APPENDIX G

Engineering Documentation Report
EDR-OD-01

US Army Corps of Engineers ®
New Orleans District

Engineering Documentation Report

EDR-OD-01

MLG to MLLW Vertical Datum Conversion

Mississippi River
Venice, Louisiana to the Gulf of Mexico
(Vicinity of Southwest Pass)

Louisiana

Prepared by:
US Army Corps of Engineers
New Orleans District
Engineering Division
Prepared by: CEMVN-ED-ST
Reviewed by: CEMVN-OD

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Appendix A- Independent Technical Review (ATR) Certification

LIST OF ACRONYMS

- AHP: Above Head of Passes
- BHP: Below Head of Passes
- CEPD: Comprehensive Evaluation of Project Datums
- EDR: Engineering Documentation Report
- HQ: Headquarters office of the United States Army Corps of Engineers
- IPET: Interagency Performance Evaluation Task Force
- LCA: Local Cooperation Agreement
- LWRP: Low Water Reference Plane
- MLG: Mean Low Gulf datum, as a historic reference
- MLG^{SWP}: In practice usage of Mean Low Gulf as localized for this project
- MLLW: Mean Lower Low Water datum
- MVN: Mississippi Valley New Orleans District
- NAVD88: North American Vertical Datum of 1988
- NOAA: National Oceanic and Atmospheric Administration
- NWLON: National Water Level Observation Network
- OPUS: Online Positioning User Service
- SWP: Mississippi River Southwest Pass
- USACE: United States Army Corps of Engineers
- USACE MVN: United States Army Corps of Engineers New Orleans District

1. Introduction

The U.S. Army Corps of Engineers, New Orleans District is converting the vertical datum for all coastal navigation projects from Mean Low Gulf (MLG) to Mean Lower Low Water (MLLW) in accordance with USACE (2014), memorandum directing conversion from USACE HQ. This memorandum describes new policy for federal navigation projects where the decision documents supporting project authorization and the project authorization in law do not reference the Mean Lower Low Water (MLLW) datum.

According to the Memorandum "Navigation Projects Compliance with Vertical Datum Guidance" dated October 24, 2014:

"For federal navigation projects where the MLLW depth differs from the depths stated in the project authorization, an Engineering Documentation Report (EDR) shall be prepared in accordance with reference 1.d, paragraph 8.3 for each project and posted on a navigation home page for each district. The EDR will be of limited scope to document the datum change only."

The Mississippi River, Baton Rouge to the Gulf of Mexico project is currently authorized to (-)55 ft. MLG and maintained to (-)45 ft. MLG, respectively. Currently, the deep draft navigation channel is maintained as follows: New Orleans to the Gulf of Mexico (includes Southwest Pass) is maintained to (-)45 ft. MLG and New Orleans to Baton Rouge (includes Deep Draft Crossings) is maintained to (-)45 ft. LWRP.

This report documents the calibration / relationship between the localized MLG as used in practice for this project and the NOAA-maintained MLLW that provides for no impact in current project channel maintenance practices. The report provides details on how this relationship was determined and will be applied. For ease of use this relationship will be used south of river mile 13.4 AHP and continuing down Southwest Pass (SWP), as this is the area covered by maintenance dredging. This area will be referred to as "Southwest Pass or SWP" in this EDR and the localized, in practice, use of MLG will be referred to as MLG^{SWP}.

1.1 Definition / Description of Datums referenced in this report

The North American Vertical Datum of 1988 (NAVD88) is a geodetic datum that is defined and maintained by the National Geodetic Survey (NGS). This datum is typically used for surveying (in addition to design and construction) and can be related to other datums as needed, to ensure project datums are referenced as required.

Mean Lower Low Water (MLLW) is a tidal datum that is defined and maintained by the National Oceanic and Atmospheric Administration (NOAA). This tidal datum is defined as the average of the lowest of the two daily low water heights observed over the National Tidal Datum Epoch (which spans a 19 year period).

Mean Low Gulf (MLG) is a legacy terrestrial datum that was originally defined relative to local mean sea level as observed at the Biloxi gage in 1899 in the Gulf of Mexico. It has been used as

a navigation (and construction) reference datum in coastal waterways such as the Gulf Intracoastal Waterway (GIWW) and the coastal portion of the Mississippi River navigation channel (Reference 2). MLG was intended to represent the low water level of the Gulf of Mexico, and was defined by District memorandum in 1944 as being 0.78 feet below local mean sea level as it was understood at that time.

The origin of the 0.78 foot offset between MLG and LMSL is not known precisely; however, this value is half the tidal range at the Biloxi (Cadet Point) Tidegage (NOAA gage 8743735)[1]. Therefore, MLG as defined is equal to Mean Low Water (MLW) at Biloxi. Mean Low Water is the average of all low tides, whereas Mean Lower Low Water is the average of only the lower of the two daily low tides. The Gulf of Mexico has diurnal tides (one low tide per day), so the difference between MLW and MLLW is academic. At Biloxi, the two are approximately one-tenth of one foot apart, which is beyond the precision of either dredging or hydrographic surveying. Consequently, it seems very likely that MLG was intended to represent the average low tide condition in the Gulf of Mexico, so that a given draft in MLG would be, on average, navigable during low tide.

Mean Lower Low Water is presently 0.46 ft. below local mean sea level at Pilottown, LA, and 0.6 ft. below local mean sea level at Pilot's Station East (at the mouth of Southwest Pass).[2] Therefore, in theory, MLG and MLLW are essentially equal as they are within 0.2 - 0.4 ft, as related to MSL.

The intent and application of MLLW and MLG were and are, also in theory, defined to represent the same water condition; as a tidal datum of a lowest daily water level that will be typically observed for that location.

However, MLG was and is not currently maintained under the rigors to be viable as a current tidal datum. Its update is not under the auspices of any agency or authority. In practice, it has become a localized reference, or in this case, a series of local staff gages referenced with MLG, and in this report, the localized reference is referred to in this document as MLG^{SWP}. Alternatively, MLG^{SWP} represents the use of MLG, in practice. This report is not defining a new datum or new epoch to MLG via ^{SWP} superscript.

1.2 Gaging Network Usage along Southwest Pass

The Survey Section Stream Gaging Unit (SGU) has maintained a series of gages along Southwest Pass, which were set and maintained to NGVD29. For ease of use another series of gages were set to the MLG datum by applying the commonly used 0.78 ft. offset. Over the years the SGU gages were surveyed and moved as necessary to allow them to properly reference NGVD29. The MLG gages were not moved as necessary in order to maintain the 0.78 ft offsets.

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[1] The published tidal datums can be found on NOAA's webpage for each gaging station.
Biloxi (Cadet Point): https://tidesandcurrents.noaa.gov/datums.html?id=8743735
[2] Pilottown: https://tidesandcurrents.noaa.gov/datums.html?id=8760922
Pilot's Station East: https://tidesandcurrents.noaa.gov/datums.html?id=8760721 .

This offset was always referenced back to the NGVD29, 1976 epoch. It is unknown why this particular epoch was chosen or why an epoch was chosen at all. This practice essentially disassociated MLG with the local water surface which made it inappropriate for use in navigation.

In 2009 surveys were performed as part of the Comprehensive Evaluation of Project Datums (CEPD) effort to establish the relationship between MLG, MLLW, and NAVD88 for this area. This required surveying the SGU gages, the MLG gages, and NOAA gages in the vicinity. The datum relationships were defined and were documented via the CEPD reporting database. In 2013, NGS published an update to NAVD88 (the 2009.55 epoch) and a new geoid model (GEOID12A). These updates significantly changed the resulting NAVD88 elevations in this area by greater than 1 foot, so new gage surveys were required to reestablish datum relationships on both sets of gages.

In 2014 and 2015, several surveys were performed to update the datum relationships (MLG, MLLW, NAVD88), which again required surveying the SGU gages, the MLG gages, and the NOAA gages. These surveys resulted in revised datum relationships. SGU recommended and established consensus for resetting the SGU gages to NAVD88, removing the MLG gages and maintaining the local MLG references by establishing offset values to the SGU gages.

In 2015, the SGU gages and the MLG gages along South West Pass were removed and the current six SGU gages were set to the most up to date NAVD88 reference, NAVD88 (2009.55) (See Map 2). MLG and MLLW offset values were determined for each gage and were supplied for use on the navigation project. These references are currently included in the Southwest Pass navigation specifications to define MLG for this contract area.

2. Pertinent Data

Physical Features	Mississippi River, Venice, Louisiana to the Gulf of Mexico (Vicinity of Southwest Pass), Louisiana
Project Purpose	For federal navigation projects where the MLLW depth differs from the depths stated in the project authorization, an Engineering Documentation Report (EDR) shall be prepared and posted on a navigation home page for each district (memo "Navigation Projects Compliance with Vertical Datum Guidance", dated October 24, 2014).
MLG^{SWP} to MLLW conversion	0' MLG^{SWP} = 3.5 ft. below MLLW
Controlling elevations	NA
Project Cost	NA
Benefit-to-cost ratio	NA

3. Project Authorization

This project was authorized as follows:

"The project was authorized by the Supplement Appropriation Act of 1985, (Public Law 99-88 dated 15 August 1985). The Water Resources Development Act (WRDA) of 1986, (Public Law 99-662) provides for innovative cost sharing between the Federal Government and non-Federal interests for construction and maintenance of the project." (References 3 and 9).

PROJECT:

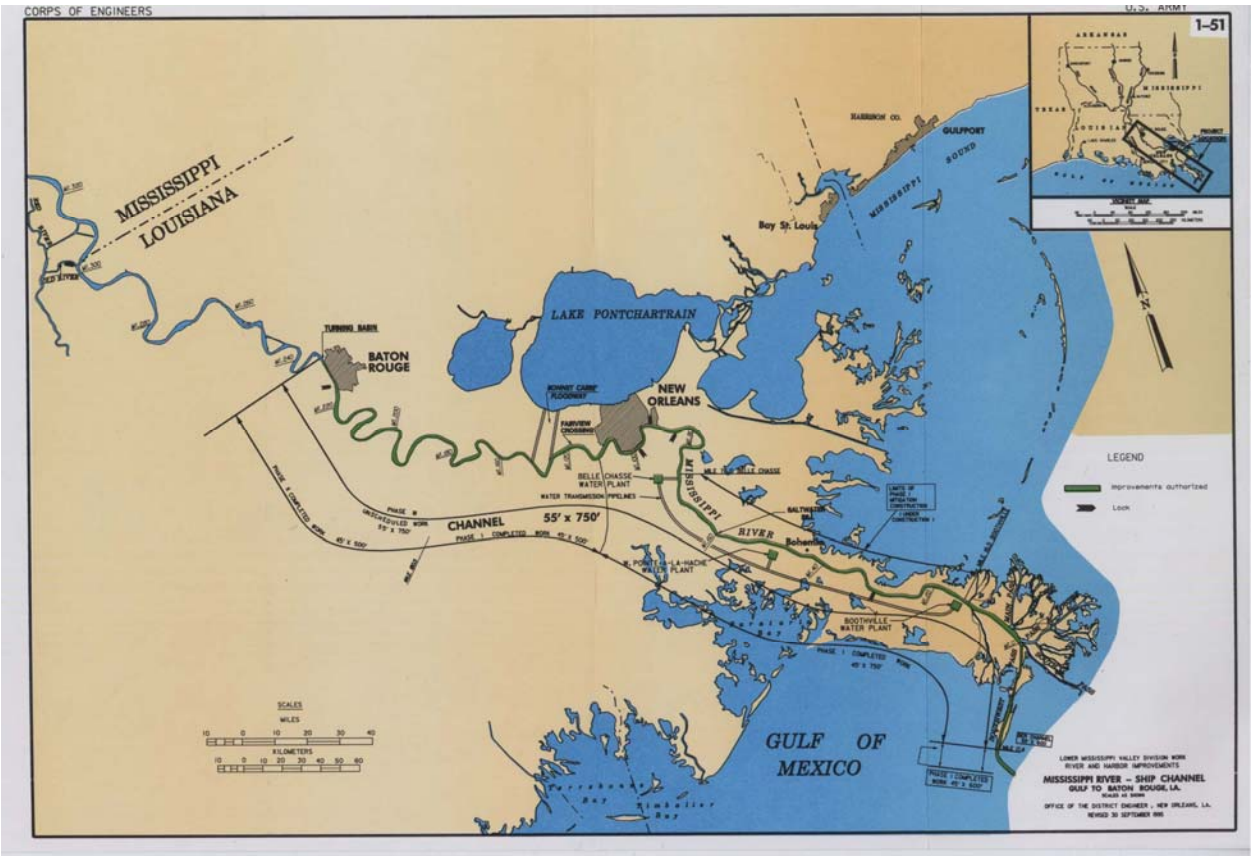
"The Mississippi River Ship Channel, Gulf to Baton Rouge, La., project will provide more efficient deep draft navigation access to the New Orleans and Baton Rouge reaches of the Mississippi River via Southwest Pass by enlarging the existing channel to a project depth of 55 feet, enlarging the adjacent channel along the left descending bank in New Orleans Harbor to a 40 foot depth, constructing a turning basin at Baton Rouge, constructing training works in the passes to reduce maintenance dredging and constructing saltwater intrusion mitigation features which are required as a result of deepening the channel." (References 3 and 9).

LOCAL COOPERATION:

The Louisiana Department of Transportation and Development (LaDOTD) is the non-Federal sponsor for this project. Local Cooperation Agreements (LCA) between the Government and the State of Louisiana were executed for each phase constructed.

CURRENT DEPTH:

The SWP portion of the project is currently maintained to (-) 45 ft. MLG^{SWP} (Reference 9).



MAP 1- Mississippi River- Ship Channel, Gulf to Baton Rouge, LA, revised 30 September 1995.

4. Previous Investigations

USACE HQ issued guidance in April 2007[3] mandating that all districts perform an assessment called CEPD, to ensure projects are referenced to the proper nationally recognized vertical datums. The guidance implemented the lessons learned from the Interagency Performance Evaluation Task Force (IPET) study conducted after Hurricane Katrina. This guidance specified that all flood risk management, hurricane risk management, shore protection, and navigation projects be included in this datum evaluation. This guidance and subsequent datum policy outlined the requirement for coastal navigation projects to be defined relative to the National Water Level Observation Network (NWLON) tidal datum (i.e. MLLW), which must be referenced to the latest official tidal datum epoch. The datum policies also require that projects located in high subsidence areas be reevaluated at least every five years in order to maintain relationships defined to the currently published datum/epoch.

The CEPD analysis and report were completed for this project in 2011, but new epochs were published for MLLW and NAVD88 requiring updated analysis in 2015. NOAA has typically updated tidal datum elevations for the nation to new National Tidal Datum Epoch (NTDE) time periods every 20-25 years. In 1998, NOAA recognized the need for a modified procedure that utilized more frequent time period updates, for determination of tidal datums for regions with anomalously high rates of local relative sea level change such as Southeast Louisiana. NGS also periodically publishes epoch updates for NAVD88 to account for local subsidence.

5. Project Description

The datum relationships provided in this report were determined in order to bring the "Mississippi River Ship Channel, Gulf to Baton Rouge" project into compliance with the requirements outlined in ER 1110-2-8160, Policies For Referencing Project Elevation Grades To Nationwide Vertical Datums, and EM 1110-2-6056, Standards and Procedures for Referencing Project Elevation Grades to Nationwide Vertical Datums. These policy documents define the requirement for referencing datums on coastal navigation projects. The following EM excerpt addresses the requirement to establish the relationship to MLLW for projects that are defined to a legacy datum, such as MLG (page 4-2):

"*USACE projects that are still defined relative to non-standard or undefined legacy datums (e.g., Mean Low Gulf (MLG), Gulf Mean Tide, MSL, NGVD, MLW, COEMLW, etc.) should have technically valid transforms to the NOAA MLLW chart/tidal datum for the area. In isolated cases, the legacy datum may be retained as the reference grade provided its relationship to NOAA MLLW datum is accurately defined based on current gage data at the project site. In such projects, depth data furnished to NOAA and other project users must indicate the primary reference gage, along with the tidal datum epoch period and the relationship between the legacy datum, NOAA MLLW, and NAVD88. Legacy "Low Water" datums must be periodically updated*

[3] EC 1110-2-6065, Guidance for a Comprehensive Evaluation of Vertical Datums on Flood Control, Shore Protection, Hurricane Protection, and Navigation Projects. This was later updated with EC 1110-2-6070, and eventually EM 1110-2-6056.

for sea level change and regional subsidence using similar computational techniques established by NOAA for coastal waters." (Reference 11)

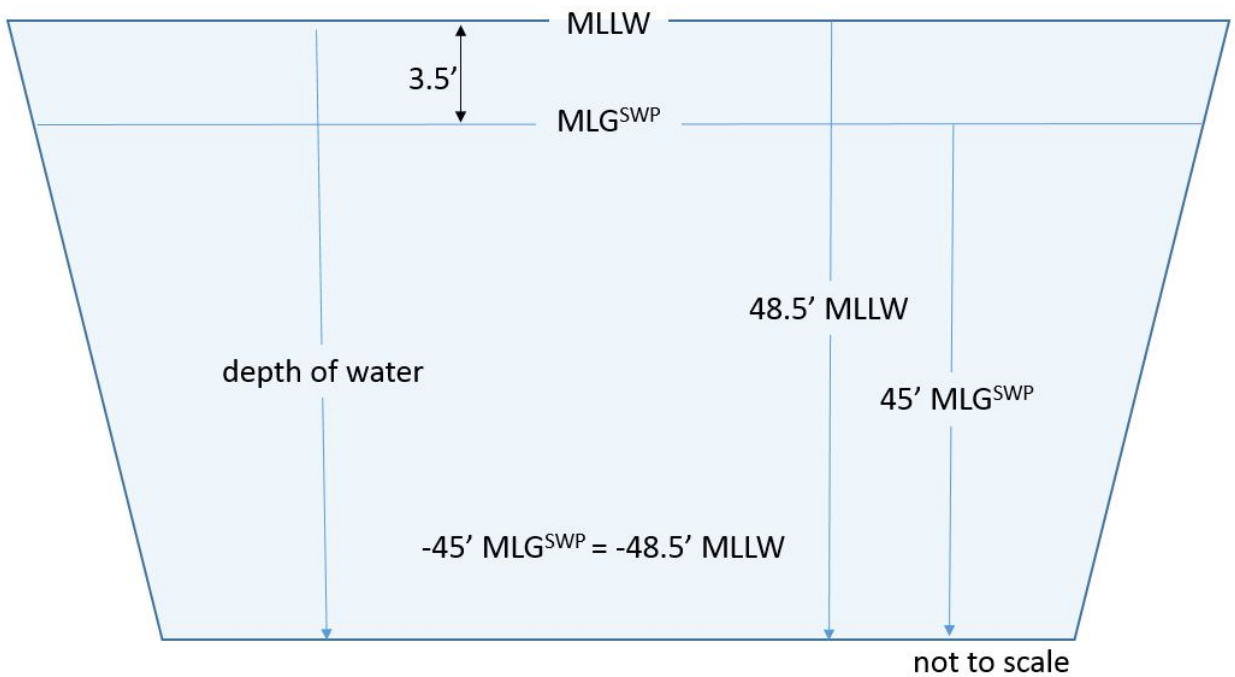
The relationships have been defined between the legacy project datum (MLG), and MLLW and NAVD88 as described in the EM. These datum relationships were used to define a MLLW-MLG calibration for SWP, which will be used to relate the currently maintained / reported MLG elevations to MLLW depths. This is only applicable where the project is considered tidally influenced. For ease of use this relationship will be used south of river mile 13.4 AHP and continuing down SWP, as this is the area requiring maintenance dredging.

The Low Water Reference Plane (LWRP) shall be referenced above river mile 104.5 AHP for maintenance dredging on the river crossings.

6. Changes

For Southwest Pass, a MLLW- MLG^{SWP} calibration value has been defined as:

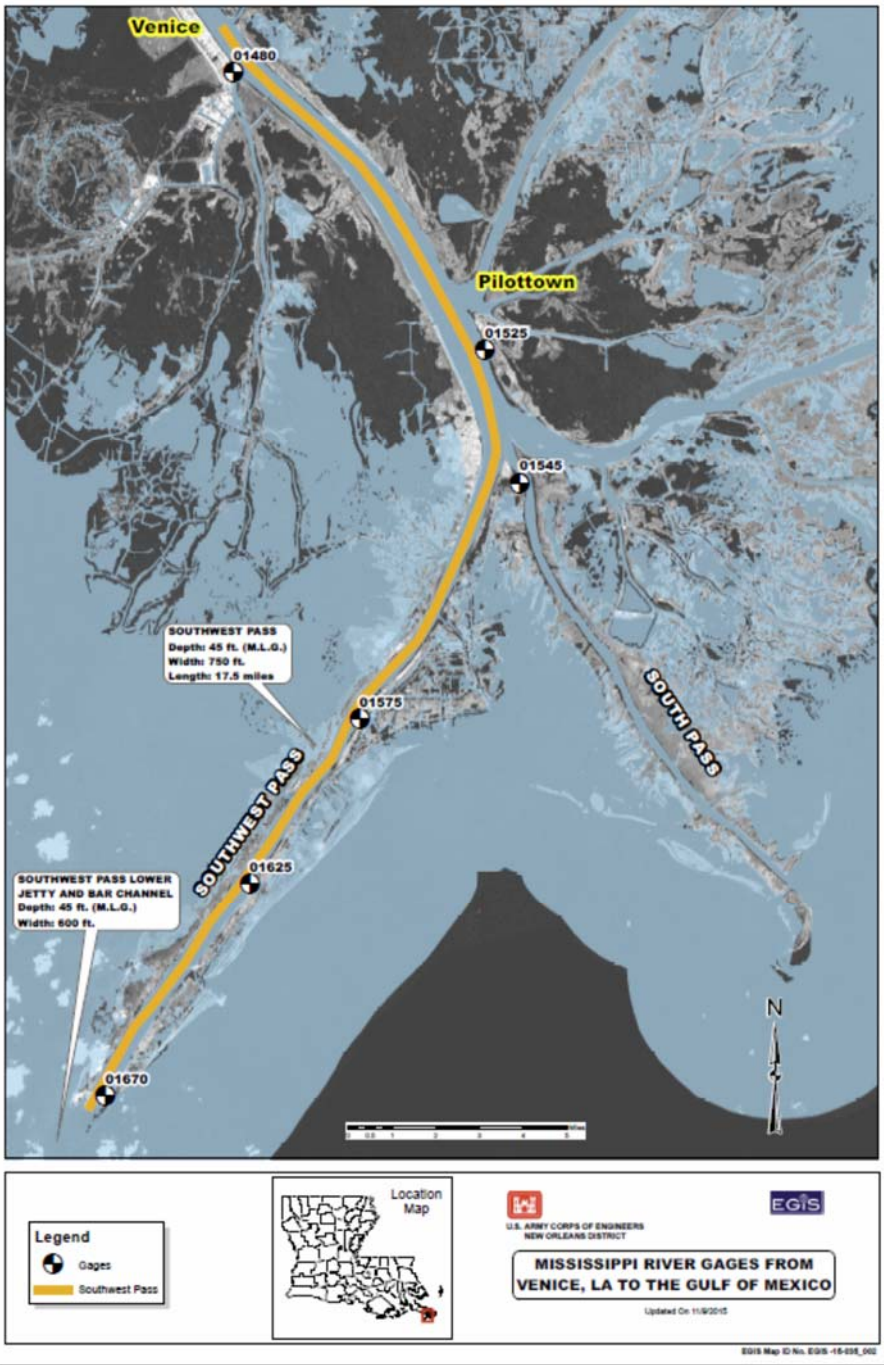
$$0.0 \text{ ft MLLW} = 3.5 \text{ ft } MLG^{SWP}$$



This calibration value will be used to define MLG for this area, by directly referencing MLLW and applying this calibration value to determine MLG^{SWP}. This calibration has been determined by referencing the modified tidal datum epoch of 2007-2011, but this same calibration will be held with future updates to MLLW. This is discussed further in Section 7.

7. Current Engineering Studies, Investigations, and Design

The following map shows the gages for Mississippi River from Venice, LA to the Gulf of Mexico:



MAP 2- Mississippi River gages from Venice, LA to the Gulf of Mexico (Updated 11/9/2015).

The datum analysis performed in 2015 for SWP resulted in the determination of NAVD88 (2009.55/OPUS), MLLW (2007-2011) and MLG^{SWP} relationships. These relationships were used to define the MLLW- MLG^{SWP} calibration for SWP, and the current relationships between these datums and NAVD88.

The MLLW and NAVD88 datum relationships will have to be periodically updated to incorporate future sea level rise and local subsidence, as well as other factors that may affect these datums (i.e. geoid models, epoch updates).

Of note, these periodic updates will not change the MLLW- MLG^{SWP} calibration value. This value will remain constant, which will allow dredging templates to rise over time along with MLLW (due to sea level rise).

After the datum analysis was completed in 2015 all gages along SWP that are maintained by the USACE MVN Stream Gaging Unit were reset to NAVD88 (2009.55/OPUS). Gage correction values were defined for each gage to adjust gage readings to MLLW (2007-2011) and MLG^{SWP}. These corrections will be considered valid until a new datum analysis for future MLLW adjustments is performed.

The MLLW-NAVD88 relationships were determined at two tide stations published by the National Oceanic and Atmospheric Administration (NOAA):

- Pilottown (Station 8760721), and
- Pilots Station East (Station 8760922).

These stations are located near USACE gages 01525 and 01670, respectively, so these relationships are referenced at the USACE gages. These MLLW – NAVD88 relationships are referenced to the 2007-2011 modified tidal datum epoch.

The MLG^{SWP} – NAVD88 relationships were determined based on surveys of staff gages that were previously set to MLG^{SWP}.

7.1. Datum offsets for Mississippi River gages from Venice, LA to the Gulf of Mexico

Table 1 provides the datum offsets at the gages that are currently used by USACE MVN Operations Division to maintain the Mississippi River from Venice, LA to the Gulf of Mexico. All gages were set to NAVD88 (2009.55) in 2015, except for USACE gage 01625 which is referenced to NAVD88 (OPUS) using GEOID12A.

TABLE 1- Datum Offsets for Mississippi River gages from Venice, LA to the Gulf of Mexico

Gage ID	Gage Name	Datum Offset
01480	Mississippi River at Venice	0' NAVD88 = (-) 0.30' MLLW = 3.20' MLG^{SWP}
01525	Mississippi River at Pilottown	0' NAVD88 = (-) 0.30' MLLW = 3.20' MLG^{SWP}
01545	Mississippi River at Head of Passes	0' NAVD88 = (-) 0.18' MLLW = 3.32' MLG^{SWP}
01575	Southwest Pass at Mile 7.5	0' NAVD88 = 0.17' MLLW = 3.67' MLG^{SWP}
01625	Southwest Pass at Light 14	0' NAVD88 = 0.39' MLLW = 3.89' MLG^{SWP}
01670	Southwest Pass at East Jetty	0' NAVD88 = 0.68' MLLW = 4.18' MLG^{SWP}

NOTES:

1. MLLW is referenced to the 2007-2011 modified tidal datum epoch.
2. NAVD88 is referenced to NAVD88 (2009.55) at all locations, except for USACE gage 01625 which is referenced to NAVD88 (OPUS 2014) using GEOID12A.

7.2. Gage Datum Offsets

Table 2 provides the gage datum offsets for the gages currently used by USACE MVN Operations Division to maintain the Mississippi River from Venice, LA to the Gulf of Mexico. All gage readings are referenced to NAVD88, but the datum offsets provided in this table can be used to adjust these gage readings to MLG^{SWP} or MLLW (2007-2011).

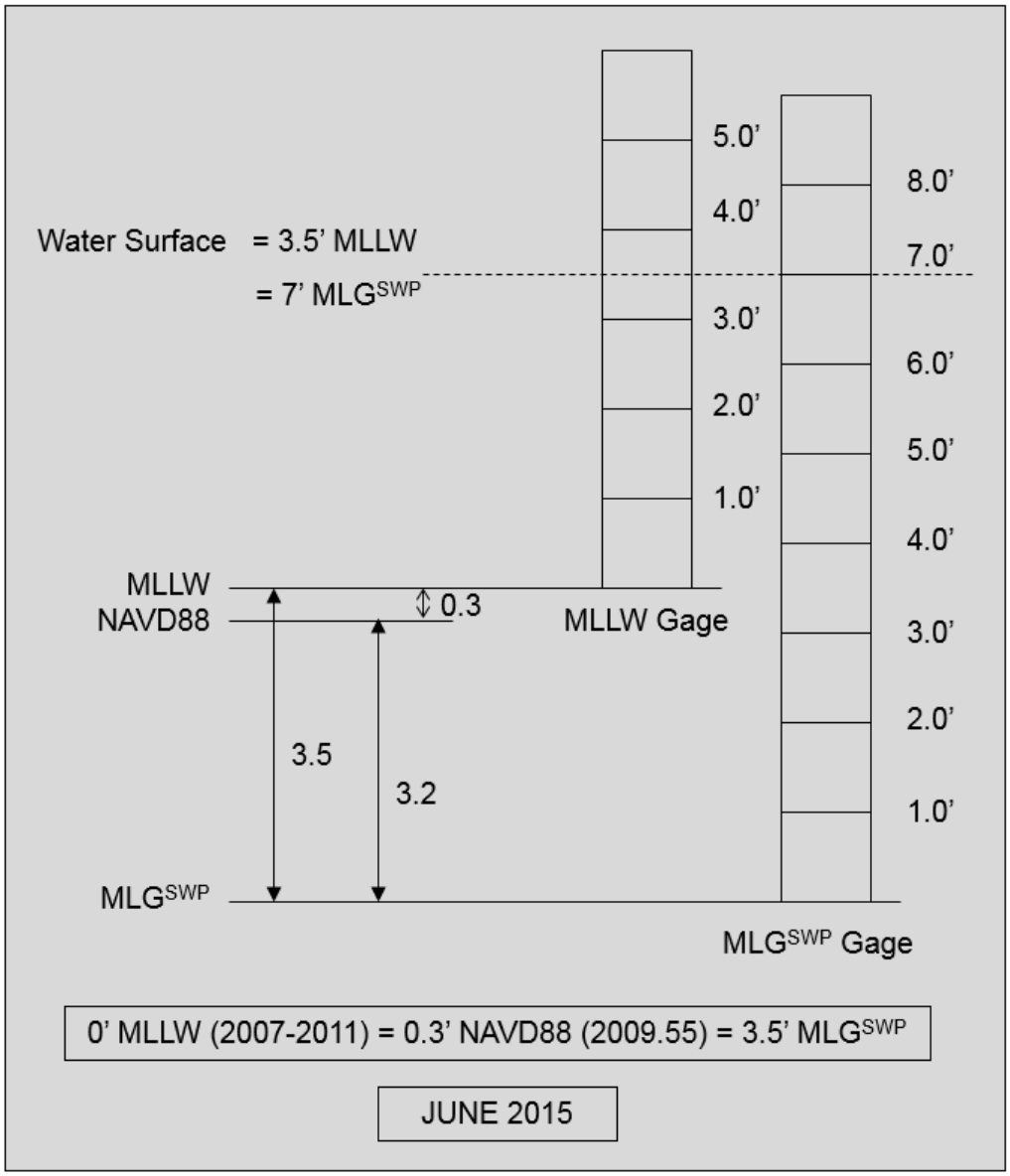
TABLE 2- Datum Offsets for Mississippi River gages from Venice, LA to the Gulf of Mexico

		Gage Datum Offsets			
Gage ID	**Gage Name**	**Gage Datum** / MLG^{SWP}	**Gage Datum / MLLW**	**Latitude**	**Longitude**
01480	Mississippi River at Venice	3.20	-0.30	29 16 19.7	89 21 07.6
01525	Mississippi River at Pilottown	3.20	-0.30	29 10 42.9	89 15 31.8
01545	Mississippi River at Head of Passes	3.32	-0.18	29 08 37.0	89 15 07.0
01575	Southwest Pass at Mile 7.5	3.67	0.17	29 03 41.5	89 18 39.4
01625	Southwest Pass at Light 14	3.89	0.39	29 00 08.0	89 21 04.9
01670	Southwest Pass at East Jetty	4.18	0.68	28 55 56.4	89 24 26.2

7.3. Datum offsets for gage 01480

Figure 1 shows the datum relationships that were determined for USACE gage 01480. The NAVD88- MLG^{SWP} and NAVD88-MLLW relationships are valid as of the date of this report.

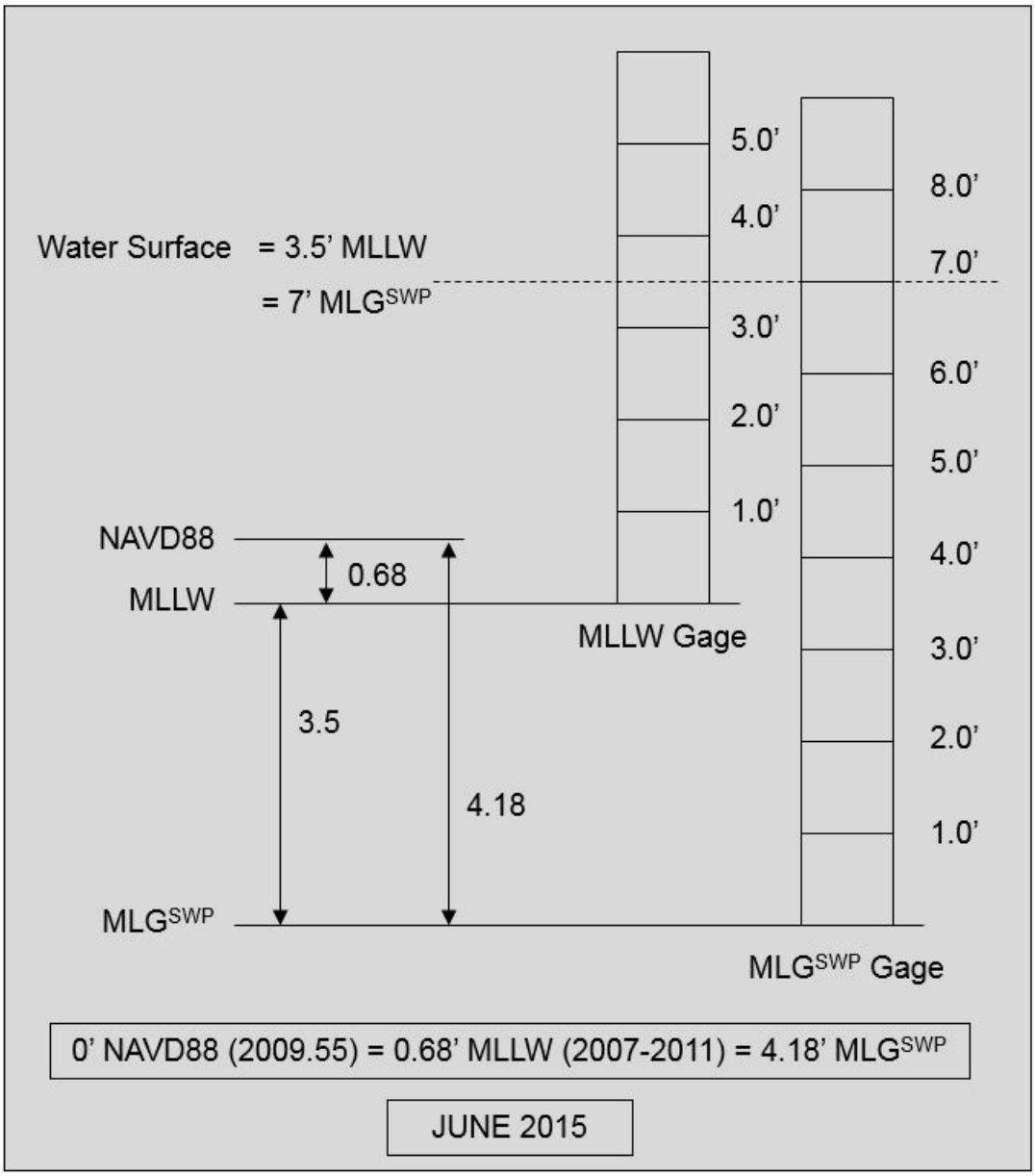
FIGURE 1
Datum Offsets for USACE Gage 01480
(Applied to a water surface reading)



7.4. Datum offsets for gage 01670

Figure 2 shows the SWP datum relationships that were determined for USACE gage 01670. The NAVD88-MLG^{SWP} and NAVD88-MLLW relationships are valid as of the date of this report.

FIGURE 2
Datum Offsets for USACE Gage 01670
(Applied to a water surface reading)



7.5. Calibration and sample calculation

In theory MLG and MLLW are essentially equal as related to LMSL, but the following relationship has been defined to document current practice for the Mississippi River from Venice, LA to the Gulf of Mexico as a MLLW- MLG^{SWP} calibration value, or in-practice usage:

0.0 ft MLLW = 3.5 ft MLG^{SWP}

This calibration value will be considered absolute and documents current practices. It will not be redefined for Mississippi River gages from Venice, LA to the Gulf of Mexico. Use of this relationship will be a no-impact change to current dredging practices, as this has been determined using the current relationship to MLG^{SWP}. However, the relationship between MLLW and NAVD88 will need to be periodically updated to incorporate the future sea level rise and local subsidence.

Dredging design templates and other associated documents are now updated to directly reference MLLW depths, and the relationship to MLG^{SWP} will be included as a note. Providing the MLG relationship will allow users to relate these project documents back to authorization language as needed.

For example, referring back to Figure 1 for gage 01480, if the project is currently maintained to a depth of (-)45ft MLG^{SWP}, this would now be described as a depth of (-)48.5ft MLLW (2007-2011), with (2007-2011) identifying the corresponding period of NOAA tidal datum update.

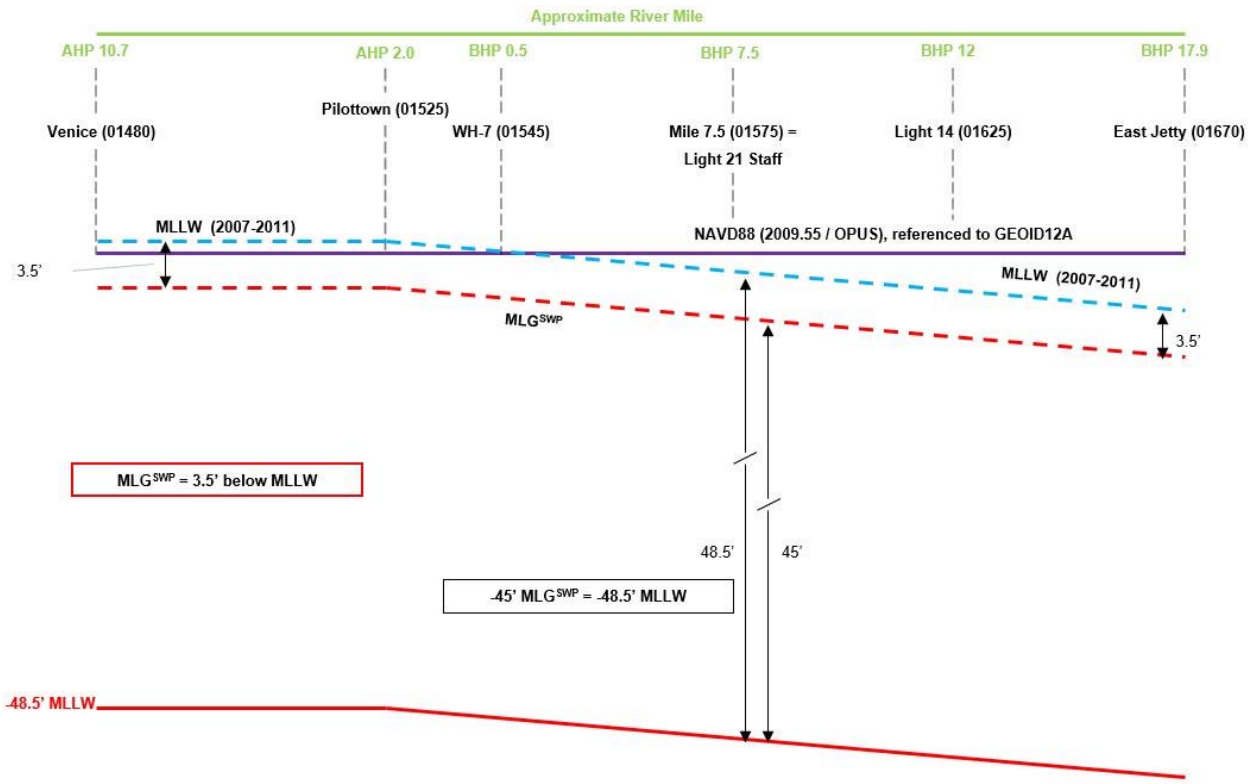
7.6. Documents to be updated as a result of the calibration

Project documents that must be updated to reflect the MLLW values are:

- Dredging templates
- Plans and Specifications
- Channel Condition survey data posted on web page

7.7. Datum Offset Chart

The following chart shows the MLG^{SWP}/MLLW/NAVD datum offsets for Mississippi River gages from Venice, LA to the Gulf of Mexico:



Due to regional subsidence and global sea-level rise, the elevations of the referenced benchmarks and the tidal datum values at the referenced gages (as well as the datum relationships) are time dependent and subject to change. Therefore, the information contained in this report shall be updated on a regular basis and/or as new information becomes available.

7.8. Future updates to MLLW/NAVD88

The MLLW-NAVD88 datum offsets defined in this report are time dependent and will have to be regularly verified / updated. EM 1110-2-6065 indicates that the periodic reassessments of controlling elevations and datum relationships should be performed at least every five years. These reassessments will not change the MLLW-MLG calibration value, only the MLLW-NAVD88 relationships that will be used to define MLLW for the Mississippi River from Venice, LA to the Gulf of Mexico. It is anticipated that NOAA will publish a modified tidal datum epoch (2012-2016) in FY18, which would require that the MLLW-NAVD88 relationship be updated and the corresponding relationship to MLG be updated accordingly using the calibration value.

8. Cost Estimate

N/A

9. Economic Analysis

N/A

10. Cost Allocation and Cost Sharing

N/A

11. Environmental Documentation and Coordination

N/A

12. Review process

This document underwent a Quality Assurance review that included individuals from the New Orleans District Corps of Engineers for the following disciplines: geospatial, civil, operations, and project management. In addition, the document was reviewed by a standard Independent Technical Review process. The ATR review was performed by an independent team from the U.S. Army Geospatial Center, Survey Engineering and Mapping (CEAGC-GSC), North Carolina. Appendix A includes the Independent Technical Review (ATR) Certification.

Review may be found in Dr. Checks:

Project: (ED-OD-01) Engineering Documentation Reports
Review: South West Pass

REFERENCES

1. Comprehensive Evaluation of Project Datums (CEPD) Final Report – Appendix 1, Mississippi River Ship Channel, Gulf to Baton Rouge. Date: 18 December 2013. Updated: 10 July 2015.

2. Mississippi River Baton Rouge to the Gulf of Mexico, Planning Report, New Orleans, Louisiana, District Office, Corps of Engineers, Department of the Army, January 1954, January 1955 and January 56.

3. River & Harbors Act March 1915, Chapter 142, Section 5. 1644 Laws Relating to Improvement of Rivers and Harbors.

4. USACE, 1999. ER 1110-2-1150: Engineering and Design for Civil Work Projects, 31 August 1999.

5. USACE, 2007. EC 1110-2-6065: Engineering and Design, Comprehensive Evaluation of Project Datums, Guidance for a Comprehensive Evaluation of Vertical Datums on Flood Control, Shore Protection, Hurricane Protection, and Navigation Projects, 1 July 2007.

6. USACE, 2009. EC 1110-2-6070: Engineering and Design, Comprehensive Evaluation of Project Datums, Guidance for a Comprehensive Evaluation of Vertical Datums on Flood Control, Shore Protection, Hurricane Protection, and Navigation Projects, 1 July 2009.

7. USACE, 2010. EM 1110-2-6056: Engineering and Design, Standards and Procedures for Referencing Project Elevation Grades to Nationwide Vertical Datums, 31 December 2010.

8. USACE, 2014. Navigation Project Compliance with Vertical Datum Guidance. Memorandum from HQUSACE. Dated 24 October 21014.

9. http://www2.mvn.usace.army.mil/eng2/edsd/proj_maps/1-51A.htm

10. ER 1110-2-8160, Policies For Referencing Project Elevation Grades To Nationwide Vertical Datums

11. NOAA, 2014. NOAA Technical Report NOS CO-OPS 068, Implementation of Procedures for Computation of Tidal Datums in Areas with Anomalous Trends in Relative Mean Sea Level

All related supporting documentation may be found in ProjectWise:

pw:\\MVN-APPW02.mvn.ds.usace.army.mil:CEMVN01\Documents\Civil Works\Mississippi River - Baton Rouge to the Gulf of Mexico\South West Pass\Engineering Documentation Report

Engineering Documentation Report

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