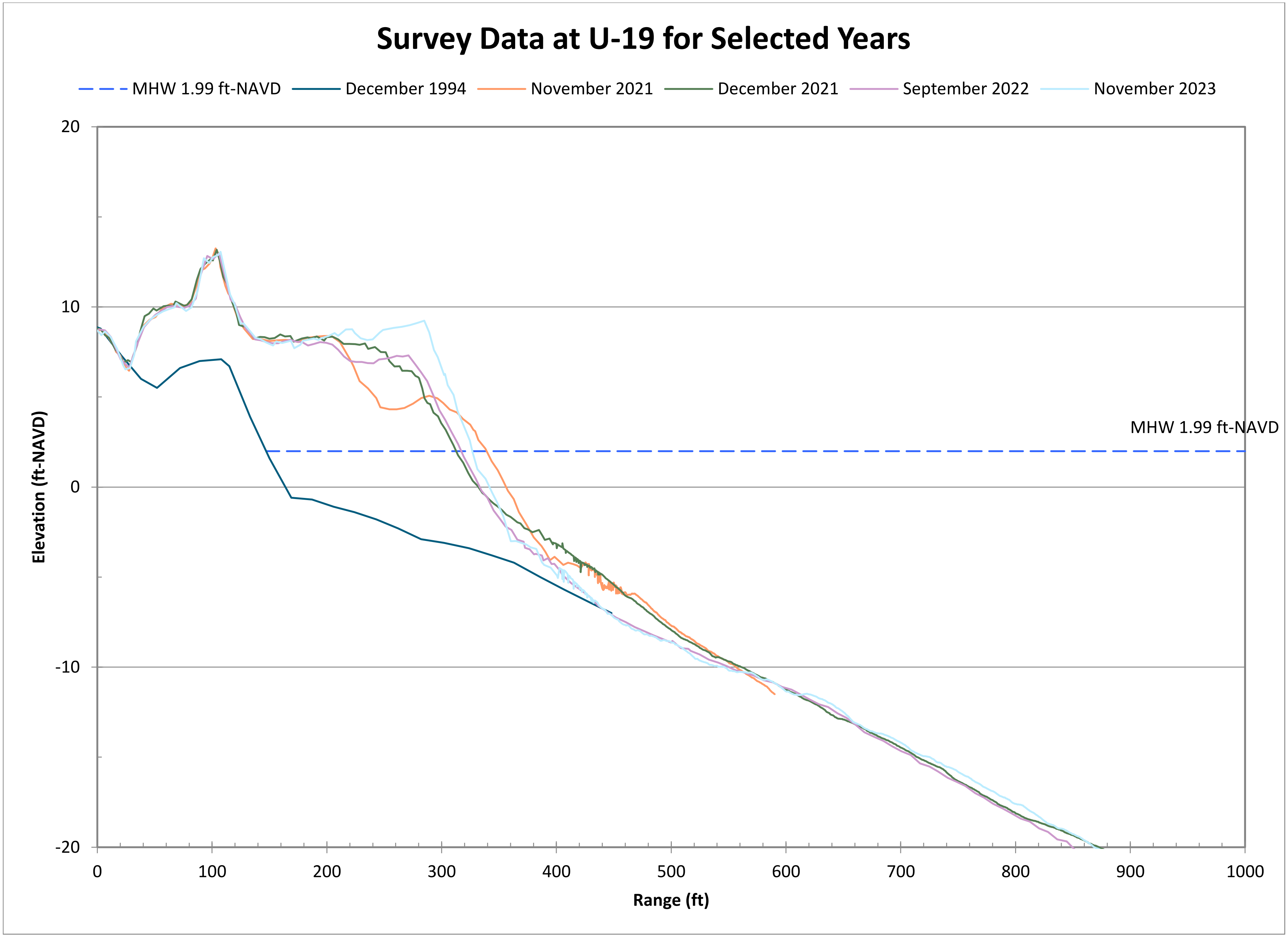
Survey Data at U-15 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
MHW 1.99 ft-NAVD
Elevation (ft-NAVD)
Range (ft)
20
10
0
-10
-20
0
100
200
300
400
500
600
700
800
900
1000



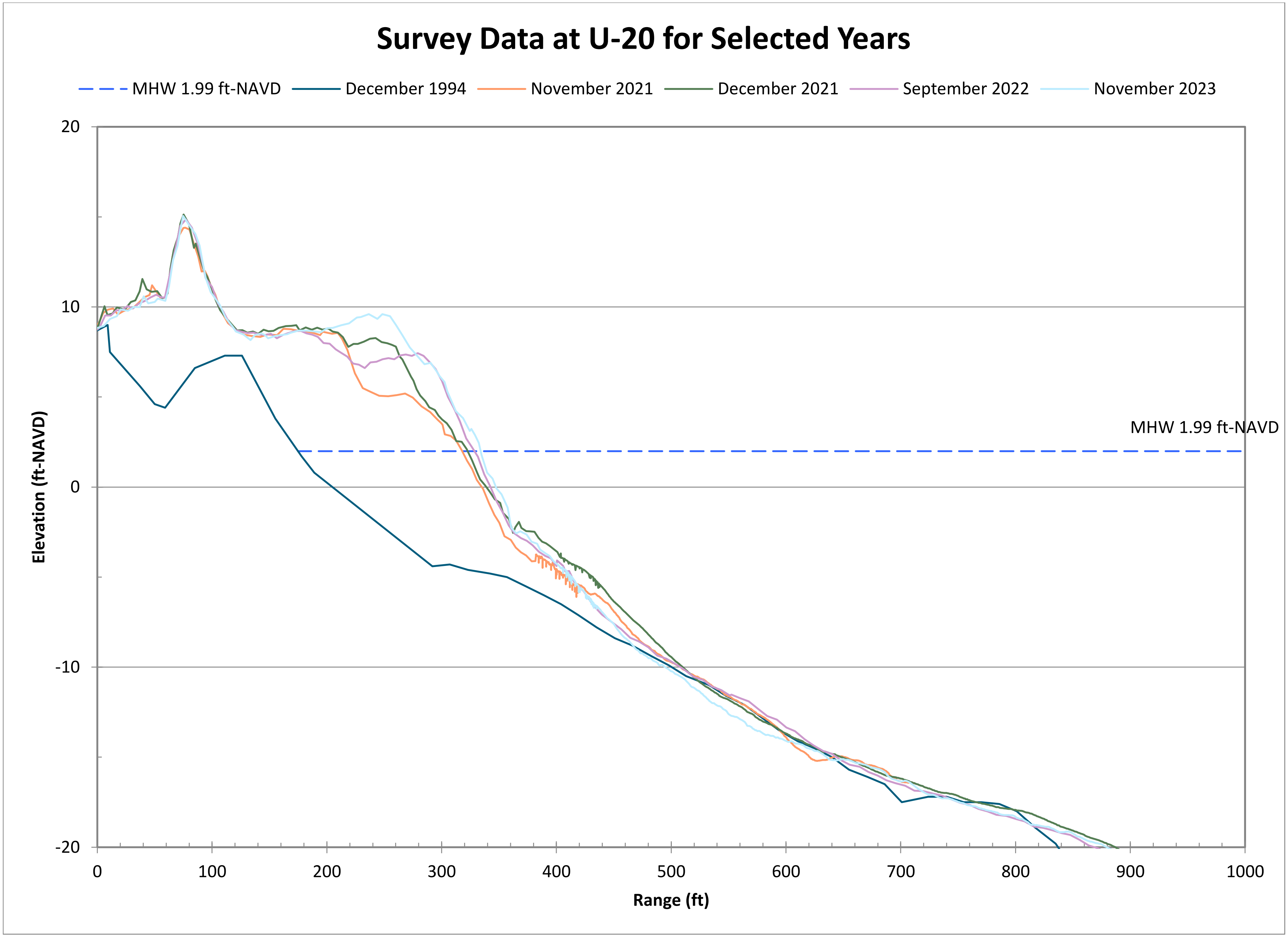
Survey Data at U-16 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)

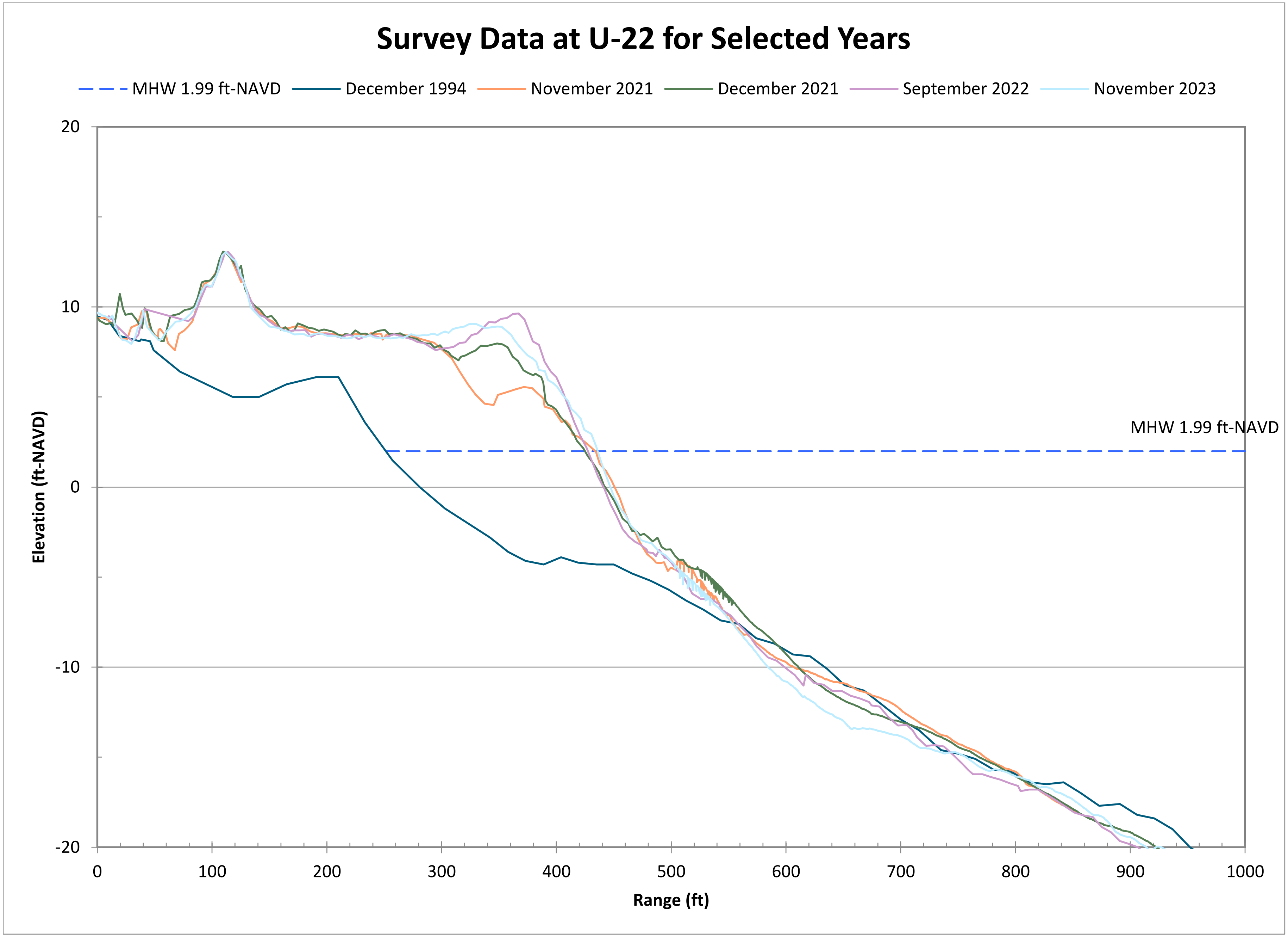


Survey Data at U-18 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
Elevation (ft-NAVD)
20
10
0
-10
-20
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)

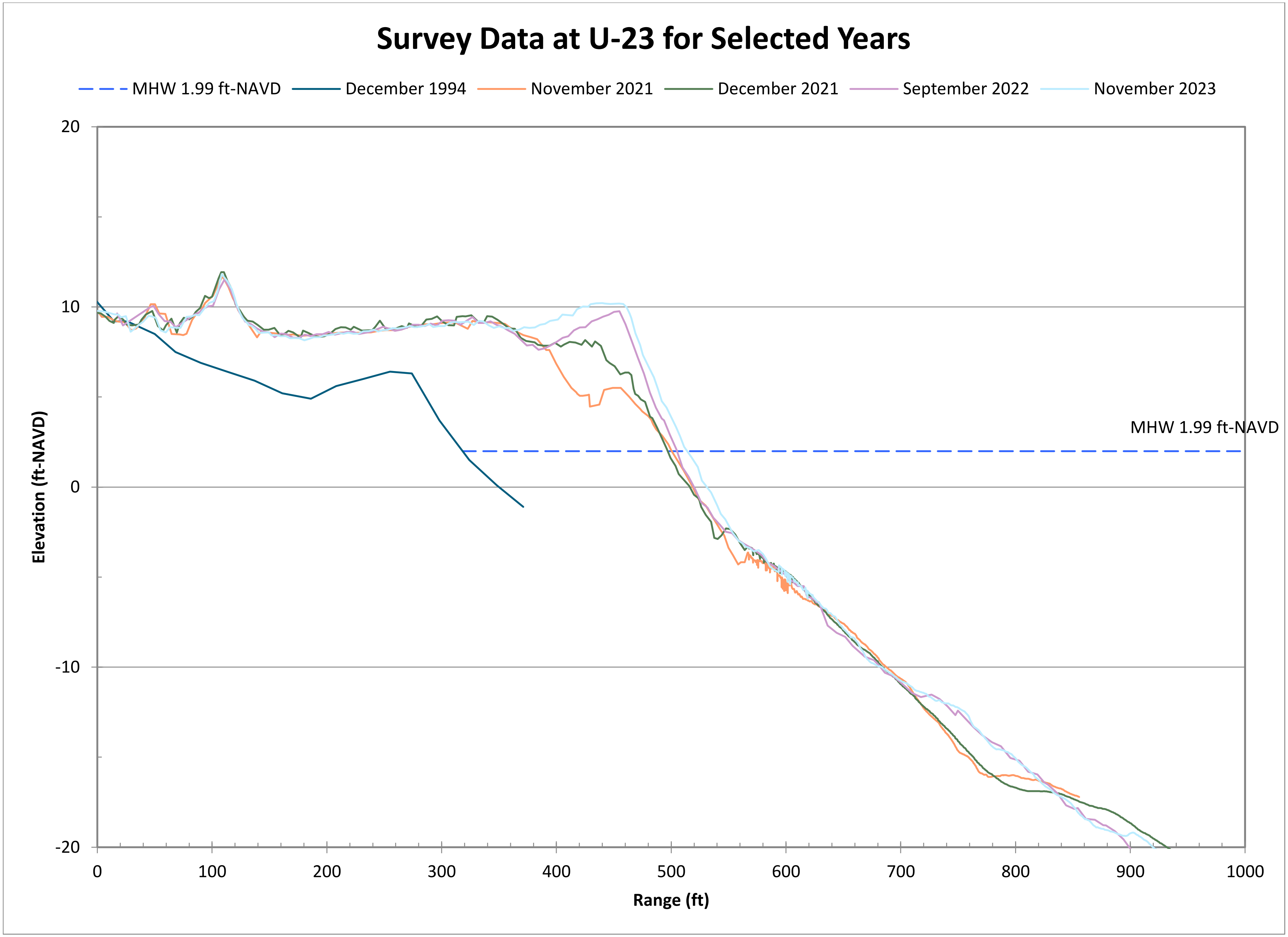


Survey Data at U-19 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)

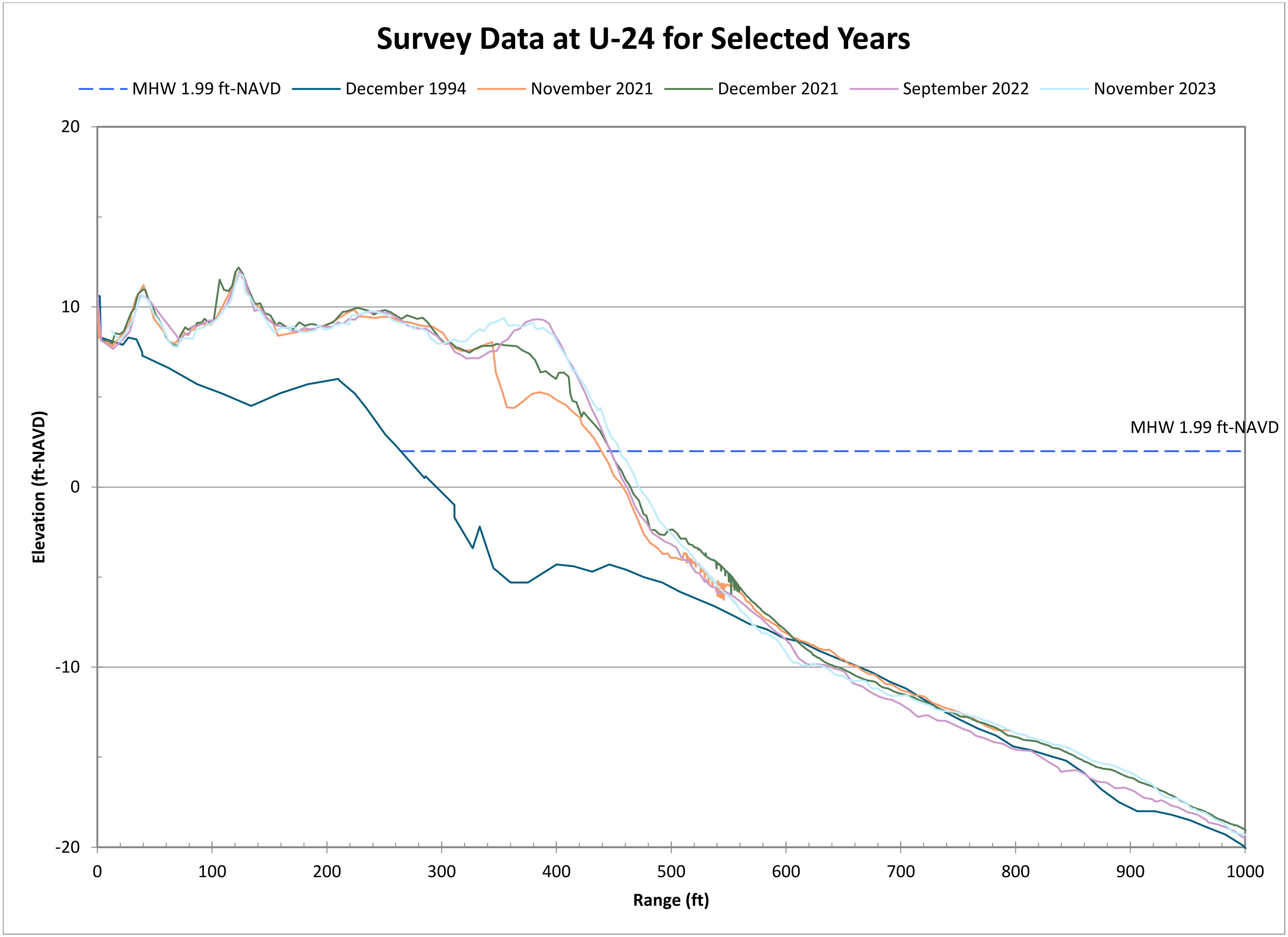

Survey Data at U-20 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)

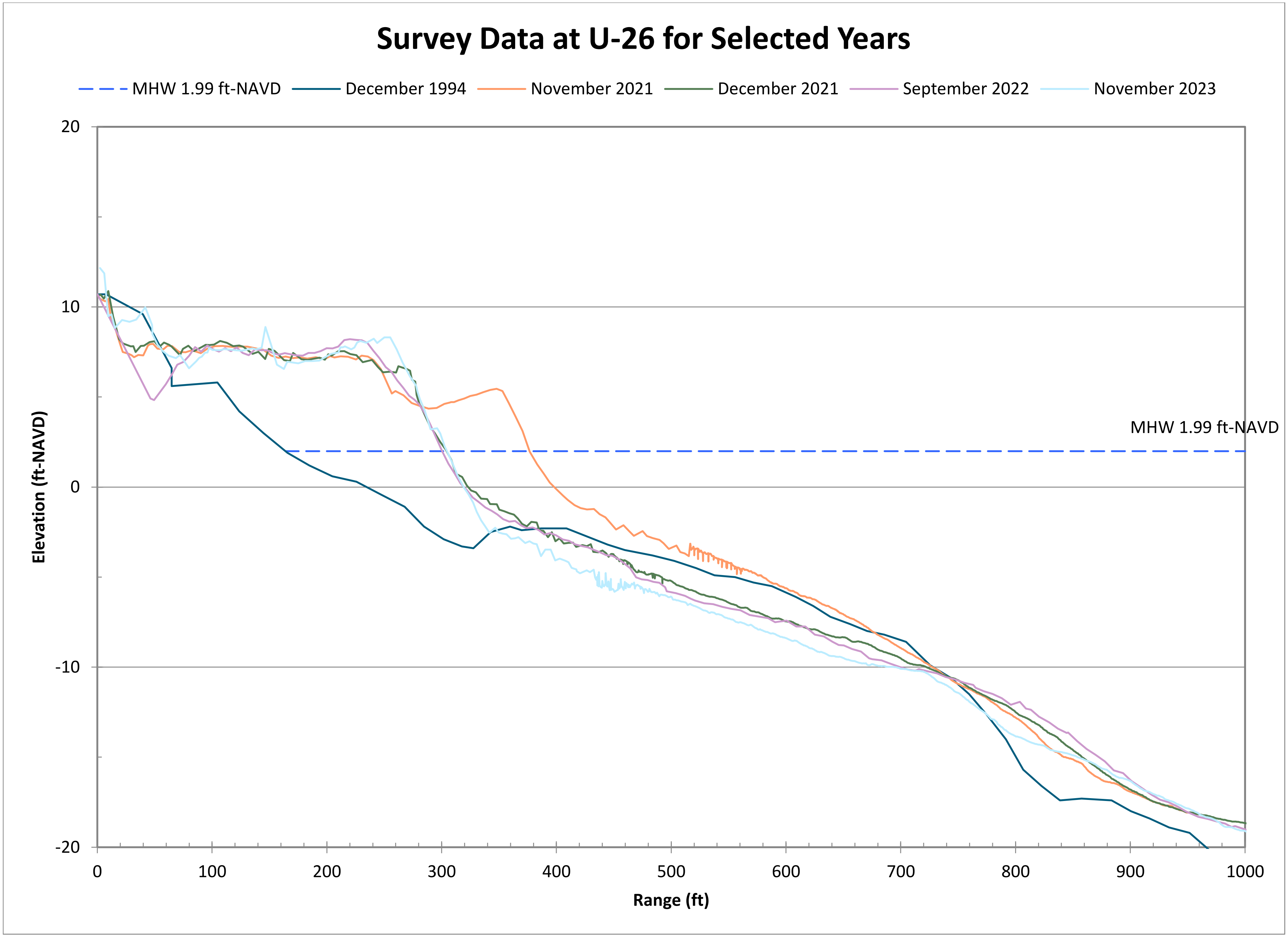


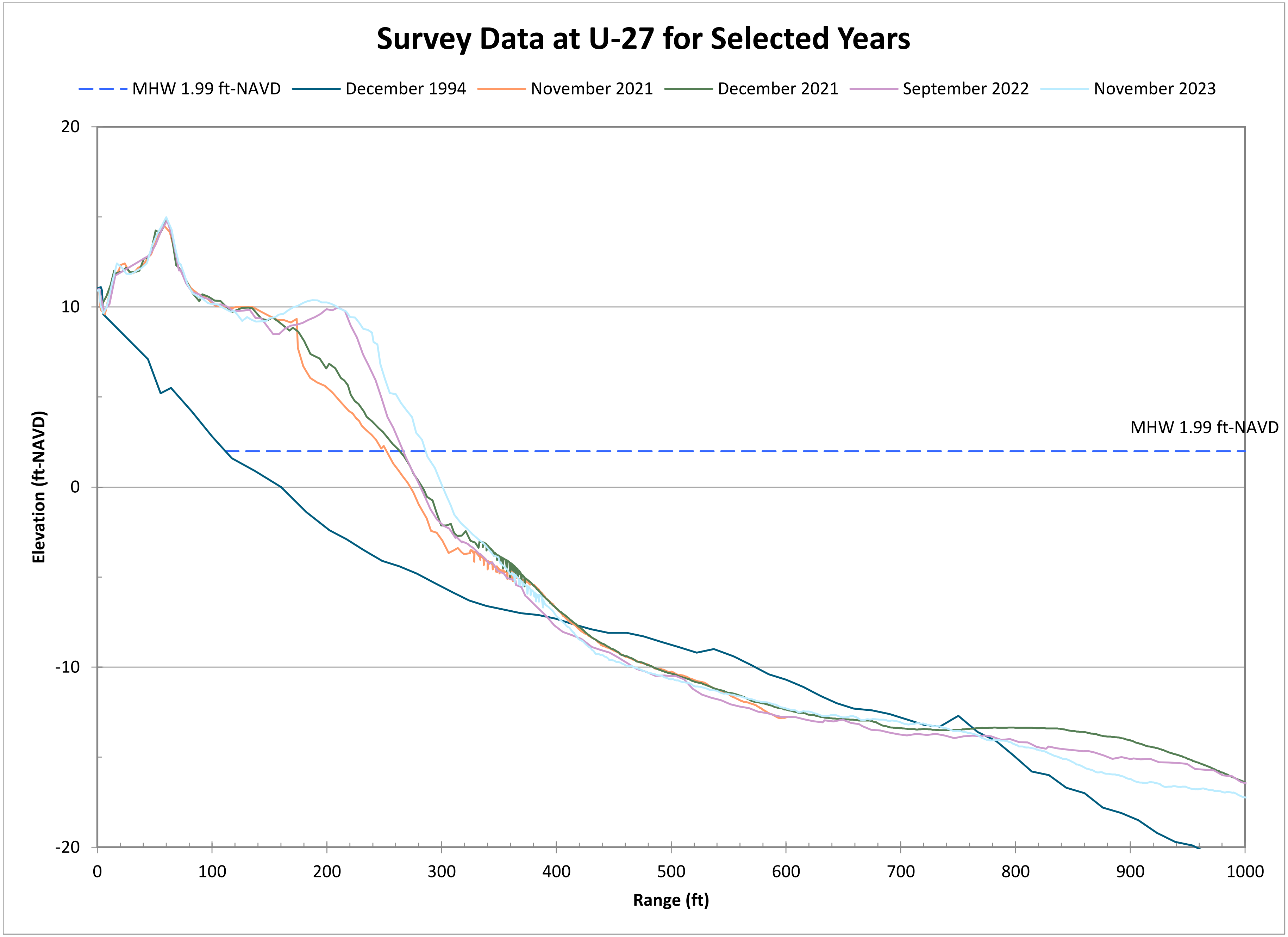
Survey Data at U-22 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)

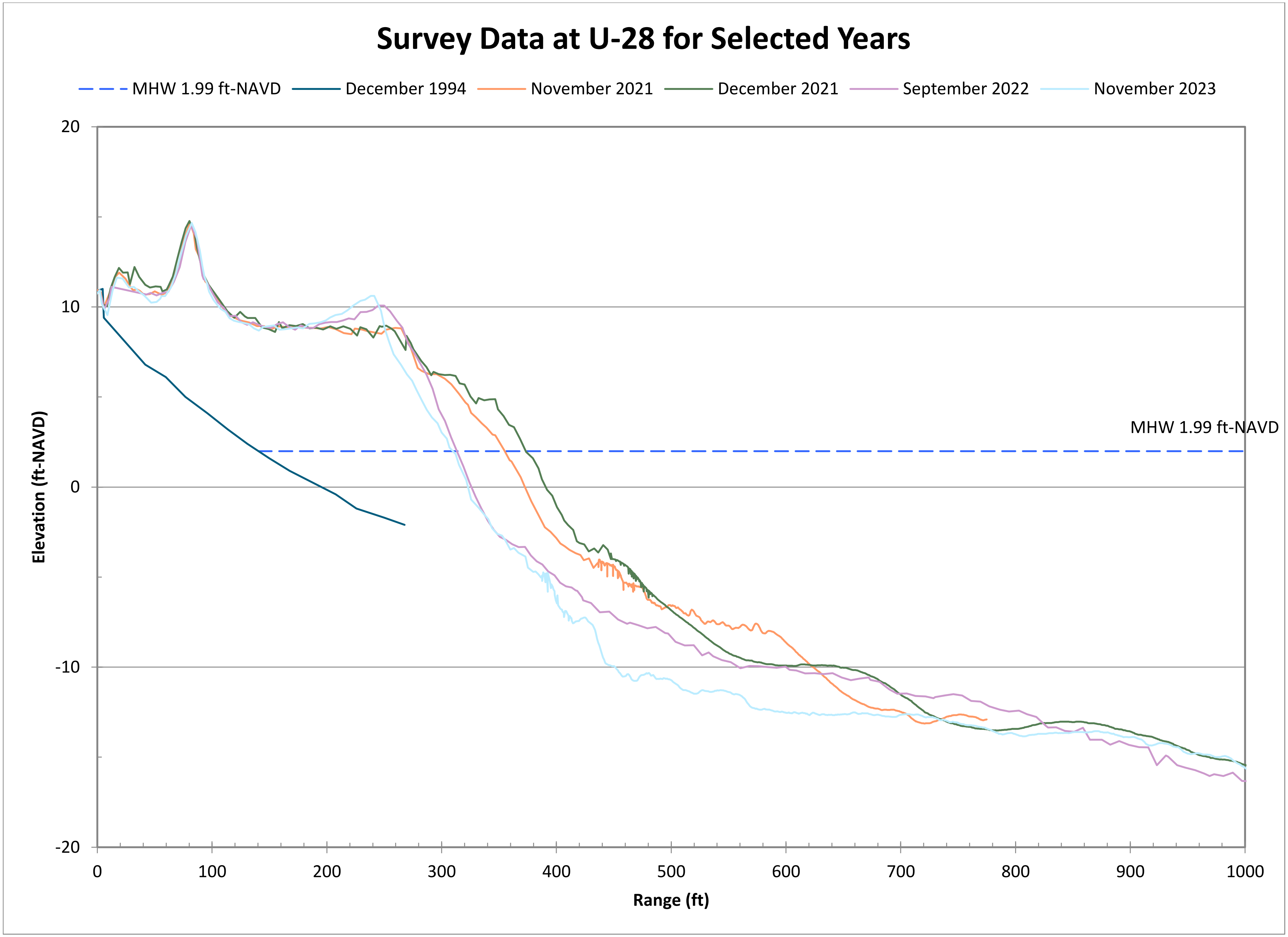


Survey Data at U-23 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)

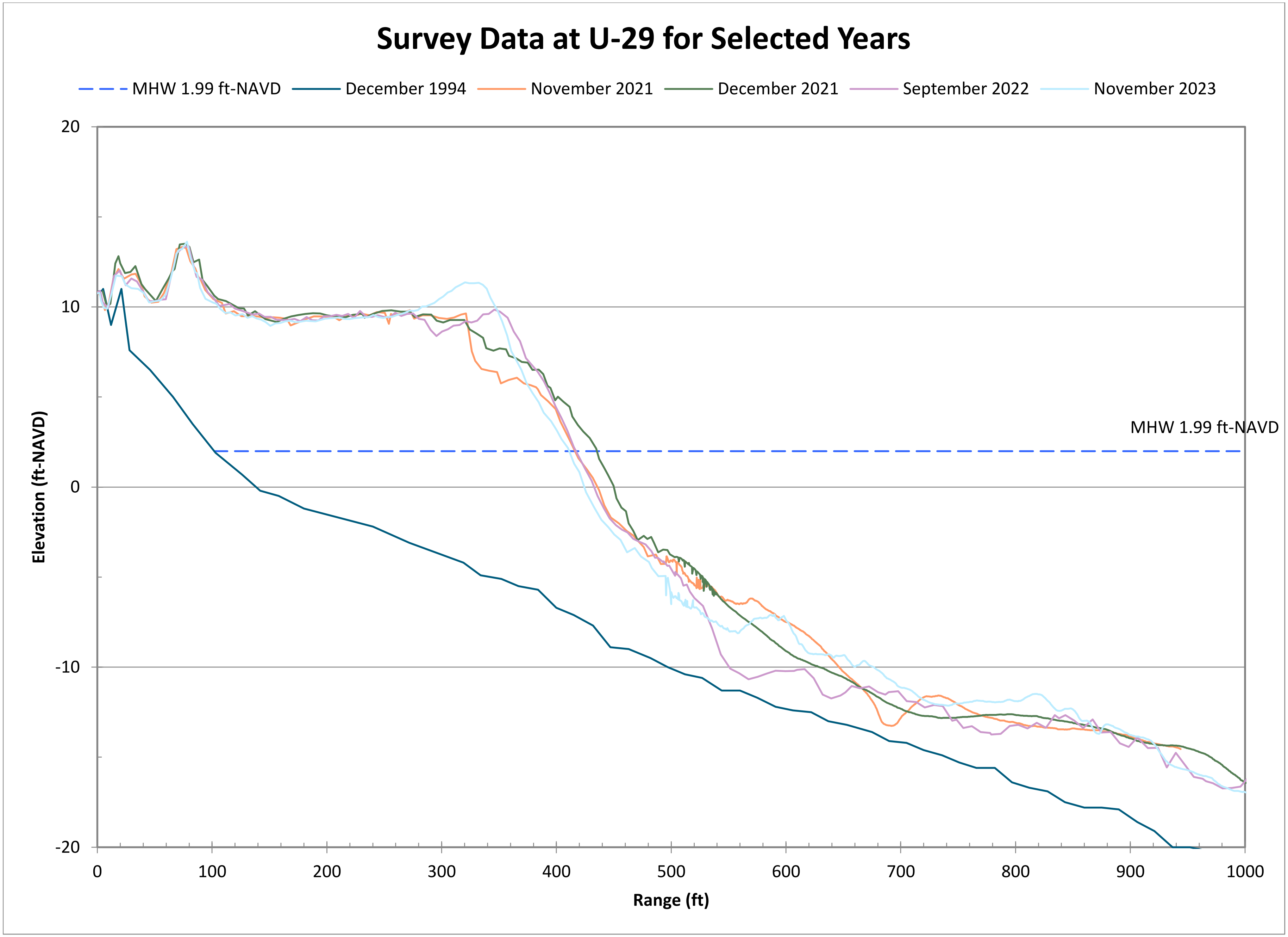

Survey Data at U-24 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)


Survey Data at U-26 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)

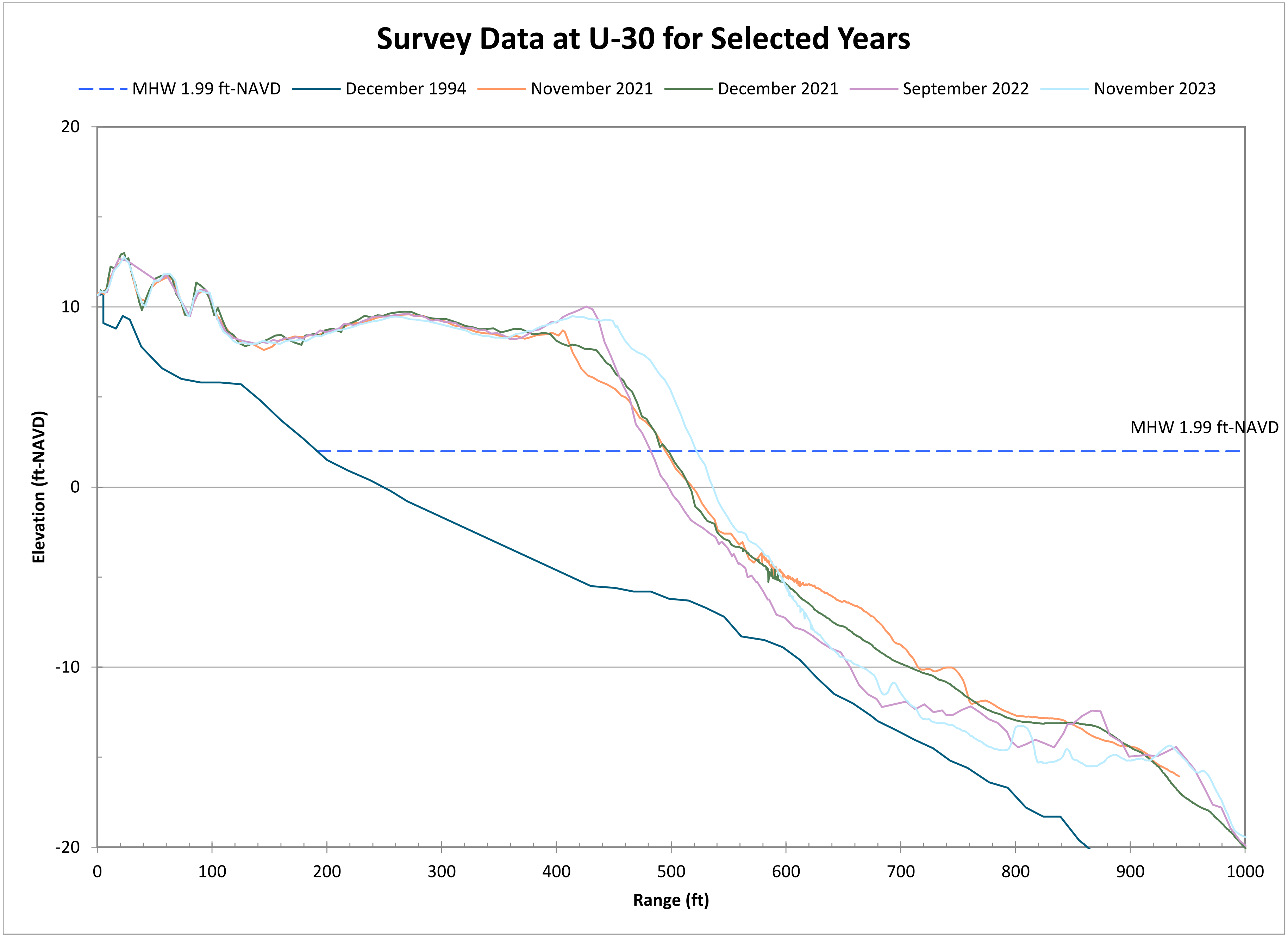

Survey Data at U-27 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
Elevation (ft-NAVD)
Range (ft)
MHW 1.99 ft-NAVD
20
10
0
-10
-20
0
100
200
300
400
500
600
700
800
900
1000



Survey Data at U-28 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)



Survey Data at U-29 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
20
10
0
-10
-20
Elevation (ft-NAVD)
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)


Survey Data at U-30 for Selected Years
MHW 1.99 ft-NAVD
December 1994
November 2021
December 2021
September 2022
November 2023
Elevation (ft-NAVD)
20
10
0
-10
-20
MHW 1.99 ft-NAVD
0
100
200
300
400
500
600
700
800
900
1000
Range (ft)