National Park Service
U.S. Department of the Interior

Mammoth Cave National Park
Mammoth Cave, Kentucky

Mammoth Cave National Park
Green River Ferry Service Life Analysis

Green River Ferry in operation.
Source: Volpe Center photographs, Dan Mannheim (June 2015)

November 9, 2015

Volpe The National Transportation Systems Center

U.S. Department of Transportation

Contents

Report Notes

This report was prepared by the U.S. Department of Transportation John A. Volpe National Transportation Systems Center, in Cambridge, Massachusetts. The project team was led by Daniel Mannheim of the Transportation Planning Division with support from Heather Richardson of the Transportation Planning Division. Oversight was provided by David Daddio of the Transportation Planning Division

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Definitions

The following terms are used in this report:

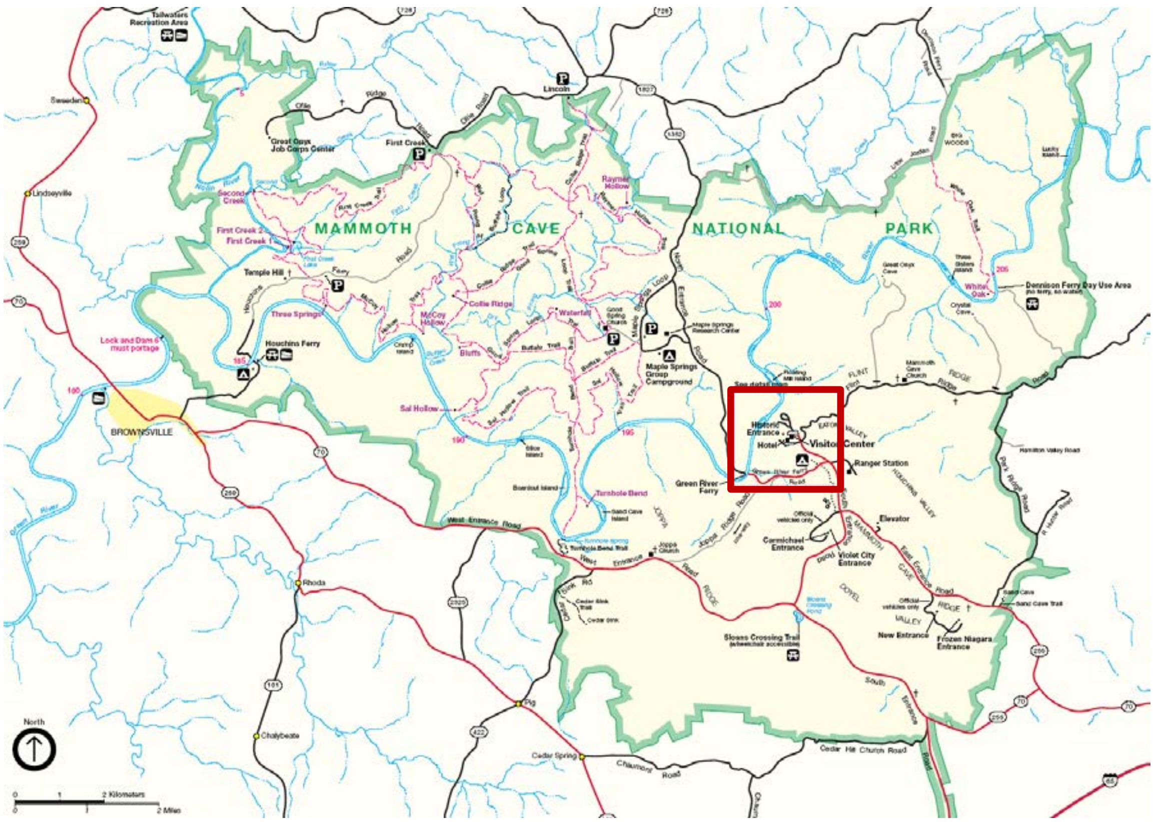
CMAQ	Congestion Mitigation and Air Quality Program
DOE	Department of Energy
DOT	Department of Transportation
FHWA	Federal Highway Administration
MACA	Mammoth Cave National Park
NPS	National Park Service
OEM	Original Equipment Manufacturer
PUSO	Public Use Statistics Office
SLEP	Service Life Extension Program

Introduction

Mammoth Cave National Park (MACA), which was established as a national park in 1941, is located in Mammoth Cave, Kentucky northeast of Bowling Green (see Figure 1). The park includes more than 400 miles of cave passageways and 53,000 surface acres with trails and recreation opportunities. The Green River flows from the northeast corner of the park to the southeast corner, bisecting park roadways at Houchins Ferry Road and Green River Ferry Road. Ferry service has been used to cross the river at these points since before 1900. At one time, there were 12 ferry sites operating within what became Mammoth Cave National Park. Operation of the ferries at that Green River Crossing and the Houchins Crossing were undertaken by the NPS soon after Mammoth Cave was created.

Figure 1: Map of Mammoth Cave National Park

Source: http://www.closertonature.com/maps/mammoth-cave-map.htm



Purpose of this Study

Both the Green River (built in 1989) and Houchins (built in 1979) ferries are nearing the end of their expected useful lives. At the same time, there are ongoing and upcoming changes in the river depth that impact ferry operations. Currently, the Green River Ferry Crossing is shut done 1 to 3 weeks a year due to low water levels and the inability of the ferry to reach the concrete ramps. During other low water events, the ferry is limited to one vehicle. Additionally, the planned removal of Lock and Dam 6 upstream from the Green River Ferry Crossing will result in a three feet drop in the water level that will occur at the Green River Crossing Site. This will significantly increase the time the ferry is closed. Finally, the current weight capacity of the ferry vessels are eight tons, which is not enough to carry heavy equipment like graders across the river.

The NPS Southeast Regional Office asked the U.S. Department of Transportation (USDOT) John A. Volpe Transportation Systems Center (Volpe) to analyze current ferry operations and recommend whether the park should pursue service life extension improvements to the current vessels or seek to purchase a new vessel for the Green River Ferry service given the issues facing the service. Staff from Volpe conducted a site visit on June 11, 2015 and met with park staff to discuss needs, constraints, and opportunities for the ferry service. The analysis will take into account a number of technical issues related to ferry operations as well as visitor experience and considerations related climate change and its impact on the river environment.

Background

Green River Ferry Road is a primary north-south route through the park, providing access to recreational trails and communities on both sides of the Green River, which divides the road and requires a ferry to cross. The National Park Service (NPS) began operating the Houchins Ferry in 1979 and the Green River Ferry in 1989 using vessels owned and operated by the park. The Houchins Ferry ceased operations in 2013 due to a government sequester and significant operating costs; however, the park still owns the vessel. The Green River ferry has continued to operate year round with the same vessel since service inception more than 25 years ago. The Green River Ferry operates daily (except for Christmas day) from 6:00 AM to 10:00 PM free of charge to users (see Table 1).

Table 1
2014 Green River Ferry Operating Information
Source: Mammoth Cave National Park and NPS Public Use Statistics Office

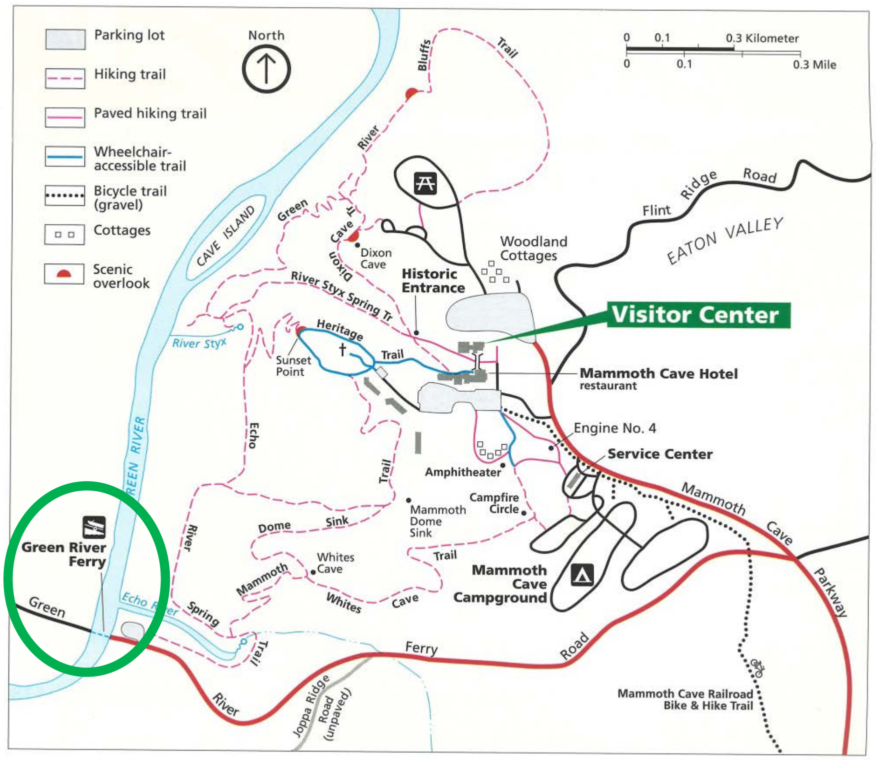
Operating Days per Year	364
Hours per Day	6:00 AM to 10:00 PM
Operator Shifts	14 per week
Vehicle Capacity on Ferry	3 vehicles or maximum of 8 tons
Trips per Year	90,000
Vehicles per Year[1]	135,000
Passengers[2] per Year	270,000
Fuel	Biodiesel (spring-fall) Regular diesel (winter)
Average Ferry Operating Costs per Vehicle Carried	~$2.00
Guide System	Cable guides replaced every 3-5 years

The Green River Ferry Crossing is located 2.0 miles from the MACA visitor center and is shown circled in green in Figure 2. The ferry crossing ramps on both sides of the river are concrete that drop off to the river bottom. Historic retaining walls placed by the Civilian Conservation Corps flank the sides of each ramp as they approach the river. The Echo River parking area is about 300 feet before the ferry ramp on the east side of the Green River and currently has capacity for approximately 40 cars.

[1] Assumes 1.5 vehicles per trip
[2] Based on estimates of approximately 2.0 passengers per vehicle; the total does not include bicyclists or pedestrians.

In 2010, a legislative change redefined ferries under the jurisdiction of the US Coast Guard from those that charge a fee to those that carry 6 or more passengers, which brought oversight of Green River ferry operations under the jurisdiction of the Coast Guard. Prior to the rule change, vessels that did not charge a fare were exempt from Coast Guard regulations and requirements. The Coast Guard requirements include inspection every two years and dry docking for a comprehensive inspection by the USCG every 5 years. The Houchins Ferry was pulled from the water in early 2015 and was undergoing improvements to pass inspection at the time this report was being written. The Houchins Ferry will be used at the Green River Ferry Crossing while the Green River Ferry is dry docked for its inspection, which is planned to start in October 2015.

Figure 2: Detail Map of Visitor Center and Green River Ferry Crossing in MACA from inset box in Figure 1. The Green River Ferry Crossing is circled in green.
Source: NPS



Use and Visitation

There were more than of 520,000 recreation and 130,000 non-recreational visitors to MACA in 2014.[3] The Green River Ferry provided crossing for more than 96,000 vehicles in 2014 and averages nearly 90,000 vehicles per year.[4] Figure 3 tracks the total visitation by type from 2006-2014. The non-recreational visitors are about one-quarter of the recreational visitors. Figure 4 breaks down 2013 visitation by month and shows peak recreation visitation from May through August. Peak Green River Ferry use also occurs between May and August, as shown in Figure 5. It was not possible to further breakdown ferry use by recreational and non-recreational vehicles, which have different persons per vehicle multipliers based on

[3] NPS Public Use Statistics Office (https://irma.nps.gov/Stats/Reports/Park/MACA)
[4] Average of ferried vehicles from 2006-2014 (NPS Public Use Statistics Office)

standards set by the NPS Public Use Statistics Office. This data is not available. Such analysis can be performed when the data is obtained.

Figure 3: Annual MACA Visitation, 2006-2014
Source: NPS Public Use Statistics Office

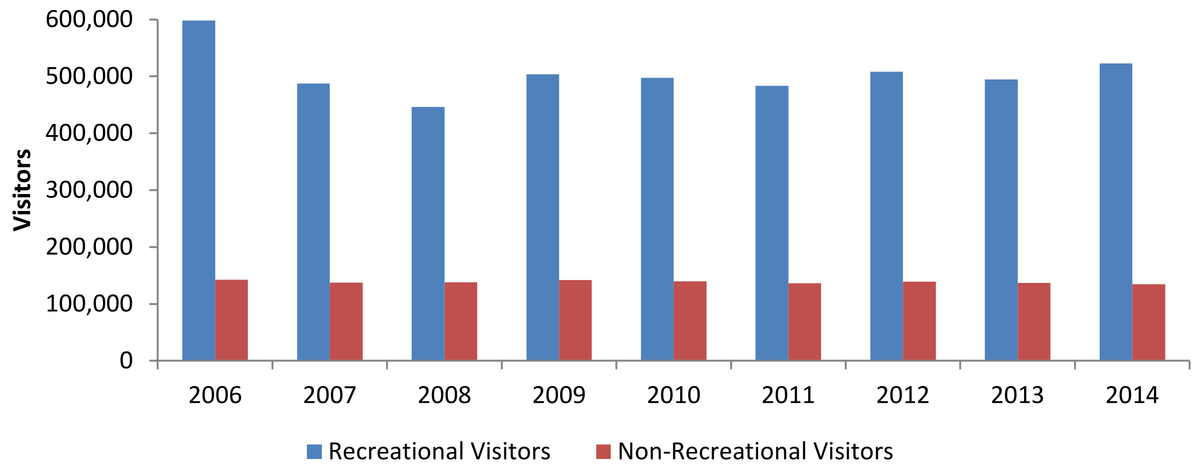


Figure 4: 2013 Monthly MACA Visitation
Source: NPS Public Use Statistics Office

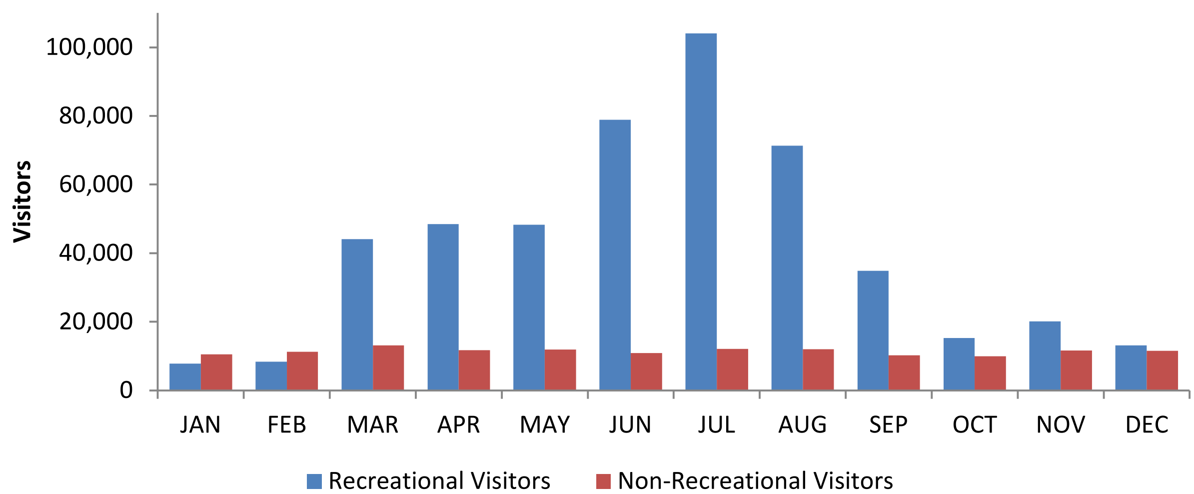
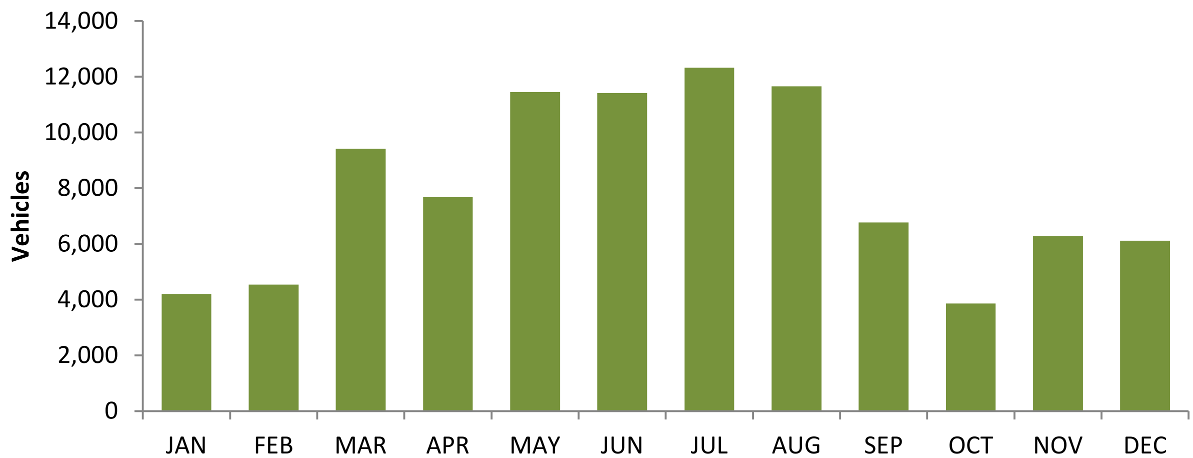


Figure 5: 2013 Monthly MACA Green River Ferry Use
Source: NPS Public Use Statistics Office



Ferry operators and park staff have stated congestion along Green River Ferry Road can be problematic during peak season (May-August). According to their observations, as many as 30 vehicles may line up along the road waiting to cross the Green River. At low river depths which occur during the peak season, the round trip may take seven minutes or a maximum of seven trips per hour.[5] The trip takes longer at higher river depths because the distance between where the water reaches the ramps is longer. With three vehicles per trip, the thirtieth vehicle in line would have to wait more than an hour to cross the river. Such congestion and long wait times could degrade the visitor experience. While congestion does not seem to back up to the intersection with the Joppa Ridge Road intersection a half mile east from the ramp, it could hurt visitor experience for those trying to access the Echo River parking area for hiking and canoeing.

For the purposes of understanding the nuances of congestion at the ferry, the project team analyzed data from July 2015, the busiest month of the year for 2015, in further detail to assess actual conditions. Assumptions are as follows in Table 2.

[5] Trip time varies by river height. Higher river depths require longer crossing times than lower depths.

Table 2: General Assumptions on Ferry Operation
Source: Mammoth Cave National Park and the Volpe Center

One-Way Trip Duration (minutes)	3.5
One-Way Trips per Hour	17
Round Trip Duration (minutes)	7
Round Trips per Hour	8
Maximum Vehicles per Hour (both directions)	50
Maximum Vehicles per Hour (one direction)	25
Maximum Vehicles per day (both directions)	816
Maximum Vehicles per day (one direction)	408
% Trips Northbound/Westbound (from Visitor Center) 7-11 am weekends	45%[6]
% Trips Southbound/Eastbound (toward Visitor Center) 7-11 am weekends	55%
% Trips Northbound/Westbound (from Visitor Center) all other times of day and week	65%
% Trips Southbound/Eastbound (toward Visitor Center) all other times of day and week	35%

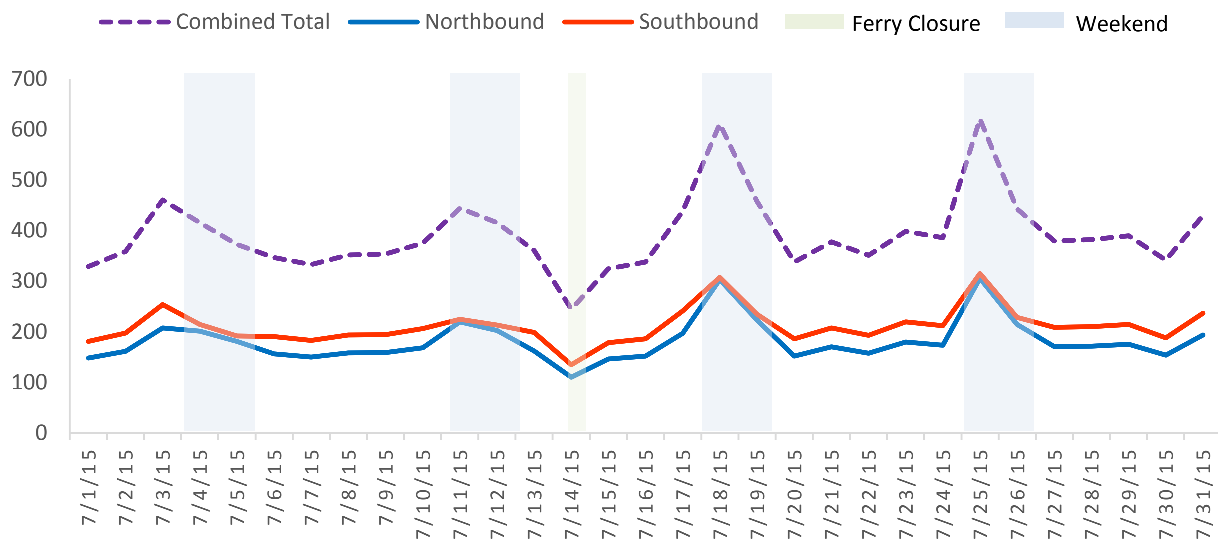
Ferry operators tally the total vehicle count by hour, differentiating among local traffic, visitors, and government vehicles. In determining local traffic versus visitor, decals on the state license plate issued by surrounding counties are used as an indicator of local use. Government and some local vehicles may be heavy equipment, in which case three vehicles would not necessarily fit on the ferry due to the 8-ton weight capacity. Therefore, some of the assumptions are generalizations and while good gauges, do not specify vehicle size or number of vehicles on a given one-way trip. Assuming the previously stated crossing times and ferry capacity, movement of a total of 816 maximum vehicles is possible per day based on 16 hours of ferry operation between 6:00 am and 10:00 pm. According to the ferry operator tallies for the month of July 2015, the maximum vehicle count in a single day was 621 on Saturday July 25th, indicating the ferry is operating within its capacity; however, the traffic must be looked at on an hourly basis to understand congestion since vehicles are not spread evenly throughout the day.

There were 16 instances in which the hourly vehicle count was greater than a maximum capacity of 50 vehicles per hour during in July 2015, indicating the ferry was operating at capacity. It should be noted however, that the 50 -vehicle number is based on average crossing time of seven minutes. As mentioned above, if the water level is lower, the crossing time is faster and there is potential for more crossings to occur and thus higher overall vehicle capacity. When directional split is taken into account according to the percentages listed in Table 2, there are five instances where the northbound morning travel indicates congestion conditions (25 or more vehicles in a given direction), and 36 instances of southbound congestion throughout the rest of the day, between the hours of 11 am and 8 pm. When the ferry is operating at maximum capacity in terms of vehicle count, it can be inferred that vehicles are queuing up along the road to board the ferry. It should also be noted that numbers below the stated threshold of 25 may also present congestion conditions since the data is not detailed down to portions of the hour. In addition, the data used in this study does not include counts and timing of canoes and other recreational boat launches that share the same ramp as the ferry. The effect of these boat launches on ferry wait times will be described in further detail below.

[6] Directional percentages are based on anecdotal evidence by ferry operators as follows: Northbound 45%, Southbound 55%, except on weekday mornings between the hours of 7:00 am and 10:30 am, it is observed as Northbound 65%, Southbound 35%. Since tallies are by hour, the 10:30 am period is rounded to 11:00 am.

The graphs on the following pages summarize the findings for the month of July 2015. It is clear in Figure 6 that the weekends are the most likely times for congestion to occur. The weekends show higher average vehicle counts at all times of day except during the hours before 9 am, as seen in Figure 7. The afternoon hours tend to be the busiest on average for all days of the week, and stay above 40 for the weekend days between 11 am and 5pm. Figure 8 depicts the hourly vehicle count on the ferry by direction of travel.

Figure 6: July Total Daily Vehicle Count[7]
Source: Mammoth Cave National Park



[7] On July 14 between the hours of 5 pm and 10 pm (closing), the ferry was not in operation. It should be noted that this closure affects the total vehicle count as well as July 14 daily average and average for this period of the day over the month-long dataset.

Figure 7: Average Hourly Vehicle Count Weekday vs. Weekend
Source: Mammoth Cave National Park

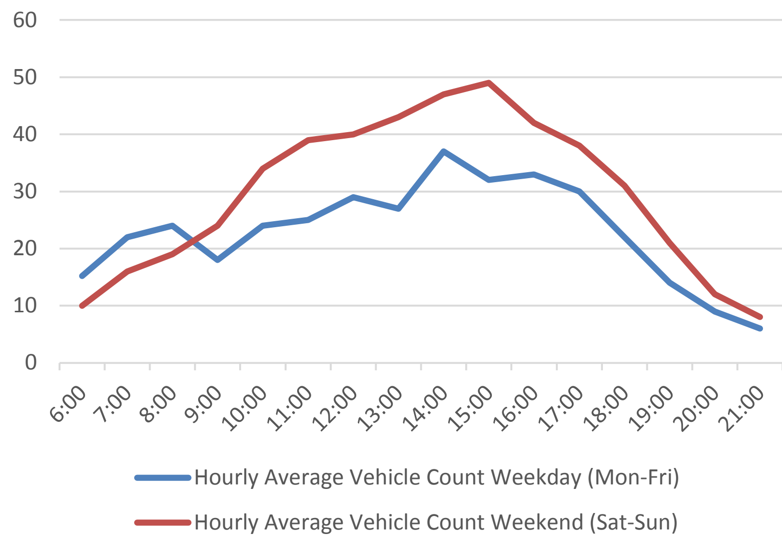
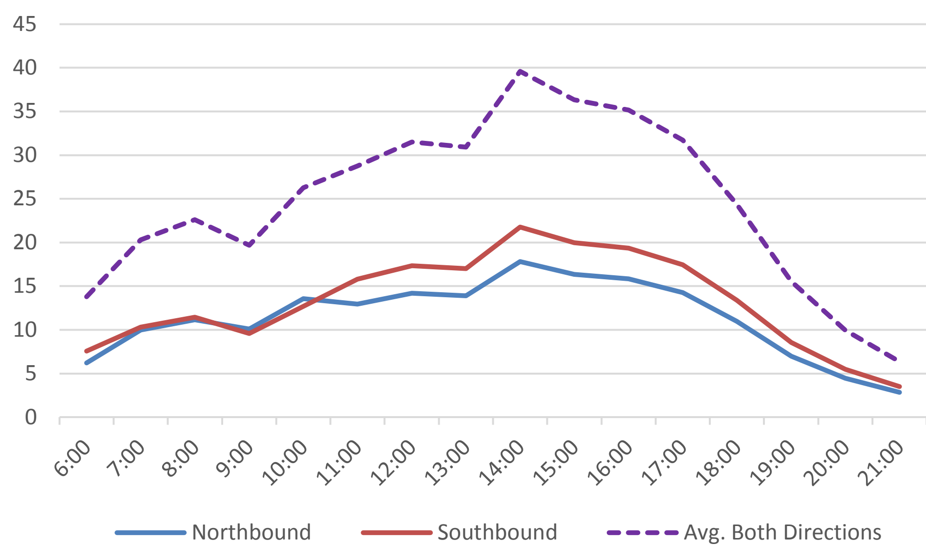


Figure 8: Average Hourly Vehicle Count
Source: Mammoth Cave National Park



Congestion at the ferry crossing is further exacerbated by use of the ramps for entry and exit of canoes and jon boats.[8] There were approximately 15,500 canoes and 500 jon boats that came in/out at the ferry crossing in 2014. Ferry operators wait at the opposite bank while the recreational boats use the ramp to

[8] Jon boats are flat bottom boats 8-24 feet long that are suitable for fishing.

avoid potential safety conflicts. The jon boats require time and significant ramp space for the boat owner to bring their vehicle and trailer to the ramp to load/unload the boat to/from the water. The process can take up to ten minutes depending on the efficiency of the boat owner and makes existing congestion worse when the launch or removal takes place during peak demand for the river crossing. There are plans in place to create a canoe launch platform on the far side of the Echo River parking area that should help mitigate some congestion from the canoe activity, although implementation is not expected until at least 2020.

Ferry Condition, Features, and Regulatory Issues

The Green River Ferry is a double-ended, three-vehicle, cable-guided ferry. The ferry has one diesel engine propelling a paddlewheel through a hydraulic system. This system allows the ferry to travel both directions across the river without turning around. Specifications of the Green River Ferry are shown in Table 3 below.

Table 3

Green River Ferry Principle Characteristics

Source: Mammoth Cave National Park

Length (w/out ramps)	59.79 feet
Beam	19.71 feet
Depth	2.75 feet
Draft	1.4 feet
Registered tonnage	27 tons
Displacement	71,457 lbs (31.9 Long Tons)
Cargo/Vehicle Capacity	16,000 lbs (7.14 Long Tons)
Passenger Capacity	18 passengers plus 1 crew
Propulsion system	Diesel-Hydraulic
Propeller	1 Paddlewheel
Horsepower	60 Horsepower
Build Year	1989

There is only one ferry operator on board at a time. All systems on the ferry are controlled by the operator from the pilot house. The operator can control the main engine, paddlewheel, generator, ramps, and stop signs without leaving the operator station.

The Green River Ferry is over 25 years old and is nearing the end of its expected useful life. In particular, there is noteworthy corrosion present on both the hull plating and internal stiffeners. Coating failure on the inside of the hull voids has significantly contributed to the steel deterioration. A full ultrasonic hull scan will be required to define the extent of corrosion and determine which areas of hull need steel replacement. Additionally, the void access hatches on the deck of the ferry are maintenance-intensive and prone to leaking.

The pilothouse on the Green River Ferry is another area of concern. The current pilot house is very narrow and uncomfortable for the operator of the ferry, who occupies the cabin for eight hours at a time. A limited number of windows on the forward and aft side of the pilot house also lead to large blind spots. These blind spots are of particular concern when canoers are trying to access the boat ramp during ferry operations. There is no direct line of site from the operator station to the kayak-removal area, causing safety issues during operation.

A recent limitation on carrying capacity of the ferry has also impacted park operations. The ferry was operated as an uninspected passenger vessel for approximately the first 20 years of service. During this time, the ferry was used to transport equipment up to 12 tons (24,000 lbs) in weight. However, in 2010, U.S. Coast Guard regulatory changes went into effect requiring that the vessel become an inspected passenger ferry. As part of the Coast Guard inspection, a stability test was performed on the ferry. The results of that stability test limited the carrying capacity of the ferry to 8 tons (16,000 lbs). This impacted park operations, as described in the Heavy Equipment Transport portion of the Mission Section later in this report.

The most recent issue affecting the Green River Ferry is a new U.S. Coast Guard requirement to have passenger safety gates on the forward and aft ends of the ferry. While the Coast Guard requirements came into effect for the MACA ferries in 2010, the ferry vessels were not scheduled for inspection prior to 2014 and the passenger safety gate requirement was not raised as an issue. Historically, passengers are required to stay in their vehicles and very few pedestrians and bicyclists use ferry, so the safety gates were not a primary concern. With the recent inspection of the Houchins ferry, the U.S. Coast Guard is requiring that MACA install safety gates on both the Houchins and Green River ferries. The pedestrian gates will need to be in place on the Houchins ferry before it can be used at the Green River Ferry crossing in fall 2015 while the Green River ferry is dry docked for inspection.

The propulsion, electrical, and auxiliary systems onboard the Green River Ferry appear to be in good condition. The main engine was replaced in 2013 and still has low engine hours. The generator is also relatively new, and the same model is still in production by the manufacturer. The hydraulic system is in good working order. Original Equipment Manufacturer (OEM) support and spare parts should be available for the foreseeable future.

Alternative Crossing Options Considered

MACA completed an environmental assessment for the rehabilitation of the Green River Crossing in 2011. Low and high level bridges were among the alternatives considered but dismissed. A low level bridge would not meet Federal Highway Administration (FHWA) standards related to high water events. While a high level bridge would meet such standards, it would have extensive environmental impacts. The bridge and connected roads would have a large footprint (both length and height of bridge out of context with the surrounding area), require excavation that could impact the cave and karst systems, have a major visual impact, and require removal of vegetation that could impact the habitat of federally threatened or endangered species. The bridge would also cost approximately $50 million to build with additional annual maintenance costs potentially exceeding those to operate the ferry. The study concluded that a bridge would be “inconsistent with the purpose of the project.”[9]

Missions

This section provides an overview of the key missions performed by the ferries at MACA. These missions include the transport of private and government vehicles and heavy park equipment. The ferry landing ramp also serves as the entry and exit point for canoes and jon boats on the Green River.

Vehicle Transport

The Green River Ferry transports an average of nearly 90,000 vehicles annually. The ferry has an eight ton capacity and can carry a maximum of three vehicles per one-way trip. The ferry carries recreational visitors to the park as well as non-recreational travelers who are typically from the local community. The

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[9] NPS. *Finding of No Significant Impact (FONSI): Green River Ferry Improvement Project*. Mammoth Cave National Park, Kentucky, November 2011.

ferry saves local travelers significant time and fuel by reducing the 40 mile distance to travel around the park. Park staff use the ferry to access areas of the park on both sides of the Green River more efficiently than driving around the park boundary. The ferry also serves as access for emergency vehicles on both sides of the park.

Heavy Equipment Transport

The park is responsible for maintaining the facilities on both sides of the Green River. Some maintenance activities require the use of heavy equipment such as a 12 ton grader, a dump truck, local emergency vehicles, equipment used by local utilities, and private individuals and contractors. The park's dump truck weighs less than 8 tons when empty but exceeds the limit when filled with salt for winter snow operations or with excavated fill from projects. Since the ferries have a current capacity of only 8 tons, the equipment is driven approximately 40 miles around the outer boundary of the park instead of crossing the river via ferry. The ferry operators must also limit crossings to a single vehicle with something in tow, such as a horse trailer, because they approach the maximum capacity.

As MACA considers whether to extend the service life of the current vessels or replace the Green River Ferry with a new boat, it must take into account the future of these missions. Issues involving capacity and weight limitations are relevant when considering anticipated increases in visitation and congestion, whether the ferry should be used for more efficient movement of equipment throughout the park, and the impacts of climate changes on the river environment. Capacity to handle increased visitor use is a high priority and each option should be evaluated regarding how it addresses the ability to move more passengers. Regarding heavy equipment and ferry weight capacity, the park should determine the frequency with which it moves the grader and dump truck, and the impact to maintenance project costs from having to drive around the park compared to the cost of increasing the weight capacity of the existing vessels or purchase a new ferry. Finally, river depth may become lower with removal of Lock and Dam 6, which pools the Green River within the Park and with potential changes in climate. Increased instances of river depths below what the ferry can operate will impact the park's ability to transport vehicles and equipment, especially during peak season. At the same time, the ferry also ceases operation when the river depth exceeds 21 feet, due to issues with currents and the height of the guide lines. Increased extreme storm events from climate change could increase the frequency of the river exceeding this depth.

Options and Analysis

This study uses a Business Case Analysis framework to evaluate recapitalization options for the Green River Ferry. The "business case" approach is a form of cost-effectiveness analysis. Starting with a defined set of requirements or capabilities – in this case the mission requirements as described above – the analysis identifies the alternative that meets those requirements at the lowest overall lifecycle cost. Additional background and assumptions regarding this type of analysis is in Appendix E.

The alternatives examined here include extending the service of the existing ferry with and without additional carrying capacity or constructing a new ferry. Leasing was not considered as an alternative due to the lack of viable leasing options in the U.S. marketplace.

For each alternative, the project team's analysis examines the costs across the lifecycle, including upfront capital costs for vessel construction, conversion, or service life extension and ongoing costs for operation and maintenance, including fuel; and residual value. For simplicity, certain costs were excluded from the analysis to the extent that they are unavoidable and/or do not vary across the alternatives. An example is crew labor, which is incurred regardless of the selected option.

Note that while cost estimates in this study have been prepared with care using the best available information, they are intended as an initial, high-level overview of alternatives, with the goal of identifying options that may warrant further in-depth study. They may not reflect actual costs and are used for general comparison purposes only. Finally, this report identifies areas of potential risk associated with different recapitalization approaches, but it does not include a comprehensive analysis of those risks.

Recapitalization Options

Like any asset, a ship is designed and built to serve for a particular length of time, after which recapitalization is required. This “design service life” is typically 30 years for commercial and government vessels. Many factors can affect a vessel’s service life, such as:

- Original design service life
- Quality of original construction
- Utilization rates
- Operating environment
- Resources dedicated to routine maintenance
- Major and minor overhauls to replace or upgrade primary and secondary systems

The Green River Ferry, built in 1989, is nearing its 30-year service life, and recapitalization is required.

Option 1: SLEP maintaining 8 ton carrying capacity

In this option, the Green River Ferry would be recapitalized through a service life extension program (SLEP) to notionally extend its operational life by 30 years (the end of the analysis period) to allow comparison against the other recapitalization options.

A SLEP is a recapitalization approach that extends the life of that system beyond its original service life. It extends the service life of a vessel by replacing obsolete, unsupportable, or maintenance-intensive equipment. Ultimately, a SLEP is aimed at saving the National Park Service money and improving the availability of an asset beyond its designed service life. A SLEP will include a complete structural evaluation and/or overhaul for the Green River Ferry. Whenever possible, upgrades will incorporate new, proven technologies to reduce lifecycle costs. A SLEP should:

- Reduce lifecycle costs,
- Seek energy efficiency, and
- Comply with all current government environmental and safety standards to the greatest extent possible.

The SLEP specifications analyzed also include an optional upgrade to enable full year biodiesel fueling. The ferry currently uses biodiesel three seasons and switches to diesel in the winter due to lower ambient temperatures. The SLEP can add the capability to use biodiesel year-round by installing a fuel tank heater, fuel line fluid warmer, and engine block heater. This upgrade improves the sustainability of the operation and may make the recapitalization eligible for clean energy grants. A set of specifications for SLEP have been created for the current Green River Ferry and are provided in Appendix A.

Option 2: SLEP increasing carrying capacity to 12 tons

Option 2 incorporates all of the changes in Option 1 as a service life extension but also includes upgrades to increase the vessel’s carrying capacity from 8 tons to 12 tons by adding pontoons for more flotation capacity. A SLEP is typically not designed to increase a ship's capability; however, this SLEP does include optional upgrades to increase the ferry’s carrying capacity. The specifications for option are also in Appendix A.

Option 3: Replacement

Under this scenario, the National Park Service would construct a new, purpose-built ferry, based on requirements developed in coordination with MACA and in compliance with all U.S. Coast Guard and EPA regulations. A new ferry would be fully capable of meeting the additional requirements of the park's transportation missions.

Preliminary specifications have been created for a replacement Green River Ferry. These specifications are included in Appendix B.

Total Cost of Ownership

Total ownership costs for any transportation system can be broken down into three basic activities: acquisition, operation, and disposal/residual value.

Acquisition Costs

Acquisition costs include activities involved in the design, construction, outfit, provision, contract for, and placement of the new system into service:

- *Design* includes all of the naval architecture and marine engineering costs for the new system. This includes any design costs for the new ferry, or all engineering required for the SLEP work package for the current ferry.
- *Construction* includes all shipyard costs for construction or service life extension of the ferry.
- *Spare parts* and consumables needed for routine maintenance and repairs to critical operational and life-safety equipment and systems.
- *Provisioning Technical Documentation* (PTD) consists of technical manuals, operating manuals, spare parts lists, and preventive maintenance and repair procedures.
- *Warranty* is the cost of providing a limited warranty on the ship and any equipment installed by the shipyard. The term of the warranty normally lasts for three years after vessel delivery.
- *Contracting* includes the cost of construction management services, such as a general agent or contractor that represents the interests of the owner (i.e. NPS) during the acquisition process.

Operating Costs

Operating costs include essential items such as operating tempo, fuel, maintenance, regulatory fees, and dry-docking costs:

- *Operating Tempo* - The Green River Ferry operates 364 days per year, 16 hours per day. In 2014, the Green River Ferry carried 96,052 vehicles.[10] At an average of 1.5 vehicles per ferry trip, the Green River Ferry would make approximately 176 one-way trips per day.

- *Fuel Consumption* - Fuel consumption rates for the current ferry (SLEP option) were calculated based on the engine's specific fuel consumption and power ratings of the current installed engine. Exact fuel consumption rates for the new ferry (replacement option) cannot be known at this point because the new ferry has not yet been designed and propulsion equipment has not been chosen. Instead, fuel consumption rates were estimated as being the same as the current ferry. Market research was performed into marine diesel engines for small ferries, and it was determined that the engine installed on the current Green River Ferry is very fuel efficient. If the new ferry continues to be diesel powered, it is unlikely that any fuel savings could be realized. Therefore, fuel consumption rates for the new ferry are estimated to be the same as the current ferry. Costs per gallon of fuel will vary throughout the life of the ferry as the fuel costs change. Fuel costs are based on the U.S. Energy Information Administration (EIA) 2014 Annual Energy Outlook.

- *Maintenance* - As a ship ages, maintenance costs increase. Empirical data shows that maintenance costs tend to be flat for the first several years of operations as the ship will require only general maintenance, such as filters, oil changes, and painting. However, as more years pass, the maintenance costs tend to increase exponentially over the life of the ship. Engines will require overhauls, pumps and valves will require replacement, and coatings will fail. When the ship reaches the end of its design service life, essential equipment will become unsupportable,

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[10] NPS Public Use Statistics Office

requiring systems to be completely re-engineered and replaced. The current maintenance costs for the existing ferry, currently 26 years old, were provided by MACA. Because the new ferry will have similar equipment and design to the current ferry, it is reasonable to assume that the maintenance costs for the new ferry would be equivalent to the current ferry when it was new. Using empirical data, the maintenance costs were calculated for each year of operation of the new ferry, as shown in Appendix D.

- *Regulatory fees and dry-docking costs* - Data on regulatory fees and dry-docking for the current ferry was provided by MACA. Regulatory fees and dry-docking costs for the new ferry are expected to be the same.

Disposal Costs/Residual Value

Disposal costs include all costs involved in properly disposing of a system at the end of its useful life. Cargo vessels and passenger ferries are often sold to other companies for continued operation, while naval vessels are sometimes transferred to allied governments for further use. Older ships and special-purpose vessels are less likely to have a second-hand market, and are more likely to be dismantled and recycled.

In this analysis, the current ferry or new ferry would exceed 30 years of age when disposal is necessary. These ferries will have no resale value and will be dismantled and recycled in a manner consistent with other ships. Most of the value of the ship will come from the value of the scrap steel. This steel scrap value can fluctuate significantly, and stood at approximately $200 per ton of steel in April 2015.[11] Industry experts estimate scrap value based on empirical data showing approximately 60 percent of the weight of the ship is in steel. The estimated residual value for Options 1 and 2 is about $3,800 while the residual value for a new ferry is roughly $4,600.

Analysis Period

It is necessary to identify a specific analysis period for any business case analysis to evaluate the Net Present Value (NPV) fairly across all options. For this study, the analysis period contemplates a total service life of 30 years. The timeline begins with a SLEP or new construction in Year 0, and ends after 30 years of operation.

Results

Capital and Total Lifecycle Costs

The project team analyzed the total upfront capital costs and estimated lifecycle costs for the anticipated 30-year operational life for Option 1 (SLEP no added capacity), Option 2 (SLEP with added capacity) and Option 3 (Replacement) in order to identify the most cost effective option for recapitalization. The results of this analysis are shown below in Table 4.

[11] MARAD Domestic Scrap Steel Report, March 2015

Table 4
Total Estimated 30 Year Lifecycle Costs (in thousands)

Cost Component	Option 1: SLEP no added capacity	Option 2: SLEP added capacity	Option 3: Replacement
Acquisition (Capital) Costs	$943,929	$ 1,132	$ 1,979
Operation Costs:			
Fuel Costs	$ 2,178	$2,178	$ 2,178
Maintenance Costs	$ 362	$362	$ 187
Regulatory and Dry-docking Costs	$ 305	$305	$ 305
Residual Value (Scrap Value)	$ (4)	$(4)	$ (5)
Total, Undiscounted	**$3,785**	**$ 3,973**	**$ 4,640**
Total, 7 percent Discount Rate	**$1,931**	**$ 2,119**	**$ 2,906**
Total, 1.4 percent Discount Rate	$3,167	$ 3,355	$ 4,064

Capital costs for Option 1-3 range from approximately $940,000 to $2 million. Option 1 (SLEP no added capacity) has the lowest estimated total ownership cost of the three options at $3.79 million, undiscounted. This is primarily due to the additional cost of pontoons for Option 2 and higher acquisition costs of a new ferry in Option 3 compared to a service life extension. By comparison, the pontoons for Option 2 increase the SLEP acquisitions costs by nearly $200,000 and Option 3 has an estimated total ownership cost of $4.6 million.

Taking into account the time value of money, Options 1 and 2 are even more favorable given the extra upfront costs of replacing rather than repairing the vessel.

Fuel use is expected to be the same for all options. Maintenance costs are expected to be almost double for the SLEP options over the life of the ship, which would add to the park's annual costs.

When considering the cost differential between Options 1 and 2 and the increased capacity of the ferry from 8 to 12 tons, a key aspect is the frequency with which the ferry needs to transport loads greater than 8 tons. According to park operations, on average one piece of heavy equipment that exceeds the eight ton limit would use the ferry per day. Assuming a round trip of eighty miles to go around the park would require two hours of labor at $25 per hour, driving around the park would cost $13,000 per year (based on 260 days) in labor alone. Over 30 years, the labor costs would reach $390,000. The estimate is conservative in that it does not include fuel or other operations and maintenance costs. Additionally, some equipment travels at much lower speeds and would require more travel time than used in the estimate.

Qualitative Comparison

The SLEP option without additional carrying capacity would essentially operate the same vehicle transport mission as today and will not be able to accommodate heavy equipment transport. Option 2 with increased carrying capacity from additional flotation would enable loads up to 12 tons and allow heavy vehicle transport. The length of the ferry will not change under either SLEP option, which would continue to limit the overall combined length of vehicles able to cross.

The new ferry will be designed to be slightly longer and with a greater carrying capacity. This will allow the new ferry to carry more vehicles at one time (up to three full-size pickups at one time) and heavier vehicles such as graders and dump trucks (up to 12 tons). The new ferry could also be designed with an even greater length, allowing the ferry to transport up to four vehicles at once to reduce potential congestion.

Conclusions

The 30 year lifecycle costs of a new ferry (Option 3) exceed those of a basic SLEP (Option 1) by approximately one million dollars (total with seven percent discount rate (see Table 4)). Based on the data available, it does not seem that there is significant congestions during the peak use times to justify funding for a vehicle that can carry more than three vehicles. However, the frequent possible use of the ferry by vehicles weighing in excess of 8 tons (daily according to the park), there is a need for the ferry to transport heavier vehicles. SLEP Option 2 can provide increased capacity for approximately $188,000 more than the total cost SLEP Option 1 over 30 years. The cost differential between Options 2 and 3 is nearly $670,000.

Next Steps

Design and Engineering

Ferry SLEP (Options 1 and 2)

If the SLEP is to be undertaken, the ideal time would be during the next drydocking of the Green River Ferry, which should occur in 2019. Assuming that it would take approximately six months to develop the SLEP work package and additional time for contracting, the preliminary specifications would need to be completed by mid-2018. The specifications should be of sufficient detail that a shipyard could create a conceptual design of modifications and upgrades taking place.

New Ferry (Option 3)

Before building a new vessel, preliminary specifications for the vessel would have to be prepared. The specifications should be of sufficient detail that a design firm could create a conceptual design of the new vessel. The specifications should include items such as the approximate size of the vessel, speed requirements, crew size and housing requirements, minimum cargo capacity to support each mission, and a preliminary list of appropriate regulations. The costs to prepare preliminary specifications and conceptual design are estimated to be 10% of the capital costs of the new vessel.

The estimated construction period of a new vessel is 9 months. To accommodate this schedule, the conceptual design for any vessel would need to be completed by early-2018. Assuming that it would take approximately one year to develop the conceptual design, the preliminary specifications would need to be completed by early-2017.

The current Green River Ferry would also have to be decommissioned and either transferred to another park or agency, or re-purposed. It is unlikely that another government agency would have use for the Green River Ferry; however, other ferry operators may be interested in using the vessel at other locations. Otherwise the existing ferry could be scrapped for recycle with a return of about $3,800.

Funding

Regardless of which option is selected, funding will be a primary concern.

Federal Highway Administration also has funding sources that may be available for use for replacement of the Green River Ferry. The NPS administers Federal Lands Transportation Program (FLTP), which may define replacement of the automobile ferry as an alternative transportation system (ATS) project, or “Category III” project. Category III encompasses all modes of surface transportation beyond traditional roadways and private vehicles, including motorized and non-motorized land and water-based transportation systems. Since the Green River Ferry is primarily for automobile transport, it may be eligible for FLTP Category I funds. SER has receives approximately $2,0 million annually in Category III and $39.4 million in Category I funds. Additionally, MACA is eligible for formula funds for the Ferry Boat Program (FBP) for capital improvements. This program is administered by the Federal Highway Administration. MACA did not receive FBP funding in 2014 but continues to be eligible. For more information on this program, see the National Park Service Primer on the Construction of Ferry Boats and Ferry Terminal Facilities Program.12

NPS has one funding source that may have the money available for implementation of the seleted alternative, the Federal Lands Recreation Enhancement Act (FLREA), which allows NPS to collect fees to manage their sites. In past approximately $175million annually has been collected nationally through the FLREA program, with approximately 80% reserved for those parks collecting fees, leaving approximately $35 million for projects ranked and chosen by the Director. Of the 20% available to all parks, an average of $4.5 million has been spent on transportation projects although since 2008, this value has steadily declined.13 The operating budget of MACA is $6.2 million, none of which is available for a ferry capital project. Mammoth Cave is also and 80% FLREA park. However, those funds are committed through 2022

MACA may also be eligible for other funding programs if it converts completely to biodiesel, a cleaner burning fuel (both SLEP options include upgrades to convert fully to biodiesel). The FHWA Congestion Mitigation and Air Quality Program (CMAQ)14 and Department of Energy (DOE) Clean Cities Program15 provide funding for projects that improve air quality and reduce dependence of fossil fuels, respectively. The CMAQ program includes a requirement for projects to be located within a non-attainment or maintenance area as designated by the US Environmental Protection Agency (EPA). MACA is located in Edmonson County, which is an air quality one-hour ozone maintenance area as determined by the EPA.16

Additional Data Analysis Possibilities

The analysis summarized by this report is based on the best available data from the park. Additional analysis regarding congestion, visitor ferry use/demand, and need for heavy vehicle transport is possible should additional quantitative become available. This data includes:

- Ferry use by recreational and non-recreational visitors
- 2011 Green River Crossing planning study and supporting data

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[12] http://www.nps.gov/transportation/pdfs/NPS_WASO_2014_Ferry_Boat_Program.pdf
[13] Based on 2006-2012 data collected for the National Long Range Transportation Plan
[14] http://www.fhwa.dot.gov/environment/air_quality/cmaq/
[15] http://www1.eere.energy.gov/cleancities/
[16] http://www3.epa.gov/airquality/greenbook/fmca.html

Appendix A: Service Life Extension Work Items

To estimate service life extension program (SLEP) costs, Volpe uses a process based on the three-digit Ships Work Breakdown Structure (SWBS) system to separate ship repair work into manageable jobs. Each job is broken into individual tasks and then assigned labor hours based on past experience and cost estimating guides. Material and equipment costs are updated on a case by case basis through Volpe database searches, internet searches, and calls to dealers and manufacturers.

The systems requiring recapitalization were identified during the initial site visit. When determining which systems need recapitalization, the main criteria was whether the system would last for another 30 years without recapitalization. Once the worklist was developed for each of the school ships, the cost of the individual work item was estimated by assigning material costs and labor hours to high-level tasks within the job, utilizing a spreadsheet developed by Volpe for just this purpose. The material cost and labor hour estimates were based on similar tasks previously accomplished for Army, Coast Guard, and National Parks Service ships, Volpe staff's previous work experience at shipyards and ship design firms, and internet searches. This procedure develops a Rough Order Of Magnitude (ROM) cost estimate for each of the SLEPs.

Vessel Particulars	
Length (w/out ramps)	59.79 feet
Beam	19.71 feet
Depth	2.75 feet
Registered tonnage	27 tons
Displacement	71,457 lbs (31.9 LT)
Cargo/Vehicle Capacity	16,000 lbs (7.14 LT)
Passenger Capacity	18 passengers plus 1 crew
Propulsion system	Diesel Engine
Propeller	1 Paddlewheel
Horsepower	60 HP
Build Year	1989

A.1. Overall Costs Summary

Includes costs associated with all tasks.

	Design & Engineering	**Material & Equipment**	**Labor**	**G&A**	**Total**
Recommended Items	$218,580	$234,090	$197,310	$233,826	$883,806
Optional Biodiesel	$9,000	$6,000	$10,100	$7,530	$32,630
Option 2 Pontoons	$54,000	$30,000	$56,200	$42,060	$182,260
Option 1 Total	$227,580	$240,090	$207,410	$241,356	$916,436
Option 2 Total	$281,580	$270,090	$263,610	$283,416	$1,098,696

A.2. Drydock & Administration

Includes expected costs for hauling the ferry in and out of the water, drydocking, contracting, spares, technical documentation, and warranty. Perform stability test after service life extension .

Description	Engineering & Equipment Labor	G&A	Total
Drydock & Administration	$123,000	$36,900	$159,900

A.3. Hull

Perform UT scan of entire hull and replace deteriorated shell plating, deck plating, bulkheads, and stiffeners. Inspect deck fittings such as cleats, bitts and bollards and repair or replace. Replace all deck hatches. Build containment below fuel and hydraulic tanks. Repaint hull and deck.

Description	Design & Engineeri ng	Material & Equipment	Labor	G&A	Total
Hull	$39,000	$37,200	$11,000	$26,160	$113,360

A.4. Voids

Blast, clean, and recoat all voids.

Description	Design & Engineeri ng	Material & Equipment	Labor	G&A	Total
Voids	$0	$10,000	$31,200	$12,360	$53,560

A.5. Main Engine

Replace main engine with new, environmentally-compliant diesel engine. Replace engine controls in pilot house. Replace engine foundations to match new engine.

Description	Design & Engineeri ng	Material & Equipment	Labor	G&A	Total
Main Engine	$23,500	$33,000	$10,680	$20,154	$87,334

A.6. Generator

Replace genset in kind with new unit.

Description	Design & Engineeri ng	Material & Equipment	Labor	G&A	Total
Generator	$4,240	$8,000	$5,560	$5,340	$23,140

A.7. Hydraulic System

Inspect hydraulic propulsion system. Rebuild hydraulic motor. Replace worn hydraulic rams, hoses, fittings, and seals.

Description	Design & Engineering	Material & Equipment	Labor	G&A	Total
Hydraulics	$1,200	$3,000	$4,080	$2,484	$10,764

A.8. Paddlewheel

Inspect paddlewheel. Replace any worn steel. Inspect shaft bearing and repair as necessary. Balance shaft and paddlewheel.

Description	Design & Engineering	Material & Equipment	Labor	G&A	Total
Paddlewheel	$2,400	$2,000	$4,760	$2,748	$11,908

A.9. Pilot House

Expand pilot house eight inches inboard to increase space for operator. Install windows in forward and aft outboard corners of pilot house to increase visibility. Replace air conditioning unit. Replace heater unit. Replace console.

Description	Design & Engineering	Material & Equipment	Labor	G&A	Total
Pilot House	$8,800	$5,100	$13,480	$8,214	$35,594

A.10. Ramps

Inspect ramps and replace deteriorated plating and stiffeners. Repaint ramps.

Description	Design & Engineering	Material & Equipment	Labor	G&A	Total
Ramps	$6,000	$2,500	$7,280	$4,734	$20,514

A.11. Electrical System

Inspect electrical system. Replace worn cable, junction boxes, and stuffing tubes.

Description	Design & Engineering	Material & Equipment	Labor	G&A	Total
Electrical System	$1,200	$2,500	$1,200	$1,470	$6,370

A.12. Outfitting

Replace ship outfitting, including VHF radio, cellular phone signal booster, personal floatation devices, and other miscellaneous outfit items.

Description	Design & Engineering	Material & Equipment	Labor	G&A	Total
Outfitting	$2,400	$3,300	$620	$1,896	$8,216

A.13. Fire Suppression

Install fixed fire suppression system in engine cabinet.

Description	Design & Engineering	Material & Equipment	Labor	G&A	Total
Fire Suppression	$10,800	$4,500	$7,960	$6,978	$30,238

A.14. Fire and Bilge System

Install fire pump and fire main system. Install fire station on deck.

Description	Design & Engineering	Material & Equipment	Labor	G&A	Total
Fire and Bilge System	$19,280	$12,000	$15,160	$13,932	$60,372

A.15. Gates

Design and install gates on bow and stern.

Description	Design & Engineering	Material & Equipment	Labor	G&A	Total
Gates	$36,200	$15,000	$20,600	$60,372	$132,172

A.16. Pontoons (Option 2 ONLY)

Increase vehicle capacity by increasing hull beam. Install pontoons on port and starboard sides of hull.

Description	Design & Engineering	Material & Equipment	Labor	G&A	Total
Pontoons	$54,000	$30,000	$56,200	$42,060	$182,260

A.17. Biodiesel Heating (Optional – included in both Options 1 and 2)

Add capability to use biodiesel year-round. Install fuel tank heater, fuel line fluid warmer, and engine block heater.

Description	Design & Engineering	Material & Equipment	Labor	G&A	Total
Biodiesel Heating	$9,000	$6,000	$10,100	$7,530	$32,630

Appendix B: Preliminary New Green River Ferry Specifications

I. General
  a. Style: Cable-guided double-ended three vehicle ferry

II. Dimensions
  a. Length (w/out ramps) 65' (capable of carrying three crew cab full-size pickup trucks)
  b. Ramp Length minimum 10'
  c. Beam (B) no greater than 21'
  d. Clear Width on Deck 11'
  e. Draft (D) no greater than draft of current unloaded vessel
  f. Capacity 12 tons (24,000 lbs) vehicle cargo
  g. Registered Tonnage Under 60 tons

III. Estimated Concept Design Costs $200K

IV. Estimated Construction and Outfitting Costs $1.73-2.23 Million (2015$)

V. Construction Period of 9 months

VI. Capacities
  a. Passenger Capacity 25 (Subchapter T)
  b. Fuel Capacity 100 gallons of diesel
  c. Propane 100 gallon bottle
  d. Hydraulic oil 30 gallons

VII. Accommodations
  a. Crew: Pilot house for one crew member. Pilot house to be approximately 10' x 7' W, located amidships on upstream side of ferry. Visibility from pilot house to allow for clear views of vehicle deck, forward and aft ramps, upstream river, and canoe docking areas from seated console position. All windows are to have light-blocking blinds. Pilot house doors are to be lockable. Pilot house to be air conditioned and heated (propane).
  b. Passengers: No accommodations for passengers. Passengers to remain in vehicles during transit. Bicyclists and pedestrians stand during transit.
  c. Toilet: Standard enclosed portable toilet for crew use to be installed on ferry.

VIII. Hull
  a. All steel construction
    i. Hull
    ii. Decks
    iii. Watertight bulkheads
    iv. Ramps
    v. Pilot house
  b. Hull and ramp shall be designed to interface with planned modified roadway grades with a minimal transition angle.

IX. Main Propulsion
  a. One diesel engine capable of propelling the ferry across river in five minutes or less at mean high water. Engine to be compliant with current EPA emission standards. Engine to be capable of running on biodiesel.
  b. Low-draft propulsion unit, such as paddlewheel or pump-jet. Propulsor shall not extend below hull. Designer to ensure propulsion unit has minimal effect on natural environment of river, river banks, and land-based loading ramps.

X. Auxiliary Systems
   a. One diesel generator capable of generating 7 KW at 60 Hz/120 V. Generator to power ship lighting, electronics, and air conditioning unit.
   b. Air conditioning unit in pilot house.
   c. Propane heating unit in pilot house.
   d. Portable toilet for crew.
   e. Hydraulically-operated ramps and vehicle gates. Main controls in pilot house with local controls at each ramp.
   f. Biodiesel heater for cold weather operation.
   g. Lighting system (cabin, deck, and navigation lights).
   h. Bilge pumping system.
   i. Fire pump and fire main system.
   j. Fire extinguishing system in engine cabinet.

XI. Ship control
   a. Ferry to operate on existing cable system
   b. Ferry to be tied up using existing mooring/anchoring system
   c. One emergency anchor
   d. VHF/FM Comms system
   e. PA System
   f. Navigation lights
   g. Ship's whistle
   h. Console to have engine controls (including start/stop), ramp controls, engine alarms, engine hour meter, fuel level indicator, battery voltage meter, and open console space for a clipboard.

XII. Emergency Systems
   a. Rescue boat
   b. Personal floatation devices (PFDs) and storage
   c. Life rings
   d. Alarm system (engine alarms, generator alarms, flooding)
   e. Signal search light
   f. Portable fire extinguishers

XIII. Regulatory Considerations
   a. Navigation 33 CFR § 83-90 (Navigation and Navigable Waters, USCG Subchapter E, Inland Navigation Rules).
   b. Small Passenger Ferry Regulations: Comply with the regulations in 46 CFR § 175-185 (Shipping, USCG Subchapter T, Small Passenger Vessels [Under 100 Gross Tons]).
   c. Personnel and Passenger Safety Comply with the International Convention for the Safety of Life at Sea (SOLAS), which ensures that the ship complies with minimum safety standards in construction, equipment, and operation. These regulations are implemented in 46 CFR § 199 (Shipping, USCG Subchapter W, Lifesaving Appliances and Arrangements).

Appendix C: Preliminary Cost Estimates for New Green River Ferry

Most cost estimating methods for ships rely on data from construction of similar vessels. Pre-developed cost models are available for common ship designs, such as tankers, containerships, and military vessels. These models can estimate the acquisition costs for new ships with good accuracy based on the multitude of data available. Conversely, small, cable-guided vehicles ferries are very specialized in terms of hull form and equipment. The search for peer services only yielded three cable-guided ferries newly constructed in the United States since 2002 and two other double-ended small river ferries with steering systems. As such, there is not enough background data to create a cost model for these ferries.

Instead, the best method of estimating the cost of construction for a conceptual design is to perform a regression analysis using the recently constructed ferries. As all of the ferries found have at least two vehicle lanes, performing a regression analysis based solely on length would not yield accurate results. Furthermore, as hull design details are not available for every ferry, other comparisons based on steel weight or underwater volume is also not possible. Using the available data, the best comparison for regression is the hull "block" volume; that is, the product of the length, beam, and depth of the ferry hulls. This calculation would approximate a volume of the hull of each ferry which, when compared to the construction cost, can be used to estimate the construction cost of a new build ferry. The specific vessels found, their specifications are listed below in Table 5.

Table 5
Ships of Comparable Type to the Green River Ferry

Ship Name	Hull Length	Hull Beam	Hull Depth	Cost in Contract Year
Buena Vista Ferry (*Buena Vista*)	63.0 feet	31.6 feet	4.0 feet	$4.0M in 2012
Wheatland Ferry (*Daniel Matheny V*)	63.0 feet	32.7 feet	4.0 feet	$1.8M in 2002
Woodland Ferry (*Tina Fallon*)	64.8 feet	30.3 feet	4.5 feet	$931K in 2007
Ryer Island Ferry (*Real McCoy II*)	84.5 feet	38.0 feet	6.0 feet	$4.3M in 2010
Puget Island Ferry (*Oscar B*)	109.2 feet	47.5 feet	6.0 feet	$5.7M in 2015

To be able to compare construction costs, all cost figures were inflation-adjusted to 2015 dollars. Two different inflation rates were used in the analysis. The first inflation rate used is the U.S. consumer price index (CPI) inflation rate, as estimated by the U.S. Department of Commerce. The second inflation calculation used the Bureau of Labor Statistics Material Index for Steel Vessel Contracts. These statistics analyze the change in shipbuilding contract costs (including shipyard labor, material, and overhead rates) between 1982 and 2015. The results of the Cost per Hull Block Volume calculations are listed below in Table 6.

Table 6
Ships of Comparable Type to the Green River Ferry

Ship Name	Cost in 2015$ (CPI rate)	CPI Cost per Hull Block Volume ($/ft^3)	Cost in 2015$ (BLS rate)	BLS Cost per Hull Block Volume ($/ft^3)
Buena Vista Ferry (*Buena Vista*)	$4.14M	520.3	$3.79M	475.8
Wheatland Ferry (*Daniel Matheny V*)	$5.53M	670.5	$2.80M	339.4
Woodland Ferry (*Tina Fallon*)	$1.07M	144.7	$1.04M	141.3
Ryer Island Ferry (*Real McCoy II*)	$4.70M	243.4	$4.41M	228.7
Puget Island Ferry (*Oscar B*)	$5.70M	183.2	$5.70M	183.2
Average		**352.4**		**273.7**

Applying the analysis to the 65-foot length, 20-foot beam, 4-foot depth of the preliminary replacement ferry design yields estimated construction prices of $1.83 million (CPI) and $1.42 million (BLS). However, this cost does not include design, outfit, spares, warranty and provisioning technical documentation, or contract management costs.

The design costs for a commercial merchant ship typically amount to approximately 10 percent of the cost of construction of the vessel.

The "outfit" for a new construction ship consists of equipment such as navigation equipment, safety and damage control gear, and basic habitability equipment. The ferry will have an initial inventory of spare parts. Because of the limited amount of equipment and outfitting on the Green River ferry, Volpe estimates the outfit and spares cost to be three percent of the cost of construction.

The warranty cost is the cost of providing a limited warranty on the ferry and any equipment installed by the shipyard. The term of the warranty normally last for three years after delivery. The provisioning technical documentation (PTD) consists of technical manuals, operating manuals, spare parts lists, and preventive maintenance procedures. Volpe estimates the warranty and PTD costs to be another five percent of the cost of construction.

This sub-total of acquisition costs is the Total Direct Cost to the Government. It consists of the construction, design, outfit, spares, and warranty & PTD. This is calculated as follows:

Item	Cost (CPI)	Cost (BLS)
Construction	$1.83M	$1.42M
Design	$183.2K	$142.3K
Outfit and Spares	$55.0K	$42.7K
Warranty and PTD	$91.6K	$71.2K
Subtotal	**$2.16M**	**$1.68M**

Additionally, there are contract management costs during design and construction. This includes the cost of contract management services, such as the use of a general agent, to administer the government contract for vessel construction. Volpe assumes charges of approximately three percent of the total contract cost.

Item	Cost (CPI)	Cost (BLS)
Subtotal	$2.16M	$1.68M
Contracting	$64.7K	$50.4K
Total	**$2.23M**	**$1.73M**

When additional information is known about the design and configuration of the Green River ferry, a more precise estimating process would be used to develop a more refined cost estimate. Known as a "one-digit SWBS (ship work breakdown structure) analysis," this process uses a cost estimating methodology developed for the U.S. Navy.

Appendix D: Maintenance Costs Estimates for Green River Ferry

To determine the future maintenance costs for this study, Volpe relied upon previous experience with operational performance and cost data for U.S. Coast Guard cutters. Volpe has been compiling and analyzing the cost data for cutters from the year the first vessel entered service (mid-1980s) until the present day. Based upon analysis of that data, Volpe has determined that the maintenance spending tends to be flat for the first several years of operation, and then begins to increase each year. Volpe has developed a series of percentage factors that can reasonably project future maintenance spending based upon the age of the vessel.

Age of Vessel	Percentage of Maintenance Cost Over Previous Year	Age of Vessel	Percentage of Maintenance Cost Over Previous Year
1	100%	9	102%
2	100%	10	103%
3	100%	11	104%
4	100%	12	105%
5	100%	13	105%
6	100%	14	106%
7	100%	15	106%
8	101%	16-30	107%

Knowing that the current maintenance spending on the Green River Ferry is $10,000 per year at age 26, an approximate maintenance cost per year can be calculated for the other years of operation.

The data can also be used to estimate the maintenance costs for the ferry after a SLEP. When a service life extension is performed, much of the ship equipment is renewed or replaced. This will lower the maintenance spending onboard the ship, as much of the equipment is new. However, the spending will not go back down to the initial spending amount, as the hull is still old and there are pieces of equipment that have not been replaced. The estimated cost for the maintenance costs after SLEP is the average of the initial maintenance cost at Year 0 and the current maintenance costs pre-SLEP. The maintenance costs will then follow the empirical data calculations above.

The maintenance cost estimates for the current ferry after SLEP and a new Green River Ferry are shown below.

Age of Vessel	Current Ferry Maintenance (after SLEP)	New Ferry Maintenance
1	$ 6,874	$ 3,749
2	$ 6,874	$ 3,749
3	$ 6,874	$ 3,749
4	$ 6,874	$ 3,749
5	$ 6,874	$ 3,749
6	$ 6,874	$ 3,749
7	$ 6,874	$ 3,749
8	$ 6,932	$ 3,749
9	$ 7,060	$ 3,780
10	$ 7,261	$ 3,850
11	$ 7,534	$ 3,960
12	$ 7,878	$ 4,108
13	$ 8,295	$ 4,296
14	$ 8,783	$ 4,523
15	$ 9,343	$ 4,789
16	$ 9,974	$ 5,095
17	$ 10,672	$ 5,439
18	$ 11,420	$ 5,820
19	$ 12,219	$ 6,227
20	$ 13,074	$ 6,663
21	$ 13,989	$ 7,130
22	$ 14,969	$ 7,629
23	$ 16,017	$ 8,163
24	$ 17,138	$ 8,734
25	$ 18,337	$ 9,346
26	$ 19,621	$ 10,000
27	$ 20,994	$ 10,700
28	$ 22,464	$ 11,449
29	$ 24,037	$ 12,250
30	$ 25,719	$ 13,108

Appendix E: Analysis Background

This study uses a Business Case Analysis framework to evaluate recapitalization options for the Green River Ferry. The "business case" approach is a form of cost-effectiveness analysis. Starting with a defined set of requirements or capabilities – in this case the mission requirements as described above – the analysis identifies the alternative that meets those requirements at the lowest overall lifecycle cost.

This business case analysis is distinguished from a benefit-cost analysis (which involves estimation of both costs and benefits) and is the primary form of analysis for government projects. This report includes a detailed comparison of lifecycle costs, because (1) each of the action alternatives has been crafted to meet at least the minimum mission requirements, and (2) for those alternatives that exceed the minimum, for example through additional vessel capabilities, these benefits could not be readily quantified into a benefit-cost framework.

In addition to quantified costs, the analysis includes a discussion of the qualitative factors associated with each alternative. Particular attention is paid to vessel capabilities that exceed the minimum mission requirements and provide additional flexibility, as well as to the potential risks of each alternative. Consequently, the study seeks to identify those alternatives that will yield the lowest cost, at reasonable risk, while providing the overall best value for the government in fulfilling the mission.

The alternatives examined here include constructing a new ferry or extending the service of the existing ferry. Leasing was not considered as an alternative due to the lack of viable leasing options in the U.S. marketplace.

For each alternative, the project team's analysis examines the costs across the lifecycle, including upfront capital costs for vessel construction, conversion, or service life extension and ongoing costs for operation and maintenance, including fuel; and residual value.

For simplicity, certain costs were excluded from the analysis to the extent that they are unavoidable and/or do not vary at all across the alternatives. An example is crew labor, which is incurred regardless of the selected option.

All cost figures presented in the analysis are in real (inflation-adjusted) terms, using 2015 dollars. Costs incurred in future years are converted to present value using a discount rate. Discounting in this context refers to an adjustment for the time value of money – essentially the principle that a given value is worth less in the future than at present, which underlies the positive interest rates on loans and investments. (For example, $1.00 deposited at 2 percent interest will be worth $1.02 next year; likewise $1.00 to be paid in a year's time would be worth roughly $0.98 today when discounted at the same 2 percent rate.) The sum of the stream of present-value costs across the full analysis period yields the overall total lifecycle cost, which is used to compare the cost-effectiveness of each alternative.

Based on OMB guidance (Circular A-94), two discount rates are used in the analysis: a 7 percent real rate, which approximates the pretax rate of return on private capital and is appropriate for analysis of government investments, and a 1.4 percent real rate, which reflects the Federal Government's actual borrowing costs as evidenced by the inflation-adjusted yield on 30-year Treasury bonds. The 1.4 percent discount rate is recommended for studies of cost-effectiveness and internal government investments. For this study, the use of the 1.4 percent rate also allows comparison of alternatives in terms of costs where the benefits to the Government have not been quantified.

Note that while cost estimates in this study have been prepared with care using the best available information, they are intended as an initial, high-level overview of alternatives, with the goal of identifying options that may warrant further in-depth study. They may not reflect actual costs and are used for general comparison purposes only. Finally, this report identifies areas of potential risk associated with different recapitalization approaches, but it does not include a comprehensive analysis of those risks.

Appendix F: Data Tables for Figures

Table for Figure 3: Annual MACA Visitation and Green River Ferry Use

Source: Visitor Use Statistics Office

Year	Recreational Visitors	Non-Recreational Visitors	Ferried Vehicles
2006	597,934	142,618	94,392
2007	487,305	137,622	86,116
2008	446,174	137,944	79,772
2009	503,856	142,177	89,394
2010	497,225	139,627	88,676
2011	483,319	136,093	78,590
2012	508,054	139,008	86,760
2013	494,541	136,896	95,733
2014	522,628	134,414	96,052

Table for Figures 4 and 5: 2013 Monthly MACA Visitation and Green River Ferry Use

Source: Visitor Use Statistics Office

Month	Recreational Visitors	Non-Recreational Visitors	Ferried Vehicles
January	7,795	10,543	4,209
February	8,393	11,218	4,538
March	44,118	13,092	9,411
April	48,492	11,757	7,684
May	48,245	11,924	11,450
June	78,842	10,914	11,417
July	104,055	12,115	12,330
August	71,310	11,993	11,664
September	34,847	10,226	6,774
October	15,222	9,960	3,860
November	20,067	11,591	6,278
December	13,155	11,563	6,118

Table for Figure 6: Total Daily Vehicle Count
Source: MACA

Date	Combined Total	Northbound	Southbound	Weekend	Ferry Closure
7/1/2015	329	148	181		
7/2/2015	359	162	197		
7/3/2015	461	207	254		
7/4/2015	416	201	215	x	
7/5/2015	373	181	192	x	
7/6/2015	347	156	191		
7/7/2015	333	150	183		
7/8/2015	352	158	194		
7/9/2015	354	159	195		
7/10/2015	375	169	206		
7/11/2015	444	219	225	x	
7/12/2015	416	203	213	x	
7/13/2015	361	162	199		
7/14/2015	245	110	135		x
7/15/2015	325	146	179		
7/16/2015	338	152	186		
7/17/2015	438	197	241		
7/18/2015	611	303	308	x	
7/19/2015	458	223	235	x	
7/20/2015	338	152	186		
7/21/2015	378	170	208		
7/22/2015	351	158	193		
7/23/2015	399	180	219		
7/24/2015	386	174	212		
7/25/2015	621	306	315	x	
7/26/2015	443	214	229	x	
7/27/2015	380	171	209		
7/28/2015	382	172	210		
7/29/2015	390	176	215		
7/30/2015	342	154	188		
7/31/2015	430	194	237		

Table for Figure 7: Average Hourly Vehicle Count Weekday vs. Weekend

Source: MACA

Time of Day	Hourly Average Vehicle Count Weekday (Mon-Fri)	Hourly Average Vehicle Count Weekend (Sat-Sun)
6:00	15	10
7:00	22	16
8:00	24	19
9:00	18	24
10:00	24	34
11:00	25	39
12:00	29	40
13:00	27	43
14:00	37	47
15:00	32	49
16:00	33	42
17:00	30	38
18:00	22	31
19:00	14	21
20:00	9	12
21:00	6	8

Table for Figure 8: Average and Maximum Hourly Vehicle Count

Source: MACA

Time of Day	Northbound	Southbound	Avg. Both Directions	July Maximum
6:00	6	8	14	23
7:00	10	10	20	31
8:00	11	11	23	47
9:00	10	10	20	42
10:00	14	13	26	45
11:00	13	16	29	51
12:00	14	17	32	56
13:00	14	17	31	55
14:00	18	22	40	55
15:00	16	20	36	59
16:00	16	19	35	53
17:00	14	17	32	50
18:00	11	13	24	47
19:00	7	9	16	38
20:00	4	5	10	22
21:00	3	3	6	16

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14. ABSTRACT
The purpose of this study is to assess whether Mammoth Cave National Park should rehabilitate the existing Green River ferry to extend its service life or replace it with a new vessel. The ferry is used to transport cars and light duty equipment across the Green River, which bisects the Green River Ferry Road. The study includes the following components: existing conditions and use, options development and analysis, total cost of ownership, and recommendations.

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