Geomorphic Assessment of Pass a Loutre and South Pass, Mississippi River Delta

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Geomorphic Assessment of Pass a Loutre and South Pass, Mississippi River Delta

A Report for Louisiana Coastal Area Science & Technology Office, Mississippi Valley Division

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Final report

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Abstract

A geomorphic assessment was conducted for the Pass a Loutre and South Pass deltaic channels of the Mississippi River bird’s-foot delta. The purpose of the study was to document long-term morphological trends in the channels through the analysis of historical stream gage data, hydrographic surveys, dredge data, and other information on anthropogenic activity in the study area. The physical limits of the study were from Head of Passes to the Gulf of Mexico outlet for both passes, and the time period was focused from 1960 to 2008. Specifically, the geomorphic assessment tasks consisted of data compilation, a geometric data analysis, analysis of stage and discharge data, and assessment of historical river engineering activity in the study area. The results of all analyses were integrated to develop an understanding of the morphologic trends in the study area. Information derived from the geomorphic assessment assists in evaluating potential activities in the area such as river diversions for freshwater marsh restoration.

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## Contents

Abstract ................................................................................................................................................... ii  
Figures and Tables ................................................................................................................................. iv  
Preface ..................................................................................................................................................... v  
Unit Conversion Factors ........................................................................................................................ vi  
1 Introduction ..................................................................................................................................... 1  
   1.1 Purpose .......................................................................................................................... 1  
   1.2 Background .................................................................................................................... 1  
   1.3 Study area description .................................................................................................. 2  
2 Study Approach ............................................................................................................................... 5  
   2.1 Geometric data analysis ............................................................................................... 5  
   2.2 Flow distribution analysis .............................................................................................. 6  
   2.3 Assessment of river engineering activities ................................................................... 6  
   2.4 Integration of results ..................................................................................................... 7  
3 Geometric Data Analysis ............................................................................................................... 8  
   3.1 Pass a Loutre geometric data analysis ........................................................................ 9  
      3.1.1 Pass a Loutre comparative cross-section analysis ................................................... 9  
      3.1.2 Pass a Loutre channel profile comparisons ............................................................ 14  
      3.1.3 Pass a Loutre channel volume analysis .................................................................. 16  
   3.2 South Pass geometric data analysis .......................................................................... 19  
      3.2.1 South Pass comparative cross-section analysis ..................................................... 19  
      3.2.2 South Pass channel profile comparisons ............................................................... 24  
      3.2.3 South Pass channel volume analysis ....................................................................... 25  
4 Flow Distribution Analysis ........................................................................................................... 27  
5 Assessment of River Engineering Activities ............................................................................. 29  
6 Integration of Results .................................................................................................................. 31  
   6.1 Pass a Loutre assessment .......................................................................................... 31  
   6.2 South Pass assessment .............................................................................................. 32  
7 Summary ....................................................................................................................................... 34  
References ............................................................................................................................................ 35  
Appendix A: Comparative Cross Sections for Pass a Loutre .......................................................... 36  
Report Documentation Page
Figures and Tables

Figures

Figure 1. Historical Mississippi River delta lobe formations (Kolb and van Lopik 1958)............ 3
Figure 2. 2010 Landsat image of the Mississippi River delta............................................................. 3
Figure 3. Example of bathymetric surface TIN developed from digital hydrographic survey data............................................................................................................................................................. 8
Figure 4. Location of Pass a Loutre comparative cross sections......................................................... 9
Figure 5. Location of Pass a Loutre comparative cross sections......................................................... 9
Figure 6. Location of Pass a Loutre comparative cross sections....................................................... 10
Figure 7. Cross-section comparison at Section R-1 HOP................................................................. 11
Figure 8. Cross-section comparison at Section R-1.5......................................................................... 12
Figure 9. Cross-section comparison for Section R-7.0....................................................................... 13
Figure 10. Cross-section comparison for Section R-14.0................................................................. 14
Figure 11. Minimum channel bed elevation profile comparison for Pass a Loutre.......................... 15
Figure 12. Average channel bed elevation profile comparison for Pass a Loutre............................. 16
Figure 13. Erosion/deposition volume between surveys for Pass a Loutre (positive values indicate deposition; negative values indicate erosion)........................................................................ 18
Figure 14. Estimated average annual erosion/deposition volume for Pass a Loutre (positive values indicate deposition; negative values indicate erosion)........................................................................ 19
Figure 15. Location of South Pass comparative cross sections......................................................... 20
Figure 16. Comparative cross sections for South Pass at RM 2.0 BHP.......................................... 20
Figure 17. Comparative cross sections for South Pass at RM 4 BHP............................................. 21
Figure 18. Comparative cross sections for South Pass at RM 6 BHP............................................. 21
Figure 19. Comparative cross sections for South Pass at RM 8 BHP............................................. 22
Figure 20. Comparative cross sections for South Pass at RM 10 BHP......................................... 22
Figure 21. Comparative cross sections for South Pass at RM 12 BHP......................................... 23
Figure 22. Minimum channel bed elevation profiles for South Pass............................................. 24
Figure 23. Average channel bed elevation profiles for South Pass.................................................. 25
Figure 24. Erosion/deposition volume between surveys for South Pass (positive values indicate deposition; negative values indicate erosion)........................................................................ 26
Figure 25. Flow distribution as a percentage of Mississippi River discharge for Pass a Loutre and South Pass. .............................................................. 27

Tables

Table 1. Location of Pass a Loutre cross sections by river mile below HOP.................................. 10
Table 2. Estimated incremental volume change for Pass a Loutre.................................................. 17
Preface

This study was conducted with funding provided by the Louisiana Coastal Area (LCA) Science & Technology Office of the U.S. Army Corps of Engineers, Mississippi Valley Division Office. This report is being published as part of the Mississippi River Geomorphology and Potamology (MRG&P) Program. The MRG&P Program is sponsored by Headquarters, U.S. Army Corps of Engineers (USACE), and is managed by the USACE Mississippi Valley Division (MVD) in Vicksburg, MS. The MRG&P Technical Director for the Mississippi Valley Division was Barb Kleiss.

The U.S. Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL), conducted this study in 2010. The principal investigator for this study was Charlie Little of the River Engineering Branch. The study was conducted under the direct supervision of Lisa Hubbard/Loren Wehmeyer, Chief, River Engineering Branch; Bruce A. Ebersole/Ty Wamsley, Chief, Flood and Storm Protection Division; and William Martin/José Sánchez, Director, CHL.

During the time of the study, COL Gary E. Johnston, COL Kevin J. Wilson, and COL Jeffrey Eckstein served as Commander and Executive Director of ERDC. Dr. Jeffery P. Holland served as ERDC Director.

ACKNOWLEDGEMENTS: Brian Vosburg of the Louisiana Coastal Protection and Restoration Authority conducted a review of this report and provided valuable comments and suggestions. His contributions are gratefully acknowledged.
# Unit Conversion Factors

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1 Introduction

1.1 Purpose

This report describes the results of a geomorphic assessment conducted for Pass a Loutre and South Pass, both distributaries located in the bird’s-foot delta of the lower Mississippi River. The geomorphic assessment includes analysis of historical changes in channel geometry and flow distribution at the passes, as well as investigation of the effects of natural and man-induced activities. Historical trends in the long-term morphology of the passes are described.

1.2 Background

The dominant morphological processes that shape the lower Mississippi River channel and deltaic channels such as Pass a Loutre and South Pass can operate over a very large range of spatial and temporal scales. There are many factors, both natural and man-induced, that can contribute to these processes. The effects of large flood events and tropical storms, changing sediment loads and characteristics, channel maintenance activities, dredging practices, diversions (natural and man-made), subsidence, and relative sea level rise are just a few such factors. Formulating the most accurate assessment of river morphology over these large scales requires evaluation of long-term trends in geometry adjustment, flow distribution, and sediment loading based on observed data. These morphological trends can be determined by means of a geomorphic assessment.

A geomorphic assessment was conducted for the Pass a Loutre and South Pass deltaic channels of the Mississippi River bird’s-foot delta. The purpose of the study was to document long-term morphological trends in the channels through the analysis of historical stream gage data, hydrographic surveys, dredge data, and other information on man-induced activity in the study area. The physical limits of the study were from Head of Passes (HOP) to the Gulf of Mexico outlet for both passes, and the time period was focused from 1960 to the present. Specifically, the geomorphic assessment tasks consisted of data compilation, a geometric data analysis, analysis of stage and discharge data, and assessment of historical river engineering activity in the study area. The results of all analyses were integrated to develop an understanding of the morphologic trends in the study area.
Information derived from the geomorphic assessment assists in evaluating potential activities in the area such as river diversions for freshwater marsh restoration.

1.3 Study area description

Deltas are deposits of river alluvium formed where a sediment-laden stream flows into the ocean or any large standing body of water. As layer upon layer of sediment is deposited in the outlet area, a blockage is eventually created in the outlet that impedes discharge of water and sediment into the receiving body of water. This obstruction eventually results in the creation of one or several distributaries that carry the water and sediment to the ocean via routes that are more hydraulically efficient. The delta formation process continues in the new outlet location until deposition of alluvium again impedes the passage of water and sediment, and the development of new outlet channels is repeated as the river seeks a more advantageous route to the sea. As the abandoned delta areas, or lobes, are cut off from the supply of fresh water and sediment, compaction and storm-induced erosion of the lobe area occurs. This results in a retreat of the old delta, allowing the ocean to regain some of the area through formation of bayous, bays, and sounds.

The development of the Mississippi River delta over the past 7,000 years (yr) has resulted in the formation of delta lobes occupying various positions from Vermillion Bay in the west to the Chandeleur Islands in the east. Figure 1 (Kolb and van Lopik 1958) shows the generalized location of the various delta lobes during this time. The currently active delta lobe is the Balize delta, also called the bird’s-foot delta due to its three-pronged outlet channel configuration (Figure 2). This lobe has been active over the past 600 to 800 yr (Fisk and McFarlan 1955).

The current delta occupies over 500,000 acres, the vast majority of which is open water/bay. Approximately 101,000 acres of the delta consists of low-lying, low-relief land interspersed with bayous, marshes, and coastal wetlands. The primary distributaries of the current delta lobe that form the descriptive bird’s foot are Pass a Loutre to the east, South Pass to the south/southeast, and Southwest Pass to the southwest. In addition to these main channels, additional distributaries include Baptiste Collette Bayou, Grand/Tiger Pass, Cubits Gap, and more recently, the West Bay Diversion. These smaller distributaries (with the exception of West Bay) are associated with subdelta formation along with the subdelta land gain-stability-loss cycle.
Currently, the active Mississippi River delta is losing land more rapidly than land is being created. Possible causes of this land loss include subsidence due to consolidation and oil/gas extraction, sea level rise, tidal
and storm erosion, natural subdelta deterioration, and reduction of river sediment loads. The total land area lost in the delta area over the last 60 yr has been approximately 113,300 acres (CWPPRA 2011).
2 Study Approach

The geomorphic assessment for Pass a Loutre and South Pass consisted of the evaluation of historical hydrographic survey data, gage and discharge data, dredge records, and human influences through various river engineering activities. The results of each analysis method are evaluated on an individual basis as well as a system context to formulate an overall understanding of the morphological trends that have occurred on the river. Oftentimes individual analyses of a geomorphic assessment can yield conflicting results, and river engineering judgment must be applied in integrating the results to form the overall assessment. Additionally, the geomorphic assessment is heavily based on historical observations and data that reflect the composite effect of numerous forces and influences on river conditions (e.g., floods, storms, human activities). Because of this, it is often problematic to attribute specific cause-and-effect relations for observed changes with any degree of confidence. Rather, the geomorphic assessment is more suitably utilized to determine long-term trends in river channel behavior.

The specific tasks of the geomorphic assessment included (1) an analysis of channel geometric data, (2) an analysis of the flow distribution patterns at the bird’s-foot delta, (3) an evaluation of historical river engineering activities, and (4) integration of all results to identify historical trends.

2.1 Geometric data analysis

The geometric data analysis was conducted with historical hydrographic survey data from decadal surveys of the lower Mississippi River and passes obtained from the U.S. Army Corps of Engineers (USACE), New Orleans District (MVN). The time periods for the specific hydrographic surveys are 1961–1963, 1973–1975, 1983–1985, 1991–1992, and 2003–2004. The majority of the survey data were in XYZ digital format; however, hard-copy survey maps were used where necessary. All survey data were incorporated into a geographic information system (GIS), and triangular irregular networks (TINs) were developed for each survey to describe the bathymetric surface for each survey. The original survey data were procured using single-beam fathometer soundings along individual transects, and spacing between transects was as much as 2,500 feet (ft).
Using the GIS, cross sections were created at regular intervals along both channels and were used to extract data from each survey TIN. The cross sections were oriented along the alignment of the original survey transects in order to minimize potential inaccuracies due to interpolation within the TIN. The extracted data from each survey were plotted to compare the cross section changes over time. In addition, the minimum elevation at each cross section was plotted versus river mile location to produce comparative longitudinal profiles for each channel.

Cross-sectional area below a reference elevation of 0.0 ft National Geodetic Vertical Datum (NGVD) was computed for each cross section. The computed areas typically do not represent a full water-edge-to-water-edge section due to the limited extent of the survey data. An estimate of the volumetric change from survey to survey was computed using the average end area method. Volumetric change computed from the TIN surfaces was not attempted because the surfaces rarely provided adequate coverage of the channel between the cross sections. An average channel thalweg bed elevation was computed at each cross section and plotted versus river mile.

2.2 Flow distribution analysis

An analysis of the flow distribution patterns for the lower Mississippi River and passes was conducted with historical discharge data. Beginning at the proximity of Venice, LA, water from the Mississippi River delta is lost through several natural and man-made distributaries. Historical discharge measurements for these outlets were gathered, and the ratio of the distributaries discharge to the main-stem Mississippi River discharge was computed. Observed changes in the computed flow distribution percentages with time were evaluated.

2.3 Assessment of river engineering activities

Human intervention and engineering activities have been conducted in the Mississippi River delta area for decades, with the primary purpose of establishing reliable navigation passages to the inland ports along the Mississippi River. Available dredge records were obtained from the New Orleans District for evaluation of potential impacts of navigation channel maintenance practices along the lower river. Additional information on channel maintenance and other river engineering activities were obtained
from MVN personnel to assist in the development of the geomorphic assessment.

2.4 Integration of results

The results of the various analyses were integrated to formulate an overall geomorphic assessment of the passes and the historical changes that have occurred during the study period. River engineering judgment was required to develop this assessment, as results from the various analyses often yield conflicting results. In addition, note that the assessment is heavily based on observed data that represents the composite effect of numerous forces on the river system that have occurred over a significant period of time. As a result, it is often difficult to attribute cause-and-effect relations for observed changes with confidence.
3 Geometric Data Analysis

Digital hydrographic survey data for decadal surveys conducted during the study period of 1960–2008 were incorporated into a GIS database. The GIS database was used to develop TIN surfaces for each survey, and bathymetric data were extracted at desired locations for comparison. The elevation data for each survey were in the original vertical datum, and no correction for datum or subsidence was attempted. The vertical datums were mean sea level (MSL) for the 1961–1963 and 1973–1975 surveys, NGVD for the 1983–1985 and 1991–1992 surveys, and NAVD88 for the 2003–2004 survey. Digital data were not available for all surveys. For Pass a Loutre, full-survey data coverage was available for all decadal surveys except the 1961–1963 survey. For South Pass, digital data were only available for the 1973–1975 and 1991–1992 hydrographic surveys. For South Pass, data for cross-section comparison were obtained from the hard-copy maps of all hydrographic surveys. An example of a TIN developed from the digital hydrographic survey data is shown in Figure 3. Note the linear orientation of the survey data along transects that have a spacing of approximately 2,500 ft.

Figure 3. Example of bathymetric surface TIN developed from digital hydrographic survey data.
3.1 Pass a Loutre geometric data analysis

3.1.1 Pass a Loutre comparative cross-section analysis

Bathymetry data were extracted from each decadal hydrographic survey for the Pass a Loutre cross-section locations shown in Figures 4 through 6. Table 1 shows the location of each cross section in river miles below HOP. The extracted data at each cross-section location were plotted for comparison, and the plots for the Pass a Loutre cross sections are shown in Appendix A.

Figure 4. Location of Pass a Loutre comparative cross sections.

Figure 5. Location of Pass a Loutre comparative cross sections.
The comparative cross sections indicate there has been a general aggrading of the Pass a Loutre channel throughout its entire length during the study time period. The cross-sections comparisons at locations within the first one-half mile below HOP indicate as much as 80–100 ft of filling in the channel, beginning in the time period between the 1973 to 1975 survey and the 1991 to 1992 survey. Figure 7 shows the cross-section comparisons for section R-1 HOP, which is just within the head of the pass adjacent to River
Mile (RM) 0.0. This area is generally within the dredge-material disposal area located at HOP. Current bed elevations in the disposal area are approximately –20 ft. The disposal area is periodically mined by the MVN to reclaim disposal capacity, and the mined material is typically used beneficially for restoration purposes in nearby coastal wetland areas.

**Figure 7. Cross-section comparison at Section R-1 HOP.**

Between the head of Pass a Loutre and Chenerie Pass, a series of middle bars/islands has developed, with the thalweg channel shifting from side to side. In general, channel depths have decreased over the same time period, with depth reductions on the order of 15–25 ft. Figure 8 shows the changes that have occurred at section R-1.5 just upstream of the head of Cheniere Pass.
From the vicinity of Chenerie Pass to near the bifurcation of Pass a Loutre and North Pass, a general reduction in channel depth occurs, but the channel shape and thalweg position remain fairly consistent. Average decreases in channel depths range from 10 to 20 ft, with the greatest changes occurring after 1975. An example of the observed changes in this reach of Pass a Loutre is shown in Figure 9 for the section located at R-7.0. The general shape of the cross section has remained fairly consistent over the elapsed time period between surveys, but channel thalweg depth has decreased by approximately 20 ft. The filling at this section has resulted in a general decrease in cross-sectional area between the 1973 to 1975 survey and the 2003 to 2004 survey. Although the surveys did not fully capture the cross section from water’s edge to water’s edge, the loss in channel cross-sectional area is estimated at approximately 66%. These observed changes are representative for the sections located between Chenerie Pass and the bifurcation of Pass a Loutre and North Pass near section R-12.5.
From the junction of North Pass to the foot of Pass a Loutre, channel depths have diminished by approximately 10 ft from the 1973 to 1975 survey to the 2003 to 2004 survey. Channel bed elevations in 2004 were approximately –4 ft, and the channel was poorly confined by the banks, being more reminiscent of a bar channel. An example of the channel cross-section conditions in this reach of the pass is shown in Figure 10 for the section R-14.

In summary, the comparative cross sections for Pass a Loutre indicate a general depositional trend throughout the entire pass over the study time period. Deposition magnitude is the greatest at the head of the pass, with as much as 80–100 ft of filling observed. Sediment deposition of approximately 5–20 ft has occurred downstream of the head of the pass to the bifurcation with North Pass for the same time period. From the intersection of North Pass to the end of the Pass a Loutre, deposition decreases, with deposition depths ranging from 4 to 12 ft between 1975 and 2004.
3.1.2 Pass a Loutre channel profile comparisons

The minimum channel bed elevation at each cross section was plotted versus the channel distance downstream of the head of the pass. The minimum channel bed elevation profiles for each survey are shown in Figure 11. Minimum channel bed elevations from the 1983–1985 hydrographic survey were obtained from the hard-copy maps and also included in the plot. The profile comparison indicates that significant deposition on the order of approximately 100 ft occurred immediately at the head of the pass between 1975 and 1992. The magnitude of deposition quickly diminishes in the first mile of the pass and ranges from 10 to 20 ft farther downstream to near North Pass. Deposition over the time period ranges from approximately 12 ft near the bifurcation of North Pass to approximately 3 ft at the end of Pass a Loutre, where water depths become extremely shallow. Please note that outside of the extreme depths immediately adjacent to the Mississippi River at the HOP, the greatest depths along the entire length of Pass a Loutre have historically occurred approximately between RM 3 and 5 below Head of Passes (BHP), the reach between Cheneire Pass and Southeast Pass. Additionally, the pass has historically had an adverse channel slope from approximately RM 5 BHP to the foot of the pass. Overall, the comparative profiles indicate that
deposition has occurred along the entire length of Pass a Loutre throughout the time period of the study, and with the exception of the deposition at the head of the pass, the rate of deposition has been fairly consistent.

**Figure 11. Minimum channel bed elevation profile comparison for Pass a Loutre.**

The average channel bed elevation was determined for each cross section and plotted versus channel distance for Pass a Loutre as shown in Figure 12. The average bed elevation was computed by dividing the cross-sectional area by the channel width. The average bed profiles indicate similar trends as the minimum elevation profiles. Significant deposition in the immediate vicinity of the head of the pass is evident between the 1970s survey and 1990s survey, and fairly consistent deposition is noted from that point to approximately the bifurcation of North Pass near RM 12 BHP. Observed deposition decreases from the area of North Pass to the end of Pass a Loutre. The average bed profiles clearly show the trend in channel slope, with normal channel bed slope from approximately RM 1 BHP to 4 BHP and an adverse channel bed slope from RM 4 BHP to the outlet of the pass.
3.1.3 Pass a Loutre channel volume analysis

A volumetric analysis was conducted using the cross-section data to estimate the trends of deposition and erosion that have occurred within Pass a Loutre. The channel area below elevation 0.0 ft NGVD was computed for each cross section, and the average end area method was used to approximate the volume under the 0.0 ft elevation lid for the reach between adjacent cross sections for each survey. The average end area method was used instead of more advanced GIS tools because survey data for the pass were limited in coverage, and GIS generated surfaces were not considered to adequately represent the area between survey transects. The difference in the approximated volume of successive surveys represents the average erosion or deposition volume for the time period between surveys. Please note that there is uncertainty in the volumetric results due to the inconsistency of cross-section coverage from water’s edge to water’s edge between surveys. Many transects from the surveys did not completely cover the cross section from bank to bank; thus, the computed cross-sectional area is not representative of the entire section. Although the volumes are subject to uncertainty, the estimated volumes are presented to illustrate the general trends in erosion and deposition.
Estimated incremental erosion and deposition volumes for Pass a Loutre are shown in Table 2 and in Figure 13. The results are presented for reaches by river mile. Positive (+) volume change is indicative of general channel deposition and negative (−) volume change is indicative of general channel erosion. Although there are missing data due to the lack of survey coverage, the volume change data overwhelmingly indicate that Pass a Loutre has been a depositional environment throughout the entire study period of 1960–2008. The largest magnitude of depositional volume change occurred in the first couple of miles of the pass between the 1970s and 1990s surveys. Observed deposition volume in the most upstream reach of the pass between the 1970s and 1990s surveys is one to two orders of magnitude greater than the volume change for the 1960s–1970s period. Sediment deposition between the 1990s and 2000s surveys is somewhat consistent throughout the entire length of the pass.

Table 2. Estimated incremental volume change for Pass a Loutre.

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* Negative (−) value indicates erosion; positive (+) value indicates deposition.

BHP = Below Head of Passes
CY = cubic yard
HOP = Head of Passes
From Figure 13, it can be seen that comparatively there was very little deposition between the 1960s and 1970s survey, although there are missing data. Deposition volume between the 1970s and 1990s surveys was the greatest in the first 2 miles below the head of the pass, was fairly consistent from that point until approximately RM 13 BHP, then decreased quickly toward the foot of the pass. Between the 1990s survey and the 2000s survey, deposition volumes are less in the upstream half of the pass and increase in the downstream half of the pass.

Since the time periods between surveys varied, the estimated incremental erosion and deposition rates were annualized and compared as shown in Figure 14. Similar to the other results presented, the average annual deposition rate is greatest in the upstream-most portion of the pass during the 1970s–1990s time period. Observed deposition rates in the reach from RM 8 to 13 BHP are fairly consistent from the 1970s to the 2000s time period. Deposition rates in the foot of the pass are greater during the more recent time period of the 1990s–2000s.
3.2 **South Pass geometric data analysis**

The hydrographic survey data for South Pass were not available in digital format for all surveys and were limited in the GIS database. The cross-section data used for the geometric analysis of South Pass were scaled by hand from the survey map books; therefore, there may be some inaccuracy in the horizontal stationing of the data. Comparison of cross sections may not be exact but should be sufficient to be considered representative of the observed changes.

### 3.2.1 South Pass comparative cross-section analysis

Bathymetric data for South Pass were obtained at cross sections at RM 2, 4, 6, 8, 10, and 12 BHP as shown in Figure 15. The comparative cross-section plots are presented in Figures 16 through 21. Please note that South Pass has been subject to maintenance dredging for portions of the study period that has altered the channel geometry. The impacts of dredging will be discussed later in the report.
Figure 15. Location of South Pass comparative cross sections.

Figure 16. Comparative cross sections for South Pass at RM 2.0 BHP.
Figure 17. Comparative cross sections for South Pass at RM 4 BHP.

South Pass Cross Section Comparison
RM 4.0 BHP

Figure 18. Comparative cross sections for South Pass at RM 6 BHP.

South Pass Cross Section Comparison
RM 6.0 BHP
Figure 19. Comparative cross sections for South Pass at RM 8 BHP.

Figure 20. Comparative cross sections for South Pass at RM 10 BHP.
The comparative cross sections at RM 2.0 BHP shown in Figure 16 indicate variability in the channel depth near the head of South Pass. There is an approximate 20 ft increase in depth from the 1960s to the 1970s survey period, little change between the 1970s and 1990s surveys, and an approximate 28 ft decrease in depth between the 1990s and 2000s surveys.

Figures 17 and 18 indicate a deeper and narrower channel at RM 4 and 6 BHP, respectively, in the 1960s than in the 2000s time period. Approximately 10–20 ft of channel filling occurs at these two locations over the time period. The rate of filling at these locations varies, with little filling occurring during the 1970s and 1990s at RM 4 BHP and little occurring between 1990s and 2000s at RM 6 BHP. Channel widths are approximately 200–250 ft narrower for the 1960s survey than for the 1970s–2000s survey periods.

The comparative cross sections at RM 8 BHP shown in Figure 19 indicate a change in the shape and depth of the channel. The channel in the 1960s time period is U-shaped and uniform. By the 1970s time period, the channel depth had increased by 10 ft, and the shape indicated a shift in the thalweg towards the right descending bank. Channel depths decreased approximately 15 ft between the 1970s and 1990s time period, with little
depth change noted between the 1990s and 2000s time period. There is little shift in the thalweg location since the 1970s time period.

Figures 20 and 21 indicate similar geometry changes have occurred at RM 10 and 12 BHP near the foot of South Pass. Channel depth between the 1960s and 1990s period decreased approximately 20 ft but increased approximately 5 ft from the 1990s to the 2000s period at both RM 10 and 12 BHP. Channel widths were fairly consistent over the entire time period at these locations.

### 3.2.2 South Pass channel profile comparisons

The minimum channel bed elevation profiles for South Pass are shown in Figure 22, and Figure 23 shows the average channel bed elevation profiles. From Figure 22, it is evident that the channel bed has fluctuated during the time period of the surveys. It is interesting that the slope of the profile for the 1960s survey is fairly uniform and appears to be the mildest of all the surveys. During the 1970s and 1990s surveys, channel depth increases of approximately 20 ft were observed in the upstream 2–3 miles of the pass. Downstream of that point, the profiles appear to be steeper than the 1960s survey. Channel filling in the upstream-most 2–3 miles of the pass occurred by the 2000s survey. There is a fair degree of variability in the profile data, however, and determining definitive trends in profile adjustment is difficult.

![Figure 22. Minimum channel bed elevation profiles for South Pass.](image)
The average bed elevation profiles for South Pass shown in Figure 23 indicate the same adverse slope as was observed for Pass a Loutre. Although the data are limited, it appears that the adverse slope begins approximately 4 miles into the pass and continues to the foot of the pass. Again, this is very similar to the characteristics observed for Pass a Loutre and is consistent with the natural behavior of deltaic distributaries.

3.2.3 South Pass channel volume analysis

Incremental erosion and deposition volume between surveys was computed for South Pass using the average end area method similar to that used for the Pass a Loutre analysis. Cross-section coverage for South Pass did not fully capture the entire width of the pass, so the volumes are considered approximations of the actual erosion and deposition between the survey periods. Additionally, the South Pass channel has been subjected to periodic maintenance dredging over various periods of time. Because of this, volumes computed from geometric changes only reflect net deposition.

The estimated erosion and deposition volume between surveys for South Pass is presented in Figure 24. The volumes were computed for reaches 2 miles in length. Positive (+) volume change indicates deposition and negative (−) volume change indicates erosion. For the time period between the 1960s and 1970s surveys, the most upstream portion of South Pass
experienced erosion and steadily transitioned to a depositional trend by the end of the pass. The computed volume change from the 1970s to 1990s survey time period indicates little change in the upstream half of the pass and a predominantly depositional trend in the downstream half of the pass. Interestingly, the trend for the 1990s–2000s time period is exactly opposite of that observed for the 1960s–1970s time period, with deposition at a maximum in the upstream portion of the pass and transitioning to an erosion trend at the outlet of the pass.

Figure 24. Erosion/deposition volume between surveys for South Pass (positive values indicate deposition; negative values indicate erosion).
4 Flow Distribution Analysis

The historical trends in the flow distribution of the Mississippi River through Pass a Loutre and South Pass were investigated using discharge observations collected by the MVN over the study time period. Discharge observations at the head of the passes were available in published MVN Gage and Discharge annual reports through the mid-1990s and as unpublished digital data obtained from the MVN for the mid-1990s to the present. The discharge data for Pass a Loutre and South Pass were tabulated, and the distribution of flow for each pass was computed as a percentage of total Mississippi River discharge at Venice, LA. This procedure was only applicable for the days when observations were reported for Pass a Loutre, South Pass, and Venice collectively.

The computed fraction of flow distribution for Pass a Loutre and South Pass is shown in Figure 25. The flow distribution percentage for Pass a Loutre is fairly consistent at approximately 28%–32% from 1960 to the mid-1970s. After the mid-1970s, the flow distribution percentage decreases steadily to approximately 8%–12% around the mid-1990s to late 1990s. Although there is considerable variability in the data, the rate of decrease in percentage during this time seems to be constant. From the late 1990s to the present, the flow distribution percentage has remained approximately 8%–12% of Mississippi River discharge at Venice.

Figure 25. Flow distribution as a percentage of Mississippi River discharge for Pass a Loutre and South Pass.
For South Pass, the flow distribution percentage was fairly steady at approximately 15%–17% from 1960 to the early 1990s. From the mid-1990s to the present, the distribution percentage slightly decreased to approximately 12%. Currently the flow distribution percentage for both Pass a Loutre and South Pass is approximately the same, approximately in the 8%–12% range. There is significant scatter in the data, most likely due to tidal effects on measured discharge in the passes.

In *The Passes of the Mississippi River*, the flow distribution percentage for Pass a Loutre and South Pass was reported as 36% and 14%, respectively (Corps of Engineers, U.S. Army, First New Orleans District 1939). These distributions were reported as a percentage of Mississippi River discharge at New Orleans rather than Venice but nevertheless provide additional understanding of conditions in the passes for the intervening time between the report and this study. The flow distribution percentage for Pass a Loutre decreased from 36% in 1939 to approximately 30% in 1960. For the longer time period, the flow distribution percentage for Pass a Loutre decreased approximately 6%–8% from 1939 to 1975, or approximately 0.2% per year. Comparatively, the flow distribution percentage decreased approximately 18%–20% from 1975 to the late 1990s, a decline of 0.8% annually. For South Pass, there was essentially no change in flow distribution percentage from 1939 to the 1960 time period. The observed minimal decline in flow distribution percentage at South Pass coincides in time with the decline observed in Pass a Loutre during the mid-1970s to late-1990s time period.
5 **Assessment of River Engineering Activities**

River engineering activities to maintain navigable conditions in the passes of the Mississippi River have occurred since the early to mid-1800s. The first appropriations for the improvement of the entrances to the Mississippi River for navigation were made in 1836 and 1837 (Corps of Engineers, U.S. Army, First New Orleans District 1939). Most concerted efforts at channel improvement were halted during the Civil War. However, efforts were renewed by 1867, and in 1875 a “no cure, no pay” proposition by Captain James Eads was accepted by Congress wherein Eads would construct jetties and auxiliary works to maintain a dependable channel in South Pass for 20 yr.

Since the time of the Eads work, most of the river engineering effort for navigation channel maintenance has been directed at Southwest Pass and South Pass. No significant efforts to improve Pass a Loutre for navigation have been attempted. Efforts to control the flow of river water into Pass a Loutre through construction of willow mattress sills at the head of the pass were attempted as early as the late 1800s, with the intent of increasing discharge in other passes deemed more suitable for navigation.

The authorized navigation channel for South Pass is 30 ft deep \(\times\) 450 ft wide (600 ft in bar channel). Dredging to maintain the channel at this depth was last performed in the mid-1970s (Broussard 2011). Maintenance dredging in South Pass resumed in 1999 at the request of the navigation community, but the channel was only maintained to a 17 ft depth and 300 ft width. The minimum channel elevation profiles presented previously in Figure 22 verify the shallower channel in the 1990s and 2000s. Since the resumption of dredging in 1999, maintenance dredging was intended to be conducted every 5 yr, but funding constraints have limited actual dredging activity. Additionally, the dredging in 1999 was limited to the bar channel and the downstream 4–5 miles of the pass, with none required for the upstream-most 7 miles of the pass below HOP. The upstream limit of dredging for subsequent dredge events was required to be extended upstream toward HOP, indicating that South Pass continues to experience sediment deposition and loss of channel conveyance.
Although no dredging has taken place in Pass a Loutre for navigation purposes, the head of the pass adjacent to the Mississippi River has been used for dredge-material disposal. Dredge-material disposal at the head of the pass occurred as early as 1941, but has been more prominent since the early 1990s as a disposal site for hopper dredges working in Southwest Pass and HOP. A complete, detailed record of dredge-material placement at the Pass a Loutre disposal area was not available, but available records indicate dredge-material disposal volumes ranging from 2.8 million cubic yards (MCY) in 2006 to 11.9 MCY in 2010. Other limited dredge contract data suggest that approximately 30% of the total Southwest Pass/HOP dredge material is disposed at the Pass a Loutre site. Due to the uncertainty in the computed volumetric changes from the hydrographic surveys, it is difficult to correlate the loss of channel capacity observed in Pass a Loutre to the dredge-material volume disposed at the head of the pass. Raphelt (2008) reports limited numerical model study results that suggest dredge material disposed at the Pass a Loutre site may have only increased the rate of deposition that was already occurring within Pass a Loutre.

The Pass a Loutre dredge-material disposal area has been periodically mined for beneficial use in restoration of the adjacent wetland/marsh areas. Mining activities were conducted in 1997, 2003, 2007, and 2009. The approximate volume of material mined from the Pass a Loutre disposal site ranges from 1.0 to 8.4 MCY per mining event. The impact of the mining activity on the channel conditions in Pass a Loutre is not clearly understood, although mined volumes can equal or exceed annual disposal volumes.

Although not specifically involving Pass a Loutre or South Pass, the deepening of the Mississippi River deep-draft navigation channel from –40 ft to –45 ft in 1987 at HOP and in Southwest Pass is an event that may have had potential impacts on Pass a Loutre and South Pass. The most likely impact would be a change in the flow distribution at HOP due to the increased capacity in Southwest Pass.
6 Integration of Results

The results of the various analyses conducted for Pass a Loutre and South Pass were integrated to develop an overall geomorphic assessment of each pass. Typically, this step involves subdividing the study reach into subreaches that exhibit similar characteristics and morphologic trends. However, the passes are relatively short with no definitive changes or breaks in trends, so assessments will be done for each pass as a single reach. The various analyses often produce conflicting results, and river engineering judgment is required to arrive at a final assessment.

6.1 Pass a Loutre assessment

Pass a Loutre has been dominated by a depositional trend throughout the entire study period of 1960–2008. The greatest changes in channel depth due to deposition occurred in the head of the pass adjacent to the Mississippi River, where depth decreases of 80–100 ft were observed between the 1970s and the 1990s. This decrease in depth is most likely associated with the increase in dredge-material disposal in this deep water area during the late 1980s and early 1990s. However, deposition trends in the remainder of the pass indicate a fairly uniform rate of deposition over the time-study time period, suggesting that the dredge-material disposal may have had little effect on deposition trends in the downstream reach of the pass. Raphelt (2008) reached a similar conclusion with limited numerical model tests; however, a more detailed numerical model investigation would be needed to verify this conclusion. During the most recent period between decadal surveys, 1990s–2000s, deposition in the upstream half of Pass a Loutre has significantly decreased, but deposition in the downstream half has continued fairly steadily. Disregarding the upstream-most portion of the pass where dredge disposal has occurred, the average depths in the pass from RM 1.0 to RM 12.0 have decreased by 10–20 ft from the 1960s, and from RM 12.0 to the foot of the pass, the average depths have decreased 4–12 ft over the same time period.

Although there is uncertainty in the volumetric computations due to limited coverage and using the average end area method, the average annual volume of deposition from the 1970s to the 2000s time period ranges from approximately 100,000 cubic yards (CY)/yr/mile to 200,000 CY/yr/mile. Every range and survey time period evaluated indicated a depositional
trend, with the exception of the reach at the very foot of the pass that indicated slight erosion for the 1970s–1990s time period.

The channel bed slope of Pass a Loutre is a normal slope for the first 4 to 5 miles of the pass and transitions to an adverse slope beyond RM 5.0 to the foot of the pass. The reason for this characteristic is not certain. The Mississippi River exhibits this same adverse slope characteristic from approximately RM 35.0 to 40.0, which is common for deltaic channels. Cheniere Pass and Southeast Pass are two significant distributaries of Pass a Loutre within the first 4–5 miles of the pass, and it is possible that additional loss of flow through these distributaries triggers the shift in the channel bed slope.

The Pass a Loutre flow distribution as a percentage of Mississippi River discharge at Venice has decreased from approximately 28% to 32% in 1960 to 8% to 12% in the late 1990s–2000s. Although there has been some decrease in the flow distribution percentage over the entire study time period, the greatest rate of change occurred from the mid-1970s to the late 1990s. The increase in flow capacity of Southwest Pass due to the deepening of the deep-draft navigation channel in 1987 may also have been a contributing factor in the observed decrease in flow percentage in Pass a Loutre. In general, the overall loss of the flow distribution percentage for Pass a Loutre coincides with the general loss of channel capacity due to sediment deposition in the pass.

### 6.2 South Pass assessment

The geometry of South Pass has been influenced by intermittent maintenance dredging over the study time period. The channel of South Pass was maintained to provide a navigation depth of 30 ft up until the mid-1970s, when funding constraints curtailed regular dredging activity. Subsequently, the pass experienced sediment deposition in the range of 5–10 ft throughout the length of the pass. Since 1999, a 17 ft-deep navigation channel has been maintained on South Pass through various dredging events. Limited dredge data indicate the upstream limit of dredging has been steadily migrating upstream toward HOP, suggesting that the depositional trend in South Pass is continuing much in the same way as Pass a Loutre.

The channel bed profile of South Pass reflects the different dredge depths that have been maintained on South Pass for various time periods. The
channel bed profile also exhibits the same trend as observed on Pass a Loutre in terms of slope aspect. The upstream-most 2–3 miles of the pass have a normal slope, while the remaining portion downstream to the foot of the pass has an adverse slope.

The flow distribution of South Pass as a percentage of Mississippi River discharge at Venice has been fairly consistent over the study time period, even as early as 1939. A flow distribution percentage of approximately 15% was observed in 1960, and a slight decrease to approximately 12% was observed from the mid-1970s to the late 1990s. This consistent trend in flow distribution percentage most likely is related to the maintenance dredging that has been periodically conducted in South Pass and has maintained flow capacity along the pass. This characteristic of South Pass is the most different from those observed for Pass a Loutre, where the flow distribution percentage decrease has been more significant.
7 Summary

A geomorphic assessment was conducted for Pass a Loutre and South Pass in the Mississippi River bird’s-foot delta area. The general time frame for the study was 1960–2008. Hydrographic survey data, discharge data for the passes and the river, dredge records, and river engineering activities were analyzed to describe observed changes and trends in channel geometry and discharge characteristics. All results were integrated to form an overall assessment of the morphological processes that have influenced trends within the passes.

The integrated results of the geomorphic assessment for Pass a Loutre and South Pass indicate that the passes have generally been in a predominantly depositional trend throughout the entire study time period. Pass a Loutre has experienced the most depletion of channel capacity from sediment deposition due to there being no maintenance dredging for navigation purposes conducted in the pass. Change in maintained navigation depths in South Pass from 30 ft to 17 ft also has allowed deposition to occur in that pass, but to a lesser degree. The rate of loss of the flow distribution in Pass a Loutre as a percentage of Mississippi River discharge at Venice was the highest during the mid-1970s to the late 1990s and has since equilibrated to some extent. The reason for the increased trend in flow distribution percentage loss from the mid-1970s to the late 1990s is not clear based on available data. Increased dredge-material disposal at the head of Pass a Loutre during this time is a potential factor. However, additional information regarding dredge-material disposal history at the head of the pass, as well as detailed numerical model investigations, is needed to identify the probable causes with a higher degree of certainty.
References


Appendix A: Comparative Cross Sections for Pass a Loutre
Pass a Loutre Cross Section Comparison
Section R-1.0

Pass a Loutre Cross Section Comparison
Section R-1.5
**REPORT DOCUMENTATION PAGE**

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<td>A geomorphic assessment was conducted for the Pass a Loutre and South Pass deltaic channels of the Mississippi River birds-foot delta. The purpose of the study was to document long-term morphological trends in the channels through the analysis of historical stream gage data, hydrographic surveys, dredge data and other information on anthropogenic activity in the study area. The physical limits of the study were from Head of Passes to the Gulf of Mexico outlet for both passes, and the time period was focused from 1960 to 2008. Specifically, the geomorphic assessment tasks consisted of data compilation, a geometric data analysis, analysis of stage and discharge data, and assessment of historical river engineering activity in the study area. The results of all analyses were integrated to develop an understanding of the morphologic trends in the study area. Information derived from the geomorphic assessment assists in evaluating potential activities in the area such as river diversions for freshwater marsh restoration.</td>
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