LIFE EXTENSION 2
CONCEPTUAL DESIGN REPORT
VOLUME IV
BIG HILL

U.S. DEPARTMENT OF ENERGY
STRATEGIC PETROLEUM RESERVE
PROJECT MANAGEMENT OFFICE
NEW ORLEANS, LOUISIANA
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PROJECT LIST

BH-MM-1338/793

BH-MM-1356

BH-MM-1357

BH-MM-1362

BH-MM-1370

BH-MM-1429

BH-MM-1523

BH-MM-1527

BH-MM-1530

BH-MM-1552

BH-MM-523

BH-MM-596

BH-MM-597

BH-MM-611

BH-MM-670

BH-MM-750

BH-MM-756

BH-MM-776

BH-MM-782

BH-MM-806

BH-SP-1307

BH-SP-1407

BH-MM-1338; BH-MM-793

Replace Raw Water Injection Pumps to Maintain Drawdown Rate

VCI Project Engineer: Brian Tuminello

Recommended Alternative:

Install New, Larger RWI Pumps

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The Big Hill SPR Site is designed to deliver crude oil to the SUNOCO terminal through a 36-inch crude oil pipeline at a delivery pressure of 70 psi at 1,100,000 barrels per day. As a result of a changed condition on the cavern production casings (smaller liner strings), the oil pressure leaving the storage cavern during the later stages of a cavern drawdown results in reduced pressure to the inlet of the existing crude oil pumps. Additionally, the changed cavern conditions for the raw water injection casings has resulted in a significant increase in flow restriction for water entering the cavern during drawdown. As a result, the existing Raw Water Injection (RWInj) pumps are not able to provide the required flow rate and pressure.

Functional Requirements

Assure sufficient, reliable raw water pumping capacity exists at the Big Hill Site to deliver the required flowrate and pressure for crude oil to flow to the receiving terminal. A comprehensive hydraulic analysis has been performed and the results indicate that water flow and pressure requirements for water entering the Big Hill caverns for drawdown is significantly greater than what the existing pumps can produce. The analysis has indicated that RWInj pump discharge pressures in the range of 1,000 to 1,050 psig are required for water delivered to the caverns to meet the mission requirements for drawdown.

This Project is one component of a series of Projects to Assure the Drawdown Rate at Big Hill is in accordance with SPR Level I Criteria. Other projects that are part of the completed Drawdown System that are affected by this BH-MM-1338, 793 project are: BH-MM-597, BH-MM-611, BH-MM-1356, and BH-MM-1357.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Brian Tuminello	VCI, Project Engineer
Lisa Eldredge	FFPO, Principal Operations Systems Engineer

Team Members

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Marty Loftin	FFPO, Supervisor Site Maintenance
Paul Riegert	FFPO, Manager Site Construction
Paul Bonin	FFPO, Supervisor Site Maintenance

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Most Important

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation.

Weight: Most Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

This alternative would leave the current, raw water injection pumps in place which will not meet the mission requirements or the functional need. The existing pump cases will not allow for different trim (impellers) to produce the significantly greater pressure requirements.

Viability: No Further Analysis

B. Install New Second Stage Raw Water Injection Pumps

This alternative would provide a new, second set of Raw Water Injection pumps to provide adequate flow and pressure to the existing storage caverns to maintain the required drawdown rate. The pumps would be physically located near the existing raw water injection pumps. An appropriate number and size of pumps would be required to meet the mission requirements as well as maintaining the Big Hill Site Reliability, Availability, Maintainability (RAM) requirements. Piping modifications, protective shelters, and electrical requirements would all have to be considered for this alternative. Additionally, a new, second set of seal flush pumps would be required to meet the bearing cooling and seal flush requirements of the new set of injection pumps. The existing seal flush pumps for the RWInj pumps and the carbon steel tank for the seal flush pumps should be replaced due to age and current condition.

This alternative is viable to meet the project functional requirements. Of all alternatives identified, this alternative would potentially be the least cost effective approach given the amount of new equipment, facility, utility, long term maintenance, and additional power consumption. The addition of new pumps would require the reliance on two of the large transformers in the Big Hill main sub-station. The Big Hill electrical system was designed to be supported by a single transformer with a second redundant transformer available. The reliability of the site during the late stages of drawdown would be reduced if the new pumps were added.

Viability: Continue Analysis

C. Modify Existing Raw Water Injection Pumps

This alternative would evaluate if the existing raw water pumps could be modified to meet the revised pressure conditions while still delivering the required flow and pressure for the drawdown mission. A comprehensive hydraulic analysis has been performed and the results indicate that water flow and pressure requirements for water entering the Big Hill caverns for drawdown is significantly greater than the existing pumps can produce (approximately 600 psig). The analysis has indicated that RWInj pump discharge pressures in the range of 1,000 to 1,050 psig are required for water delivered to the caverns to meet the mission requirements for drawdown. There are no known modifications of the existing pumps that can produce the required pressure and flow.

Viability: No Further Analysis

D. Install New, Larger Raw Water Injection Pumps

This alternative would evaluate if new, larger RWInj pumps could be provided to meet the required flow and pressure conditions for the drawdown mission. This alternative would be performed in lieu of project BH-MM-631 which is intended to replace the electric motor driver and skid base for this set of existing RWI pumps. This alternative has the potential for being a very cost effective approach to meeting the project specific requirements. Additionally, this alternative would result in the replacement of the existing set of seal flush pumps with a new set capable of providing the required flow and discharge pressure.

This alternative would result in new, current technology materials and design for pumps in raw water service**.** Depending on the recommended pump, modifications to the electric motor driver, cabling and starters will most likely be required.

Viability: Continue Analysis

E. Reduce the Site's Operational Requirements at the Late Stages of Drawdown

This alternative would result in no modification of the existing pumps and no new additional or replacement pumps. Instead, the flowrate and pressure delivery requirements would be reduced to a new, lower number depending on the result of an engineering hydraulic analysis. This would be a very cost effective alternative but would not meet project specific requirements as currently defined.

This alternative does not meet the current mission requirements and would not meet the project functional requirements. This alternative would require a revision or deviation to the DOE Level I mission requirements.

Viability: No Further Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A, C, and E are eliminated from further consideration. The remaining alternatives, B and D are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Install New Second Stage Raw Water Injection Pumps

This alternative would provide a two stage set of RWInj pumps and utilize the existing pumps as the first stage and a new, complete set of 2nd stage pumps to provide the necessary water pressure to the caverns. A comprehensive hydraulic analysis has been performed and the results indicate that water flow and pressure requirements for water entering the Big Hill caverns for drawdown is significantly greater than the existing pumps can produce. A second set of RWInj pumps could provide the necessary pressure and flowrate when run in series with the existing pumps. This would result in two, matched sets of pumps to produce the required flow and pressure. A second set of pumps would require additional supporting infrastructure including electrical system, seal flush / bearing cooling system, process controls and pump shelter building. This alternative must consider the additional equipment to be operated and maintained and the affect that would have on the life cycle cost especially if the existing pumps were not replaced.

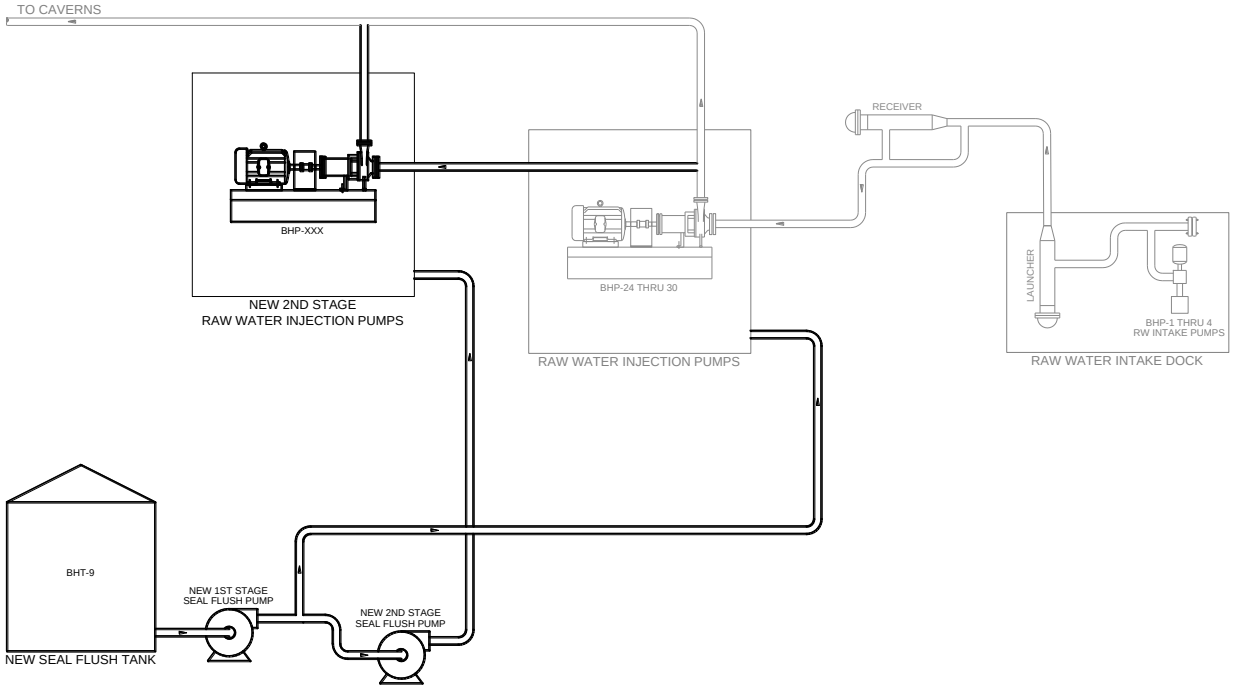

Figure 1 – New Seal Flush Tank, 1st and 2nd Stage Flush Pumps, and 2nd Stage Raw Water Injection Pumps

Assumptions & Constraints

A fundamental assumption for this alternative is that sufficient space exists in close proximity to the existing RWI pump shelter for installation of the new, 2nd stage set of pumps. The new set of pumps would require new supporting electrical, instrumentation, and mechanical system additions for automation of pump operation and control. Detailed engineering analysis would have to validate or disprove this assumption. The new pump / motor units would be purchased as Long Lead Equipment. An analysis would need to determine if the 4.16 kV motor control centers have sufficient space for the new, additional motor starters. The second set of RWI pumps would increase the seal flush / bearing cooling water demand. A new, second set of seal flush pumps to operate in series with new, replacement seal flush pumps (BHP-89 and 90) would be required for both sets of RWInj Pumps and the existing seal flush tank size would need to be evaluated for adequate size and fill rate.

Benefits & Effectiveness

This alternative would meet mission requirements and would result in a highly effective system due to being able to re-use much of the existing system.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Installing New, Second Stage RWInj Pumps

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
Sufficient space does not exist under the existing RWInj pumps shelter for the new, second set of RWI pumps.	A separate, high pressure raw water pump pad and shelter would need to be designed and constructed.	Medium – High	Medium Risk Hazard
Power requirements resulting from new set of pumps may exceed load capacity of existing transformer at the RW pump load center.	Additional design, engineering and installation to size and install a second transformer and all associated motor starters and controls.	Low – High	Low Risk Hazard

B. Install New, Larger RWI Pumps

This alternative would evaluate if new RWInj pumps could be provided to meet the required flow and discharge pressure conditions to support the drawdown mission. This alternative has the potential for being a very cost effective approach to meeting the project specific requirements and having the lowest life cycle cost. A thorough hydraulic analysis has determined that Raw Water pressures at the discharge of the RWI pumps needs to be in the 1,000 to 1,050 psig range. Multi-stage (either two stage or three stage) horizontal, centrifugal pumps should be able to be manufactured to meet the required flow (200 MBD/pump) and discharge pressure requirements. These pumps would require a new, properly sized set of seal flush pumps and a new seal flush water tank. The electric motor driver for this type of pump is approximately in the 3,500 to 4,000 HP range and as a result, larger power cabling and motor starters would be required. Modifications to the lifting equipment that is part of the RWInj pump shelter may be required based upon actual weight of new pumps and motors procured. With the new, larger pumps, process control valves, piping, and system automation would be required to deal with the high pump discharge pressures in the initial stages of cavern drawdown. An optimal design of these new pumps is that they could be located and installed underneath the existing pump shelter where the existing RWI pumps are located.

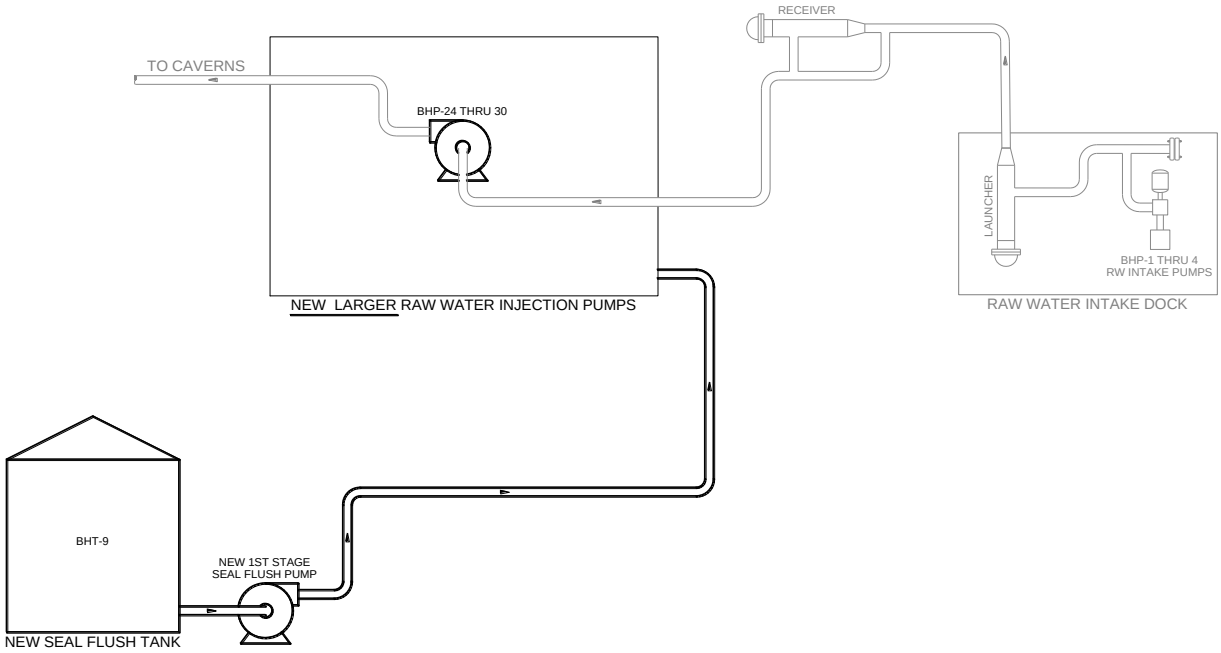

Figure 2 – New Seal Flush Tank, 1st Stage Flush Pump, and Larger Raw Water Injection Pumps

Assumptions & Constraints

A fundamental assumption for this alternative is that new RWInj pumps can be specified and procured to produce higher discharge pressures while not adversely impacting the existing pressure rating of downstream piping systems and components. Detailed engineering analysis would have to validate or disprove this assumption. The new pumps and motors would be procured as Long Lead Equipment (LLE). New seal flush pumps would also be procured as LLE. The flow and pressure control equipment would need to be thoroughly analyzed to allow for a wide range of cavern raw water injection pressures during the various stages of drawdown and corresponding cavern inventory levels.

Benefits & Effectiveness

This alternative, would meet mission requirements and would result in the least number of operating pumps to support the drawdown mission. If it is determined that the new pumps can fit under the existing shelter, a significant cost avoidance would be realized if a new pump pad and shelter did not need to be constructed.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Installing New, Larger RWI Pumps

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
New RWInj pumps meeting the functional requirements would produce discharge pressures that exceed the system capability thus creating adverse impacts on downstream piping system.	New piping may be required and / or a revised pressure control scheme will need to be designed meeting the appropriate SIL rating.	Medium – High	Medium Risk Hazard
New RWInj pumps will require additional horsepower exceeding the existing cable and starter capacity.	Additional design, engineering and installation to replace existing cables and starter (if necessary).	High – High	High Risk Hazard
New, larger RWInj pumps cannot be located under the existing RWI pump shelter.	Design and construction of a new, RWI pump pad and shelter.	Medium – High	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Install 2nd Stage RWI Pumps

This alternative would provide a two stage set of RWInj pumps and utilize the existing pumps as the first stage and a new, complete set of 2nd stage pumps to provide the necessary water pressure to the caverns. A comprehensive hydraulic analysis has been performed and the results indicate that water flow and pressure requirements for water entering the Big Hill caverns for drawdown is significantly greater than the existing pumps can produce. A second set of RWInj pumps could provide the necessary pressure and flowrate when run in series with the existing pumps. This would result in two, matched sets of pumps to produce the required flow and pressure. A second set of pumps would require additional supporting infrastructure including electrical system, seal flush / bearing cooling system, process controls and pump shelter building. This alternative must consider the additional equipment to be operated and maintained and the affect that would have on the life cycle cost especially if the existing pumps were not replaced.

B. Install New, Larger RWI Pumps

This alternative would evaluate if new RWInj pumps could be provided to meet the required flow and discharge pressure conditions to support the drawdown mission. This alternative has the potential for being a very cost effective approach to meeting the project specific requirements and having the lowest life cycle cost. A thorough hydraulic analysis has determined that Raw Water pressures at the discharge of the RWI pumps needs to be in the 1,000 to 1,050 psig range. Multi-stage (either two stage or three stage) horizontal, centrifugal pumps should be able to be manufactured to meet the required flow (200 MBD/pump) and discharge pressure requirements. These pumps would require a new, properly sized set of seal flush pumps and a new seal flush water tank. The electric motor driver for this type of pump is approximately in the 3,500 to 4,000 HP range and as a result, larger power cabling and motor starters would be required. Modifications to the lifting equipment that is part of the RWInj pump shelter may be required based upon actual weight of new pumps and motors procured. With the new, larger pumps, process control valves, piping, and system automation would be required to deal with the high pump discharge pressures in the initial stages of cavern drawdown. An optimal design of these new pumps is that they could be located and installed underneath the existing pump shelter where the existing RWI pumps are locate.

Comparison of Alternatives

Core Team Member Ratings

	Constructability During Ongoing Oil Deliveries	**Ease of Operations**	**Ease of Maintenance**	**Safety During Construction**	**Sustainability**	**Security During Construction**
	Most Important	*Most Important*	*Most Important*	*Most Important*	*Important*	*Important*
Alternative A	*Good*	*Marginal*	*Adequate*	*Good*	*Adequate*	*Good*
	Good	*Marginal*	*Adequate*	*Good*	*Adequate*	*Good*
	Excellent	*Good*	*Good*	*Good*	*Excellent*	*Good*
Alternative B	*Excellent*	*Excellent*	*Excellent*	*Good*	*Excellent*	*Good*
	Excellent	*Excellent*	*Excellent*	*Good*	*Excellent*	*Good*
	Marginal	*Good*	*Excellent*	*Good*	*Good*	*Good*

Cost Comparison

	Total Estimated Cost (TEC)	Life Cycle Cost (LCC)
Alternative A	**$75,338,977**	**$78,609,129**
Alternative B	**$79,538,016**	**$80,747,156**

Recommended Alternative

B. Install New, Larger RWI Pumps

Based on the technical evaluation of the Core Team Members, Alternative B was clearly rated overall superior on the evaluation criteria. The initial cost and life cycle cost of Alternative A was slightly lower than Alternative B, although there is increased maintenance cost and risk associated with Alternative A. The key technical benefits associated with Alternative B include less energy usage and easier maintenance associated with seven new pumps instead of seven new smaller pumps with seven aged existing pumps. Therefore, Alternative B is the recommended preferred alternative based on the technical advantages outweighing the slightly higher initial costs.

BH-MM-1356

Replace Raw Water Header

VCI Project Engineer: Lorna Madison

Recommended Alternative:

Below Grade Replacement

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The mission need at the Big Hill (BH) site is to replace the Raw Water Header portion of the raw water distribution system. The Raw Water Header system is required to inject raw water into the individual caverns to transfer crude oil for drawdown and other site operations. The 42-inch Raw Water Header is approaching 30 years of age and, as a result, is at an increased risk of loss of mechanical integrity.

Should the Raw Water Header experience loss of mechanical integrity, drawdown would be suspended until repairs could be implemented. Extended repair times will compromise the site's ability to meet drawdown requirements.

Drawdown reliability of the crude oil delivery system of the Strategic Petroleum Reserve (SPR) at Big Hill must be maintained to ensure that petroleum from the SPR can be delivered during severe supply interruptions in order to meet obligations under the International Energy Program.

Functional Requirements

- The Raw Water Header should provide 100% operating reliability for drawdowns over an estimated 25-year service life of the Life Extension 2 (LE 2) initiative.
- Header replacement shall provide the hydraulic efficiency needed to meet the Level I crude oil drawdown requirement of 1,100,000 barrels per day.
- Header design should ensure that the need for in-place inspection and repair techniques can be minimized or eliminated.
- Header replacement activity should not compromise drawdown readiness.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Lorna Madison	VCI, Project Engineer
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III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate alternatives and select a recommended preferred alternative.

Constructability during Ongoing Oil Deliveries

The selected alternative is able to be implemented with little or no impact to ongoing oil delivery operations. Raw Water Header replacement activity should not compromise drawdown readiness.

Weight: Most Important

Safety during Construction

The selected alternative when implemented will be able to be constructed and operated safely. The site's ability to address safety and security concerns during implementation shall not be impacted. A robust contractor work plan shall be vetted by the Government for all safety concerns that might be of note during construction.

Weight: Most Important

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment. Raw Water Header replacement shall provide the hydraulic efficiency needed to meet the Level I crude oil drawdown requirement of 1,100,000 barrels per day.

Weight: Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration. The Raw Water Header should provide 100% reliability on drawdowns over the 25-year life of LE 2. Header design should ensure that the need for in-place inspection and repair techniques can be minimized or eliminated.

Weight: Important

Sustainability

The selected alternative when implemented will be able to achieve the Department of Energy (DOE) Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

The project scope of work is set by considering alternatives to replace the Big Hill Raw Water Header (Figure 1), which is nearing the end of its useful life.

In order to meet the drawdown rate for crude oil, the required raw water flow rate was calculated to be 1,200,000 barrels per day. This is a change from the original design which called for a higher flow rate (1,400,000 barrels per day) for raw water to support initial cavern leaching operations at the site. Since all cavern leaching has been completed, the calculated rate of 1,200,000 barrels per day of raw water is substituted as the proper design raw water flow rate for this analysis.

The existing Raw Water Header is an integral part of the raw water distribution piping as shown in Figure 1. The Raw Water Header is comprised of approximately 2,280 linear feet of 42-inch pipe connected to 760 linear feet of 36-inch pipe, 820 linear feet of 30-inch pipe, and 1,440 linear feet of 24-inch pipe in a branching

tree configuration to efficiently deliver raw water to individual cavern wellheads through 16-inch lateral piping to each cavern. This piping network is installed below grade.

The piping is externally coated, wrapped, and cathodically protected against external corrosion.

The Raw Water Header was placed in operation in 1991 and has operated up to now with few significant leaks. Inspections data for the header are limited to two scans of reduced diameter sections of the underground raw water piping uncovered in June-August, 2012 to repair minor leaks. Both scans revealed substantial remaining wall thickness with significant service life remaining. No other data has been collected on external and internal pipe corrosion rates to predict the remaining life of the Header. However, it is anticipated that the remainder of the system is nearing the end of its useful life.

Replacing the Raw Water Header is essential to meeting the Big Hill Level I drawdown requirement of 1,100,000 barrels per day of crude oil.

A. Status Quo

The status quo is to maintain and operate the existing system in place. The existing Raw Water Header has served the Big Hill site well since it was commissioned into service in 1991.

Although the system is protected externally, it is still susceptible to corrosion. The original life of the Header was projected to be 25 years, and it has been operational for 24 of those. The existing piping has held up well for that time with no significant leaks experienced to date. However, the existing piping cannot be monitored below grade for conditions that could lead to loss of integrity. Drawdown would be suspended to address leaks upon discovery. The time that it would take to locate, isolate, mobilize for repair, and repair the leak would severely impact drawdown capabilities.

Given the nature of the corrosion, the risk increases of jeopardizing the mission by failing to plan a Raw Water Header replacement strategy to address corrosion and preserve drawdown capability over the next 25 years.

Viability: <u>No Further Analysis</u>

B. System Monitoring

This alternative consists of maintaining the existing system in place, continuing to operate the existing system while adding capability to monitor the condition of the Raw Water Header in place, and evaluating the remaining life of the piping to recommend replacement of sections of the Header as needed.

Various system monitoring programs are available to determine the condition of the existing below grade Raw Water Header to provide either detection of probable loss of integrity or actual loss should it occur. These systems would allow the existing Header to remain operational until replacement of the Header or sections of the Header are required. Examples of monitoring systems include the following:

1. <u>Intelligent Pigs.</u> - Portions of the existing Raw Water Header system would be monitored with these types of inspection tools to predict header failure in advance. Pig launchers and receivers must be positioned in the appropriate locations to send and receive the devices for inspection of the Header. Those segments of the Raw Water Header that cannot be monitored would be so equipped to provide information on the condition of the Header. Repair or replacement would follow the results of these inspections.

2. <u>Continuous Leak Detection.</u> - This type of monitoring system is applicable when loss of mechanical integrity has occurred. Inlet and outlet flows would be monitored, and a material balance made to determine whether material is being lost from the system. Accuracy of detection is dependent upon the accuracy of the flow measurements. The system must be operated on a continuous basis for some time to provide sufficient data for an accurate material balance to be performed. When leakage is detected, other means of detecting location must be used such as by visual siting.

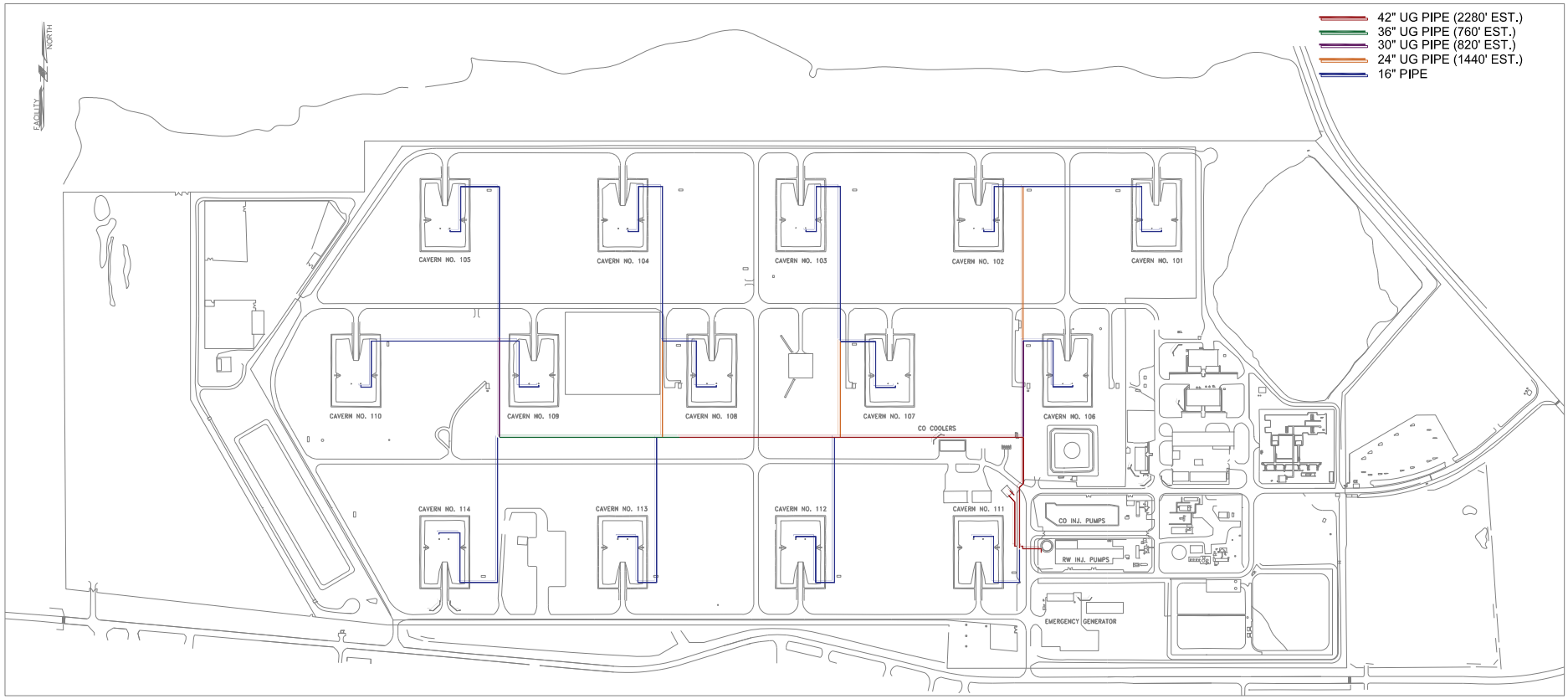

FIGURE 1 – Existing Raw Water Header Piping and Diameters

3. Continuous Leak Detection. - This type of monitoring system is applicable when loss of mechanical integrity has occurred. Inlet and outlet flows would be monitored, and a material balance made to determine whether material is being lost from the system. Accuracy of detection is dependent upon the accuracy of the flow measurements. The system must be operated on a continuous basis for some time to provide sufficient data for an accurate material balance to be performed. When leakage is detected, other means of detecting location must be used such as by visual siting.

4. Pressure Test. - This type of monitoring would be performed in the static condition by the application of pressure on the system using raw water without flow. Loss of integrity is detected by a continuous drop in system pressure. When leakage is detected, other means must be used to detect the location of the leak such as visual siting of upwelling of leaked water.

The success of each of these options is limited. For example, the existing Raw Water Header is not amenable to pigging in its current configuration. Considerable modifications (elimination of pipe diameter reductions, elimination of long radius elbows and pinch points, installation of pig bars across tees, etc.) would be required to the existing Header to make the line piggable. Alternative corrosion testing might provide a cheaper, more easily executed alternative to pigging. In contrast, the continuous leak detection and pressure testing, while recommended best practices, only aid in discovery of a leak after the fact. Moreover, prediction and detection of leaks in themselves do not provide the 100% operating reliability required. Rather they mandate follow-up repair and/or replacement of defective sections, which may negatively impact drawdown readiness.

Given the nature of corrosion, the risk increases over time of jeopardizing the mission by failing to actually replace the Raw Water Header to preserve drawdown readiness status.

Viability: No Further Analysis

C. Above Ground Replacement

This alternative consists of installing a new above ground Raw Water Header system that will provide the same raw water distribution as the existing below grade Header. The above ground Header would follow the same general routing as the below grade Header. The exact placement of the new Header to avoid existing interferences would be decided during detailed design. The above ground Header would utilize the same large diameter pipe sizes for connecting segments to preserve the hydraulic efficiency of the existing piping. Special arrangements would be made to run the Header under or over roadways to preserve site access. New valves would be installed in the new Header to facilitate timely cut over to the new Header. Tie-ins would be made at appropriate locations to connect the new Header to the existing Header to cut over operation to the new Header. The new piping would be mounted on pipe supports, cathodically protected, and painted to cope with exposure to the weather. The existing below grade Header would be abandoned in place upon completion of the new Header.

Bringing the Header above ground facilitates Header access for inspection, repair, and any future modification of tie-ins to the Header.

This approach may prove logistically more difficult to implement than below grade replacement.

Viability: Continue Analysis

D. Below Grade Replacement

This alternative consists of installing a new below grade Raw Water Header system to provide the same raw water distribution as the existing below grade Header. The new header would utilize plot area in proximity to the existing below grade Header to install a new Raw Water Header alongside the existing below grade Header, following the same routing as the existing Header. The exact depth and placement of the new Header to avoid existing interferences would be decided during detailed design. The new Header would utilize the same pipe sizes for connecting segments to preserve the hydraulic efficiency of the existing piping. New valves would be installed in the new Header to facilitate timely cut over to the new Header. Tie-ins would be made at appropriate locations to connect the new Header to the existing Header to cut over operation to the new Header. The new piping would be wrapped, coated, and cathodically protected in similar fashion to the existing below grade Header. The existing below grade Header would be abandoned in place upon completion of the new Header.

Burying the new Header below grade constitutes acceptable risk with respect to monitoring the new underground piping for remaining life and leaks given the exceptional 24+ years of service with the existing underground Header. This approach may prove logistically more difficult to implement than above ground replacement.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A and B, are eliminated from further consideration. The remaining alternatives, C and D, are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

Assumptions & Constraints

- Insufficient data are available to estimate the remaining life of the below grade Raw Water Header currently in place to provide comfort operating the existing header without replacement over the next 25 years of service.
- The scope of Raw Water Header replacement is limited to the 42-inch, 36-inch, 30-inch, and 24-inch diameter piping in the raw water transfer piping network and excludes the 16-inch lateral connections to individual cavern wellheads.
- The scope includes replacement of any valves installed in the Raw Water Header as defined above. Replacement of the valves with new valves is required to complete construction of the new Crude Oil Header to enable quick cut over from the existing Header to the replacement Header to commission the replacement Header.
- The assumption is made that the cabling to any valves which are replaced can be reused with only minor modification.
- The existing Raw Water Header has served its purpose for the last 24 years with no evidence of failure to justify an upgrade in metallurgy.
- The current hydraulic efficiency of the below grade raw water distribution system will be preserved in designing and installing a replacement Raw Water Header system.
- Hydraulic modeling has shown that the existing raw water transfer piping network hydraulically limits compliance with Level I drawdown rates over the course of oil displacement from individual caverns. The limitation is exaggerated by the increase in water side pressure drop across the wellhead string imposed by remediation on the performance of the existing Raw Water Injection Pumps such that replacement of the Raw Water Injection Pumps is recommended as a separate project.
- No increase in Raw Water Header sizing is recommended to reduce distribution piping pressure drop. The increase in piping costs for increasing Header pipe segment sizes does not lead to an increase in hydraulic efficiency to aid the sizing of replacement Raw Water Injection Pumps.
- No decrease in Raw Water Header sizing is recommended. Decreasing the pipe diameter of Header sections to derate the system for lower raw water flow in the absence of cavern leaching to reduce project costs is not justified by the potential impact on sizing replacement Raw Water Injection Pumps for incrementally higher discharge pressure.
- Permanent exposure of the existing below grade piping to facilitate inspection and repair is not an option given the poor water drainage on-site.

A. Above Ground Replacement

This alternative would install a full replacement Raw Water Header above grade in parallel to the existing below grade Header. Upon completion, Big Hill would cut over operation to the new above ground Header and abandon the below grade Header in place.

Benefits & Effectiveness

The replacement of the Raw Water Header above grade parallel to the existing below grade header allows for multiple benefits and addresses current mission needs.

- This alternative provides the most simplistic approach to replacing the existing below grade Raw Water Header with minimal disturbance to Big Hill drawdown readiness.
- The Big Hill site will be able to meet the required Level I crude oil drawdown rate of 1,100,000 barrels per day with this strategy.

Risk & Mitigation Factors

There are associated risks with replacement of the Raw Water Header above ground. The table below summarizes the risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Above Ground Replacement

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Probability of failure of existing below grade Raw Water Header increases with continued use.	Pursue more aggressive corrosion monitoring and fitness for service testing (pressure testing with water) on-site at Big Hill to project remaining life of sections of existing below grade piping. Install new above ground Header in advance of forecast of end of life.	High - High	High Risk Hazard
Above ground piping is exposed to increased stresses.	Complete piping stress analysis as part of detailed design effort to properly design piping and supports.	High - High	High Risk Hazard
New above ground piping is subject to internal corrosion while idled before commissioning.	Pack new piping with raw water with corrosion inhibitor while purging line of residual air to prevent onset of internal corrosion prior to use.	High - High	High Risk Hazard
Above ground piping weathers more quickly given its exposure.	Revise maintenance procedures to include periodic inspection of piping system and re-painting of exposed piping as needed.	Low - Medium	Low Risk Hazard
Above ground Header is not ready to commission in time to address onset of leaks in existing below grade Header.	Detail construction schedule with contingencies to tie-in sections of new above ground Header as needed to address discovery of leaks if/when they occur.	High - High	High Risk Hazard
Safety incidents during installation and tie-in of new above ground Header.	Adhere to project safety guidelines in accordance with the Federal & Industry Safety Standards during construction.	Medium - Medium	Medium Risk Hazard

B. Below Grade Replacement

This alternative would install a full replacement Raw Water Header below grade in parallel to the existing below grade Header. Upon completion, Big Hill would cut over operation to the new below grade Header and abandon the existing Header in place.

Benefits & Effectiveness

The replacement of the Raw Water Header below grade parallel to the existing below grade header allows for multiple benefits and addresses current mission needs.

- This alternative provides a simple strategic approach to replacing the existing below grade Raw Water Header with minimal disturbance to Big Hill drawdown readiness.
- The Big Hill site will be able to meet the required Level I crude oil drawdown rate of 1,100,000 barrels per day with this strategy.

Risk & Mitigation Factors

There are associated risks with replacement of the Raw Water Header below grade. The table below summarizes the risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Below Grade Replacement

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Probability of failure of existing below grade Raw Water Header increases with continued use.	Pursue more aggressive corrosion monitoring and fitness for service testing (pressure testing with water) on-site at Big Hill to project remaining life of sections of existing below grade piping. Install new below grade Header in advance of forecast end of life.	High - High	High Risk Hazard
New below grade piping is subject to internal corrosion while idled before commissioning.	Pack new piping with raw water with corrosion inhibitor injection while purging line of residual air to prevent onset of internal corrosion prior to use.	High - High	High Risk Hazard
New below grade piping is subject to external corrosion at welded sections.	Apply external coating across welded sections after construction and before wrapping pipe.	High - High	High Risk Hazard
Below grade header is not ready to commission in time to address onset of leaks in existing below grade Header.	Detail construction schedule with tie-in staging to the new below grade Header to minimize the consequences of discovery of leaks if/when they occur.	High - High	High Risk Hazard
Safety incidents during installation and tie-in of new below grade Header.	Adhere to project safety guidelines in accord with the Federal & Industry Safety Standards during construction.	Medium - Medium	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Above Ground Replacement

This alternative would install a full replacement Raw Water Header above grade in parallel to the existing below grade Header. Upon completion, Big Hill would cut over operation to the new above ground Header and abandon the below grade Header in place.

B. Below Grade Replacement

This alternative would install a full replacement Raw Water Header below grade in parallel to the existing below grade Header. Upon completion, Big Hill would cut over operation to the new below grade Header and abandon the existing Header in place.

Comparison of Alternatives

Core Team Member Ratings

	Safety During Construction	Constructability During Ongoing Oil Deliveries	Ease of Operations	Ease of Maintenance	Sustainability
	Most Important	*Most Important*	*Important*	*Important*	*Less Important*
Alternative A	*Good*	*Good*	*Excellent*	*Adequate*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Good*	*Excellent*
	Good	*Good*	*Excellent*	*Good*	*Excellent*
Alternative B	*Good*	*Good*	*Excellent*	*Good*	*Excellent*
	Good	*Excellent*	*Excellent*	*Good*	*Excellent*
	Good	*Good*	*Excellent*	*Adequate*	*Excellent*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$36,381,242**	**$37,094,288**
Alternative B	**$31,014,869**	**$31,140,349**

Recommended Alternative

B. Below Grade Replacement

Based on the technical evaluation of the Core Team Members, Alternative A was rated slightly higher than Alternative B on one evaluation criteria and the same on all other criteria. The initial cost and life cycle cost of Alternative B were both lowest of the alternatives. Therefore, Alternative B is the recommended preferred alternative based on very similar technical merits, but lower initial and life cycle costs.

BH-MM-1357

Replace Crude Oil Header

VCI Project Engineer: Lorna Madison

Recommended Alternative:

Below Grade Replacement

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The mission need at the Big Hill (BH) site will replace the Crude Oil Header portion of the crude oil delivery system. The Crude Oil Header is required to transfer crude oil for drawdown. The 36-inch Crude Oil Header is approaching 30 years of age and, as a result, is at an increased risk of loss of mechanical integrity.

Should the Crude Oil Header experience loss of mechanical integrity, drawdown would be suspended until repairs could be implemented. Extended repair times will compromise the sites ability to meet drawdown requirements.

Drawdown reliability of the crude oil delivery system of the Strategic Petroleum Reserve (SPR) at Big Hill must be maintained to ensure that petroleum from the SPR can be delivered during severe supply interruptions and to meet obligations under the International Energy Program.

Functional Requirements

- The Crude Oil Header should provide 100% operating reliability for drawdowns over an estimated 25-year service life of the Life Extension 2 (LE 2) initiative.
- Header replacement shall provide the hydraulic efficiency needed to meet the Level I crude oil drawdown requirements of 1,100,000 barrels per day at a suitably high delivery pressure.
- Header design should ensure that the need for in-place inspection and repair techniques can be minimized or eliminated.
- Header replacement shall preserve the segregation of sweet and sour crude oil deliveries.
- Header replacement activity should not compromise drawdown readiness.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Lorna Madison	VCI, Project Engineer
Stephen Brothers	FFPO, Principal Operations System Engineer

Team Members

Ed Orloski	VCI, Process Engineer
William Leet	VCI, Process Engineer
Rachel Gray	VCI, Process Engineer
Lisa Eldredge	FFPO, Principal Operations System Engineer
Buddy Delaune	FFPO, Principal Mechanical Engineer
David Morrow	FFPO, Sr. Mechanical Engineer
Paul Riegert	FFPO, Manager, Site Construction
Steven Crawford	FFPO, Site Mechanical Process Engineer

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommendation.

Constructability during Ongoing Oil Deliveries

The selected alternative is able to be implemented with little or no impact to ongoing oil delivery operations. Crude Oil Header replacement activity should not compromise drawdown readiness.

Weight: Most Important

Safety during Construction

The selected alternative when implemented will be able to be constructed and operated safely. The site's ability to address safety and security concerns during implementation shall not be impacted. A robust contractor work plan shall be vetted by the Government for all safety concerns that might be of note during construction.

Weight: Most Important

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment. Crude Oil Header replacement shall provide the hydraulic efficiency needed to meet the Level I crude oil drawdown requirements of 1,100,000 barrels per day, while preserving the segregation of sweet and sour crude oil deliveries.

Weight: Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration. The Crude Oil Header should provide 100% reliability on drawdowns over the 25-year life of LE 2. Header design should ensure that the need for in-place inspection and repair techniques can be minimized or eliminated.

Weight: Important

Sustainability

The selected alternative when implemented will be able to achieve the Department of Energy (DOE) sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

The project scope of work is set by considering alternatives to replace the Big Hill Crude Oil Header (Figure 1), which is nearing the end of its useful life.

The existing Crude Oil Header is an integral part of the crude oil distribution piping as shown in Figure 1. The Crude Oil Header proper is comprised of approximately 4,360 linear feet of 36-inch diameter pipe connected to 2,040 linear feet of 30-inch pipe and 370 linear feet of 24-inch pipe in a loop configuration to efficiently gather crude oil from the individual cavern wellheads through 16-inch lateral piping to each cavern. The bulk of this piping network is installed below grade. The piping is externally coated, wrapped, and cathodically protected against external corrosion.

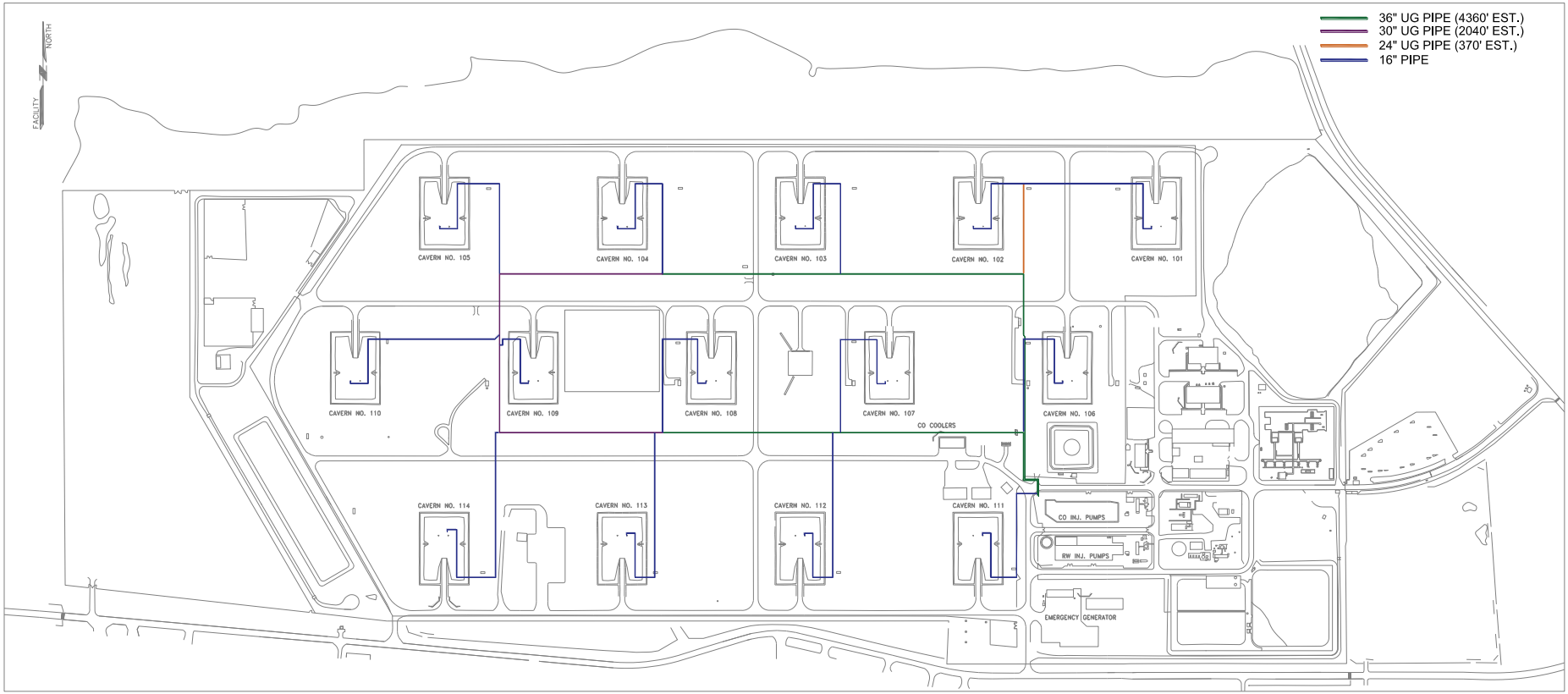

FIGURE 1 – Existing Crude Oil Header Piping and Diameters

The Crude Oil Header was placed in operation in 1991 and has operated up to now with few significant leaks. No inspections data have been collected on the header since it was commissioned into service. No data have been collected on external and internal pipe corrosion rates to predict the remaining life of the Header. However, it is anticipated that the remainder of the system is nearing the end of its useful life.

Replacing the Crude Oil Header is essential to meeting the Big Hill Level I drawdown requirement of 1,100,000 barrels per day of crude oil.

A. Status Quo

The status quo is to maintain and operate the existing system in place. The existing Crude Oil Header has served the Big Hill site well since it was commissioned into service in 1991.

Although the system is protected externally, it is still susceptible to corrosion. The original life of the Header was projected to be 25 years, and it has been operational for 24 of those. The existing piping has held up well for that time with no significant leaks experienced to date. However, the existing piping cannot be monitored below grade for conditions that could lead to loss of integrity. Drawdown would be suspended to address leaks upon discovery. The time that it would take to locate, isolate, mobilize for repair, and repair the leak would severely impact drawdown capabilities.

Given the nature of corrosion, the risk increases of jeopardizing the mission by failing to plan a Crude Oil Header replacement strategy to address corrosion and preserve drawdown capability over the next 25 years.

Viability: <u>No Further Analysis</u>

B. System Monitoring

This alternative consists of maintaining the existing system in place, continuing to operate the existing system while adding capability to monitor the condition of the Crude Oil Header in place, and evaluating the remaining life of the piping to recommend replacement of sections of the Header as needed.

Various system monitoring programs are available to determine the condition of the existing below grade Crude Oil Header to provide either detection of probable loss of integrity or actual loss should it occur. These systems would allow the existing Header to remain operational until replacement of the Header or sections of the Header are required. Examples of monitoring systems include the following:

1. <u>Intelligent Pigs.</u> - Portions of the existing Crude Oil Header system would be monitored with these types of inspection tools to predict header failure in advance. Pig launchers and receivers must be positioned in the appropriate locations to send and receive the devices for inspection of the Header. Those segments of the Crude Oil Header that cannot be monitored would be so equipped to provide information on the condition of the Header. Repair or replacement would follow the results of these inspections.

2. <u>Continuous Leak Detection.</u> - This type of monitoring system is applicable when loss of mechanical integrity has occurred. Inlet and outlet flows would be monitored, and a material balance made to determine whether material is being lost from the system. Accuracy of detection is dependent upon the accuracy of the flow measurements. The system must be operated on a continuous basis for some time to provide sufficient data for an accurate material balance to be performed. When leakage is detected, other means of detecting location must be used such as by visual siting.

3. <u>Pressure Test.</u> - This type of monitoring would be performed in the static condition by the application of pressure on the system using raw water without flow. Loss of integrity is detected by a continuous drop in system pressure. When leakage is detected, other means must be used to detect the location of the leak such as visual siting of upwelling of leaked water.

The success of each of these options is limited. For example, the existing Crude Oil Header is not amenable to pigging in its current configuration. Considerable modifications (elimination of pipe diameter reductions, elimination of long radius elbows and pinch points, installation of pig bars across tees, etc.) would be required to the existing Header make the line piggable. Alternative corrosion testing might provide a cheaper, more easily executed alternative to pigging. In contrast, the continuous leak detection and pressure testing, while recommended best practices, only aid in discovery of a leak after the fact. Moreover,

prediction and detection of leaks in themselves do not provide the 100% operating reliability required. Rather they mandate follow-up repair and/or replacement of defective sections, which may negatively impact drawdown readiness.

Given the nature of corrosion, the risk increases over time of jeopardizing the mission by failing to actually replace the Crude Oil Header to preserve drawdown readiness.

Viability: No Further Analysis

C. Above Ground Replacement

This alternative consists of installing a new above ground Crude Oil Header system that will provide the same crude oil distribution as the existing below grade Header. The above ground Header would follow the same general routing as the below grade Header. The exact placement of the new Header to avoid existing interferences would be decided during detailed design. The above ground header would utilize the same large diameter pipe sizes for connecting segments to preserve the hydraulic efficiency of the existing piping. The fourteen 30-year-old motor operated valves (MOV's) installed above ground in the Header would be replaced with new MOV's to preserve current operating practice for segregating sweet and sour crude deliveries as well as to expedite commissioning of the replacement Header. Special arrangements would be made to run the Header under or over roadways to preserve site access. Tie-ins would be made at appropriate locations to connect the new Header to the existing underground Header to cut over operation to the new Header. The new large diameter Header piping would be mounted on pipe supports, cathodically protected, and painted to cope with exposure to the weather. The existing below grade Header would be abandoned in place upon completion of the new Header.

Bringing the Header above ground facilitates Header access for inspection, repair, and any future modification of tie-ins to the Header.

This approach may prove logistically more difficult to implement than below grade replacement.

Viability: Continue Analysis

D. Below Ground Replacement

This alternative consists of installing a new below grade Crude Oil Header system to provide the same crude oil distribution as the existing below grade header. The new header would utilize plot area in proximity to the existing below grade Header to install a new Crude Oil Header alongside the existing below grade Header, following the same routing as the existing Header. The exact depth and placement of the new Header to avoid existing interferences would be decided during detailed design. The new Header would utilize the same pipe sizes for connecting segments to preserve the hydraulic efficiency of the existing piping. The fourteen 30-year-old MOV's installed above ground in the existing Header would be replaced with new MOV's to preserve current operating practice for segregating sweet and sour crude deliveries as well as to expedite commissioning of the replacement Header. Tie-ins would be made at appropriate locations to connect the new Header to the existing Header to cut over operation to the new Header. The new piping would be wrapped, coated, and cathodically protected in similar fashion to the existing below grade Header. The existing below grade Header would be abandoned in place upon completion of the new Header.

Burying the new Header below grade constitutes acceptable risk with respect to monitoring the new underground piping for remaining life and leaks given the exceptional 24+ years of service with the existing underground Header. This approach may prove logistically more difficult to implement than above ground replacement.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A and B, are eliminated from further consideration. The remaining alternatives, C and D, are examined below as alternatives A and B, respectively. The below

analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

Assumptions & Constraints

- Insufficient data are available to estimate the remaining life of the below grade Crude Oil Header currently in place to provide comfort operating the existing header without replacement over the next 25 years of service.
- The scope of Crude Oil Header replacement is limited to the 36-inch, 30-inch, and 24-inch diameter piping in the crude oil transfer piping network and excludes the 16-inch diameter lateral connections to individual cavern wellheads.
- The scope includes replacement of the fourteen 30-year-old MOV's installed underground in the header to preserve current operation practices for segregating sweet and sour crude deliveries. Replacement of the valves with new valves is required to complete construction of the new Crude Oil Header to enable quick cut over from the existing Header to the replacement Header to commission the replacement Header.
- The cabled wiring to the existing MOV's will be reused to wire up the new MOV's.
- The existing Crude Oil Header has served its purpose well for the last 24 years with no evidence of failure to justify an upgrade in metallurgy.
- The current hydraulic efficiency of the below grade crude oil distribution system will be preserved in designing and installing a replacement Crude Oil Header system.
- No increase in Crude Oil Header sizing is recommended. Hydraulic modeling has shown that the existing crude oil transfer piping network does not hydraulically limit compliance with Level I drawdown rates over the course of oil displacement from individual caverns.
- No decrease in Crude Oil Header sizing is recommended. Hydraulic checks on pipe velocities and momentum factors confirm that the existing piping is properly sized.
- Permanent exposure of the existing below grade Crude Oil Header to facilitate inspection and repair is not an option given the poor water drainage on-site.

A. Above Ground Replacement

This alternative would install a full replacement Crude Oil Header above grade in parallel to the existing below grade Header. Upon completion, Big Hill would cut over operation to the new above ground Header and abandon the below grade Header in place.

Benefits & Effectiveness

The replacement of the Crude Oil Header above grade parallel to the existing below grade header allows for multiple benefits and addresses current mission needs.

- This alternative provides the most simplistic approach to replacing the existing below grade Crude Oil Header with minimal disturbance to Big Hill drawdown readiness.
- The Big Hill site will be able to meet the required Level I drawdown rate of 1,100,000 barrels per day with this strategy.

Risk & Mitigation Factors

There are associated risks with replacement of the Crude Oil Header above ground. The table below summarizes risks with the correlation mitigation strategy. The table also describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Above Ground Replacement

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Probability of failure of existing below grade Crude Oil Header increases with continued use.	Pursue more aggressive corrosion monitoring and fitness for service testing (pressure testing with water) on site at Big Hill to project remaining life of sections of existing below grade piping. Install new above ground Header in advance of forecast of end of life.	High - High	High Risk Hazard
Above ground piping is exposed to increased stresses.	Complete piping stress analysis as part of detailed design effort to properly design piping and supports.	High - High	High Risk Hazard
New above ground piping is subject to internal corrosion while idled before commissioning.	Pack new piping with raw water with corrosion inhibitor while purging line of residual air to prevent onset of internal corrosion prior to use.	High - High	High Risk Hazard
Above ground piping weathers more quickly given its exposure.	Revise maintenance procedures to include periodic inspection of piping system and re-painting of exposed piping as needed.	Low - Medium	Low Risk Hazard
Above ground Header is not ready to commission in time to address onset of leaks in existing below grade Header.	Detail construction schedule with contingencies to tie in sections of new above ground Header as needed to address discovery of leaks if/when they occur.	High - High	High Risk Hazard
Safety incidents during installation and tie-in of new above ground Header.	Adhere to project safety guidelines in accord with the Federal & Industry Safety Standards during construction.	Medium - Medium	Medium Risk Hazard

B. Below Grade Replacement

This alternative consists of installing a full replacement Crude Oil Header below grade in parallel to the existing below grade Header. Upon completion, Big Hill would cut over operation to the new below grade Header and abandon the existing Header in place.

Benefits & Effectiveness

The replacement of the Crude Oil Header below grade parallel to the existing below grade header allows for multiple benefits and addresses current mission needs.

- This alternative provides a simple strategic approach to replacing the existing below grade Crude Oil Header with minimal disturbance to Big Hill drawdown readiness.
- The Big Hill site will be able to meet the required Level I drawdown rate of 1,100,000 barrels per day with this strategy.

Risk & Mitigation Factors

There are associated risks with replacement of the Crude Oil Header below grade. The table below summarizes risks with the correlation mitigation strategy. The table also describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Below Grade Replacement

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Probability of failure of existing below grade Crude Oil Header increases with continued use.	Pursue more aggressive corrosion monitoring and fitness for service testing (pressure testing with water) on-site at Big Hill to project remaining life of sections of existing below grade piping. Install new below grade Header in advance of forecast end of life.	High - High	High Risk Hazard
New below grade piping is subject to internal corrosion while idled before commissioning.	Pack new piping with raw water with corrosion inhibitor injection while purging line of residual air to prevent onset of internal corrosion prior to use.	High - High	High Risk Hazard
New below grade piping is subject to external corrosion at welded sections.	Apply external coating across welded sections after construction and before wrapping pipe.	High - High	High Risk Hazard
Below grade Header is not ready to commission in time to address onset of leaks in existing below grade Header.	Detail construction schedule with tie-in staging to the new below grade header to minimize the consequences of discovery of leaks if/when they occur.	High - Low	Low Risk Hazard
Safety incidents during installation and tie-in of new below grade Header.	Adhere to project safety guidelines in accord with the Federal & Industry Safety Standards during construction.	Medium - Medium	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Above Ground Replacement

This alternative would install a full replacement Crude Oil Header above grade in parallel to the existing below grade Header. Upon completion, Big Hill would cut over operation to the new above ground Header and abandon the below grade Header in place.

B. Below Grade Replacement

This alternative consists of installing a full replacement Crude Oil Header below grade in parallel to the existing below grade Header. Upon completion, Big Hill would cut over operation to the new below grade Header and abandon the existing Header in place.

Comparison of Alternatives

Core Team Member Ratings

	Safety During Construction	**Constructability During Ongoing Oil Deliveries**	**Ease of Operations**	**Ease of Maintenance**	**Sustainability**
	Most Important	*Most Important*	*Important*	*Important*	*Less Important*
Alternative A	*Good*	*Good*	*Excellent*	*Adequate*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Good*	*Excellent*
	Good	*Good*	*Excellent*	*Good*	*Excellent*
Alternative B	*Good*	*Good*	*Excellent*	*Good*	*Excellent*
	Good	*Excellent*	*Excellent*	*Good*	*Excellent*
	Good	*Good*	*Excellent*	*Adequate*	*Excellent*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$46,171,643**	**$46,884,689**
Alternative B	**$39,758,133**	**$39,883,613**

Recommended Alternative

B. Below Grade Replacement

Based on the technical evaluation of the Core Team Members, Alternative A was rated slightly higher than Alternative B on one evaluation criteria and the same on all other criteria. The initial cost and life cycle cost of Alternative B were both lowest of the alternatives. Therefore, Alternative B is the recommended preferred alternative based on very similar technical merits, but lower initial and life cycle costs.

BH-MM-1362

Replace and Relocate Hydraulic Security Barrier

VCI Project Engineer: Corb Elsbury

Recommended Alternative:

Design an Employee Parking Area Entrance with Wafer Access Entry

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

Replace and/or relocate the Big Hill Hydraulic Security Barrier (HSB) used for site access control to locations commensurate with their intended function of intrusion deterrence and not traffic control.

Functional Requirements

The HSB is to meet the Department of Energy (DOE) Order 473.3 A. security parameters and have a functional design (used as intended). Physical barriers serve as the demarcation of the site security area. Activated barriers must be used to deter and delay unauthorized access. Barriers are also used to support and prevent stand-off attacks as well as control/deny potential avenues of approach. At a minimum, analysis is required to determine protection measures against Vehicle Borne Improvised Explosive Devices (VBIEDs). Controls for motorized gates (HSBs) must be located within protective force posts/facilities and designed to facilitate manual operation during power outages. The following are functional requirements for the HSB on the Strategic Petroleum Reserve (SPR) site:

- All potential vehicle approach routes to identified target areas must have barriers installed that will preclude an adversary from reaching the target.
- Speed reducing barriers must be used to slow adversary vehicles to achieve site specific threat/target system response requirements.
- Requirements must be consistent with the operation of the facility and protection goals as documented in the vulnerability assessment (VA).

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
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III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation. Safety is of the greatest importance.

Weight: Most Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems. The Site Security Specialist shall coordinate with the site leadership and contractor to accommodate for down time to particular assessment systems during construction.

Weight: Most Important

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations. Close coordination with the Site Security Specialist and site/maintenance operations will allow for minimal impact on oil delivery operations.

Weight: Less Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan. Energy consumption shall be considered in all upgraded equipment criteria.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

Leave existing barriers in place and implement a robust preventive maintenance plan to preclude downtime. The current system was constructed in ~2004, and therefore, is not a viable option due to life

cycle replacement needs. When operability testing shows degraded system performance, the typical site maintenance schedule is disrupted.

Viability: No Further Analysis

B. Reprogram HSB and Replace Existing HSB Component Parts

The current HSB shall be reprogrammed to allow for separate use of the security drop arm and HSB. This will allow for the HSB to be left in the down position, depending on security posture levels. The HSB internal component parts shall be replaced for this alternative.

Viability: Continue Analysis

C. Design an Employee Parking Area Entrance with Wafer Access Entry

Relocate the employee parking area entrance for use by badged employees to an alternate location. Replace HSB internal component parts and install a security wafer reader accompanied with intercom and fixed camera

Viability: Continue Analysis

D. Install an Electric Powered HSB

Install an electric powered HSB that is engineered to meet DOE crash specifications in place of the existing hydraulic powered HSB. The electric barrier alternative will require excavation, complete electrical retrofit, and battery bank installation (back-up power). The electric powered barrier did effectively address the problem set of replacing outdated equipment, however, the alternatives study group felt maintenance would still be an issue since the use of the barrier would not be changed. Therefore, this alternative is not considered a viable option.

Viability: No Further Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A and D are eliminated from further consideration. The remaining alternatives, B and C are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Reprogram HSB and Replace Existing HSB Component Parts

The HSB shall be reprogrammed to allow for separate use of the security drop arm and HSB (steel wedge barrier). This will allow for the HSB to be left in the down position, depending on security posture levels. The HSB internal component parts shall be replaced to address end of life cycle conditions for this alternative.

The existing HSBs were integrated into the site access control system at the same time that onsite parking was moved outside the site perimeter (~2004). The HSBs are located in such a way that every vehicle, whether entering or exiting the site, to include employee parking, must pass through the HSB. As a result, the HSBs suffer from high failure rates and high maintenance costs as well as repeated incidents of vehicle damage and potential risks to personnel; this is due to serving the function of a traffic control gate rather than their intended function of intrusion deterrence. In the current configuration, the Protection Force (PF) potentially operates the security drop arm and steel wedge barrier in excess of ~200 times a day. Issues concerning unscheduled maintenance repairs and service calls are costly and likely will continue after refurbishment due to continued repetitive use. The Nasatka Security Company (manufacturer and proprietor of the current barriers in use on the SPR) provides options to alleviate the challenge with the existing configuration. Offered are services providing reprogramming and installation of a color liquid crystal display (LCD) touch screen with updated barrier programming options; completely encrypted for security.

Replacing all internal component parts provides a very cost effective way to prolong the life cycle of the existing Nasatka HSBs. The Nasatka HSBs are proprietary and interior components must be replaced from their spare parts listing.

Assumptions & Constraints

- The existing HSB model is not too old to be reprogrammed.
- Vulnerability Assessments (VA) may require the HSB to operate as before, as a traffic device – returning the problem set to the original concern of overuse.
- If the existing HSB is too old to be reprogrammed, the replacement of component parts will remedy this issue.
- Site security shall make minimum re-writes to any entrance security procedures.

Benefits & Effectiveness

The site shall reprogram the HSB will allow for overall improved security and safety measures over the life of the HSB. The information below summarizes mission support and the benefits and effectiveness of reprogramming the existing HSB and replacing parts that are at their life cycle end.

- Reprogramming allows for the separate use of the security drop arm and HSB steel wedge gate, thereby allowing the PF latitude to decide HSB positioning based on security postures (DOE 473.3 A., Attachment 3, Section A 3-29 [1][a]).
- Allows for HSB steel wedge gate to remain in down position during determined security postures but still control access to the site (DOE 473.3 A., Attachment 3, Section A 3-29 [1][a]).
- Allows barriers to be used for its intended design of an intrusion detergent and not a traffic control device (DOE 473.3 A., Attachment 3, Section A 3-29 [1][a]).

Risk & Mitigation Factors

Some potential risks associated with re-programming the existing HSB and replacing component parts include reducing security posture during construction and failure of the HSB internal components. The table below summarizes the mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site as well as how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Re-Programming the Existing HSB and Replacing Parts			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Reducing security posture during construction.	Move K-12 rated barriers into place (chicane) while component parts are replaced on HSB.	High - Medium	Medium Risk Hazard
Vulnerability Assessments require the HSB to perform as a traffic control device.	Implement a robust maintenance program and plan for HSB refurb ~2 times over its next life cycle.	High-High	High Risk Hazard
The HSB require routine maintenance.	Come up with strategic maintenance schedule and plan to avoid security risk.	Low - Medium	Low Risk Hazard
Visitor or vendor “piggy backs” during employee entrance.	Programming the HSB ensures the security drop arm lowers after each vehicle; fixed camera observation allows for the “E-up” option when situation dictates.	Low - Low	Low Risk Hazard

B. Redesign an Employee Parking Area Entrance with Wafer Access Entry

Design an additional parking lot entrance at the employee parking area that shall include installing wafer entry apparatus (K12-rated security drop arm, wafer entrance/exit reader, intercom and fixed camera) and K-rated jersey barriers for badged DOE employees. Large vehicles and incoming visitors continue to use the existing HSB entrance, thus allowing the HSB steel wedge gate and security drop arm to remain in the current programmed configuration. Replace HSB component parts that are identified as having reached the end of their life cycle.

The existing HSBs were integrated into the site access control system at the same time that onsite parking was moved outside the site perimeter (~2004). The HSBs are located in such a way that every vehicle, whether entering or exiting the site, to include employee parking, must pass through the HSB. As a result, the HSBs suffer from high failure rates and high maintenance costs as well as repeated incidents of vehicle damage and risk to personnel; this is due to serving the function of a traffic control gate rather than their intended function of intrusion deterrence. In the current configuration, the Protection Force (PF) potentially operates the security drop arm and steel wedge barrier in excess of ~200 times a day. Issues concerning unscheduled maintenance repairs and service calls are costly. This alternative potentially reduces the HSB to an operating pace of ~10 per day for deliveries and those requiring site vehicle entry.

The current employee parking area perimeter fence contains an additional gate which is secured and rarely used. An additional employee entrance is easily designed utilizing this existing gate in conjunction with the security wafer concept. Virtually the same configuration exists at the DOE office complex parking area located at Building 900 in New Orleans, Louisiana; the additional entrance allows the PF flexibility to screen visitors and vendors while allowing for expeditious employee entrance operations simultaneously. Employees approach the security drop arm, scan their security wafer (issued by site or New Orleans security office), the security drop arm raises and the employee proceeds through a chicane (replicates the use of the steel wedge barrier) of K12 rated barriers to their parking space. The security drop arm shall be programmed to drop after each employee vehicle, allowing for the PF to positively identify each employee by wafer as well as camera recognition prior to entry.

Replacing all internal component parts provides a very cost effective way to prolong the life cycle of the existing Nasatka HSBs. The Nasatka HSB components are proprietary and must be replaced from their parts listing.

Assumptions & Constraints

- The site may experience a small realignment of parking spaces.
- The existing additional gate at the employee parking lot is sufficient and easily converted to an employee only entrance.
- Security wafers are attained in a timely manner in order not to disrupt entrance operations.
- Component part refurb eliminates costly/unscheduled maintenance.
- Vulnerability Assessment (VA) shall define final detailed design.

Benefits & Effectiveness

The addition of a security wafer apparatus that will allow for improved security and safety measures. The information below summarizes the benefits/effectiveness as wells as addressing specific site mission needs by redesigning the current parking area with wafer entry apparatus.

- Visitors and large vehicles continue to use the existing HSB entrance, employees use alternate employee entrance; resulting in less HSB use and expedited employee entrance operations (DOE 473.3 A., Attachment 3, Section A 3-29 [1][a]).
- Allows for the HSB to be used for its primary purpose, intrusion deterrence (DOE 473.3 A., Attachment 3, Section A 3-29 [1][a]).

- Less frequent use of the HSB prolongs the life cycle of operating components and costly unscheduled maintenance (DOE 473.3 A., Attachment 3, Section A 3-29 [1][a]).

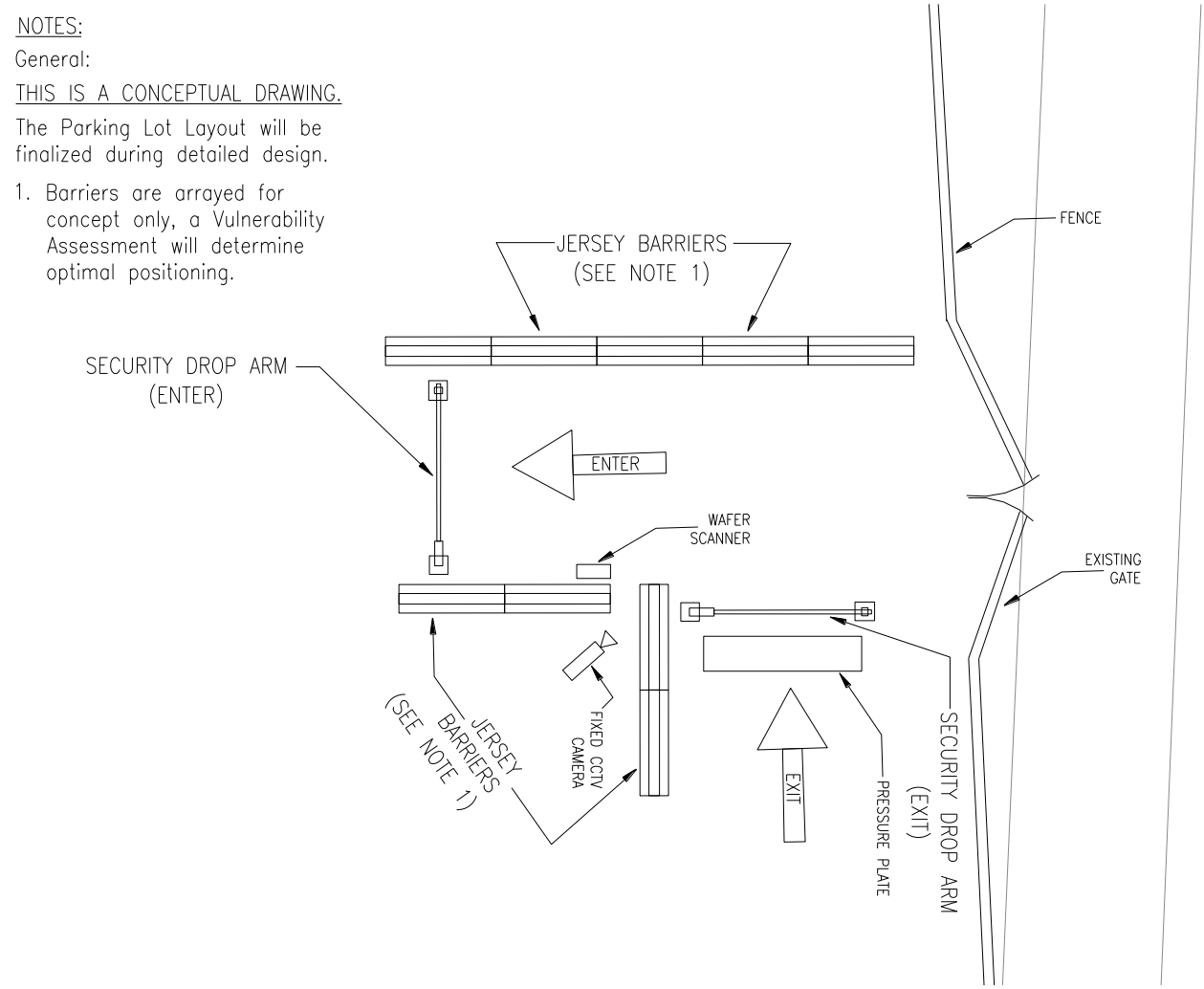

Figure 1 – Conceptual Employee Parking Lot Entrance and Exit Layout

Risk & Mitigation Factors

With any new upgrade at the site come associated risks. Some potential risks associated with adding a parking area with a wafer entry apparatus include reducing security posture during construction, failing of the wafer apparatus, maintaining the wafer entry apparatus and HSB, and failing of the HSB internal components. The table below summarizes the above mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Adding a Parking Area with a Wafer Entry Apparatus			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**

Reducing security posture during construction.	Move K-12 rated barriers into place (chicane) while component parts are replaced on HSB.	High - Medium	Medium Risk Hazard

Risk and Mitigation Strategies for Adding a Parking Area with a Wafer Entry Apparatus (continued)

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Wafer entry apparatus fails.	Employees use original HSB entrance until fixed.	Low - Low	Low Risk Hazard
Both the wafer entry apparatus and the HSB require routine maintenance.	Robust routine maintenance schedule; an existing PF plan exists to avoid this security risk.	Low - Medium	Low Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Reprogram HSB and Replace Existing HSB Component Parts

The current HSB shall be reprogrammed to allow for separate use of the security arm and HSB (raise & lower); allowing for the HSB to be left in the down position depending on security posture levels. The HSB, in the down position option, allows for less wear and tear on the equipment, as well as using the barrier as it was intended – for security and not a traffic control device. Replacing the HSB component parts that are identified as having reached the end of their life cycle and conducting re-programming of the barrier mechanism allows separate use of the barrier and the security arm.

B. Design an Employee Parking Area Entrance with Wafer Access Entry

Design an additional parking lot entrance at each employee parking area that includes, installing wafer entry apparatus, security drop arm, intercom and K-rated barriers accompanied with a security camera for badged employees; large vehicles and visitors continue to use the existing HSB entrance (the HSB remains in the up position at all times otherwise). Replace HSB component parts that are identified as having reached the end of their life cycle.

Comparison of Alternatives

Core Team Member Ratings

	Ease of Operations	**Ease of Maintenance**	**Safety During Construction**	**Security During Construction**	**Constructability During Ongoing Oil Deliveries**	**Sustainability**
	Most Important	*Most Important*	*Most Important*	*Most Important*	*Less Important*	*Less Important*
Alternative A	*Good*	*Good*	*Good*	*Excellent*	*Excellent*	*Good*
	Good	*Good*	*Good*	*Excellent*	*Excellent*	*Good*
	Good	*Good*	*Good*	*Good*	*Excellent*	*Adequate*
Alternative B	*Excellent*	*Excellent*	*Good*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Good*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Good*	*Good*	*Good*	*Excellent*	*Adequate*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$370,426**	**$705,309**
Alternative B	**$674,145**	**$674,145**

Recommended Alternative

B. Design an Employee Parking Area Entrance with Wafer Access Entry

Based on the technical evaluation of the Core Team Members, Alternative B was clearly rated equal or superior on all evaluation criteria. The key factor in the higher technical rating was that Alternative B best solves the actual problem of reducing the number of times the HSB needs to raise and lower on a given day. The initial cost of Alternative A was significantly lower, however, the life cycle cost of Alternative A was higher than Alternative B. With the initial investment cost savings of Alternative A negated by the increased life cycle costs, Alternative B is the recommended preferred alternative.

BH-MM-1370

Heat Exchanger Bundle Spares

VCI Project Engineer: Lorna Madison

Recommended Alternative:

New Isolation Valves and Spare Tube Bundles (SeaCure)

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The heat exchangers at each Strategic Petroleum Reserve (SPR) site are mission critical. Without the heat exchangers, the SPR drawdown capability is severely limited. The existing heat exchanger internal components (tube bundles) have been in service for over a decade and are subject to corrosion due to the properties of the available water sources. While the anticipated service life of the existing tube bundles is unknown and projections based on the analysis of corrosion coupons show an extended life, tube bundles in general suffer degradation over time such that individual bundles may need to be taken out of service for tube maintenance or repair. Irrespective of the service life predicted or achieved, an effective repair and replacement strategy must be developed. If the heat exchangers cannot be guaranteed reliable, taken out of service for repair, or replaced with readily available spare bundles, the SPR drawdown rate cannot be met, and the mission would be compromised.

Functional Requirements

- Heat exchanger tube bundle sparing when combined with material selection of spares and operating philosophy must provide design cooling capacity with 100% reliability during drawdown over the life of the Life Extension 2 (LE 2).
- Tube bundle material selection combined with bundle sparing should provide a 25-year service life.
- Spare tube bundles must fit into the existing exchanger shells and provide the same heat transfer, same flow capacity, and same or lower pressure drop as the original tube bundles.
- Positive shutoff isolation valves must be provided to isolate the exchangers to plug tubes in place and/or to replace tube bundles as required in support of the sparing philosophy.

FIGURE 1 – Heat Exchanger Tube Bundle Transport

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

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Paul Riegert	FFPO, Manager Site Construction

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as necessary to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate alternatives and select a recommendation.

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment. Cooling capacity is critical to meeting mission needs. Current design cooling capacity must be met or exceeded. Tube bundle sparing must allow development of operating procedures designed to produce 100% cooling capacity on every drawdown over the 25-year life of LE 2 without the expectation of tube failures during a drawdown.

Weight: Most Important

Safety during Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. The site's ability to address safety and security concerns during implementation shall not be impacted. Project work plans must invoke SPR protocols to establish a safe work environment for all construction related activity.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration. Spare tube bundles must fit existing exchanger shells with metallurgy compatible with service requirements to meet or exceed the 25-year life of LE 2.

Weight: Important

Sustainability

The selected alternative when implemented will be able to achieve the Department of Energy (DOE) sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan. Exchanger bundle sparing should be minimized to reduce materials and energy consumption in support of sustainability goals.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

The Big Hill (BH) site in Texas is equipped with five parallel Crude Oil Coolers (Figures 2.1 & 2.2). The exchangers provide sufficient surface area to cool 1,100,000 barrels per day of 111°F crude oil down to 97°F by using 1,133,000 barrels per day of 80°F raw water. This level of cooling cannot be accomplished with any one of the exchangers out of service. Ability to meet the crude oil Level I drawdown criterion is at risk when one or more exchangers suffer simultaneous tube bundle failures.

The five Crude Oil Exchangers are arranged in a single exchanger train. In this configuration, the exchangers are not equipped with means to isolate the exchanger train or individual exchangers to plug leaking tubes such that the failure of a single tube at Big Hill will force suspension of a drawdown to address the leak. Double block and bleed capability is provided with gate valves on the raw water inlets to each of the 5 exchangers. Only single isolation gate valves are provided on crude oil inlet and outlines as well as the raw water outlet lines. None of these single valves provide the positive shutoff required to safely isolate the exchangers during a drawdown to repair leaking tubes.

Currently the exchanger tube bundles are constructed of SeaCure tube material. This material is a high performance ferritic stainless steel. It was specifically developed as a lower cost alternative to titanium, which is resistant to chloride crevice corrosion and chloride pitting. Preliminary testing indicated that this metallurgy was a good choice for upgrading the original carbon steel (CS) tube bundles installed in the Crude Oil Coolers at Big Hill to address ongoing corrosion issues with under deposit pitting observed with stagnate brackish water and biological growth in the exchanger bundles. The original CS tube bundles were replaced with SeaCure tube bundles to overcome the rapid tube bundle corrosion failures experienced with the original CS tube bundles. The SeaCure tube bundles have been in service for more than 10 years with no loss of performance. Monitoring has shown no significant increase in pressure drop across the exchanger shell and tubes, and no leaks have been observed in the field. However, this constitutes limited history with respect to service life from which to project remaining tube bundle life. Given the progressive nature of corrosion and the lack of data to project remaining tube life, the reliability of the Crude Oil Coolers is subject to question. This introduces some risk in continuing to reliably operate the Big Hill site to the Level I drawdown rate of 1,100,000 barrels per day over the next 25 years.

The Crude Oil Coolers at Big Hill were provided by a different fabricator than the one who supplied the shell and tube heat exchangers to the West Hackberry, Bryan Mound, and Bayou Choctaw SPR sites. Yuba designed the exchangers at Big Hill. Struthers supplied the exchangers to the other SPR sites. Differences in detailed design render the Yuba tube bundles for Big Hill incompatible with Struthers shells, and Struthers tube bundles incompatible with Yuba shells. Hence, spare tube bundles cannot be shared between Big Hill and the West Hackberry, Bryan Mound, and Bayou Choctaw sites. This imposes higher risk and a more aggressive bundle sparing philosophy at Big Hill relative to the other sites.

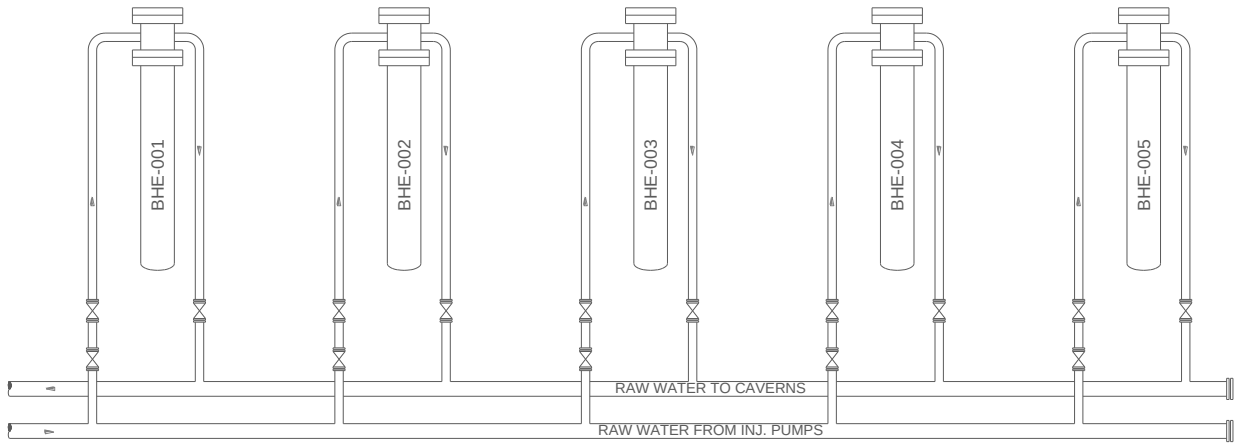

FIGURE 2.1 – Raw Water Heat Exchanger Tube Bundles

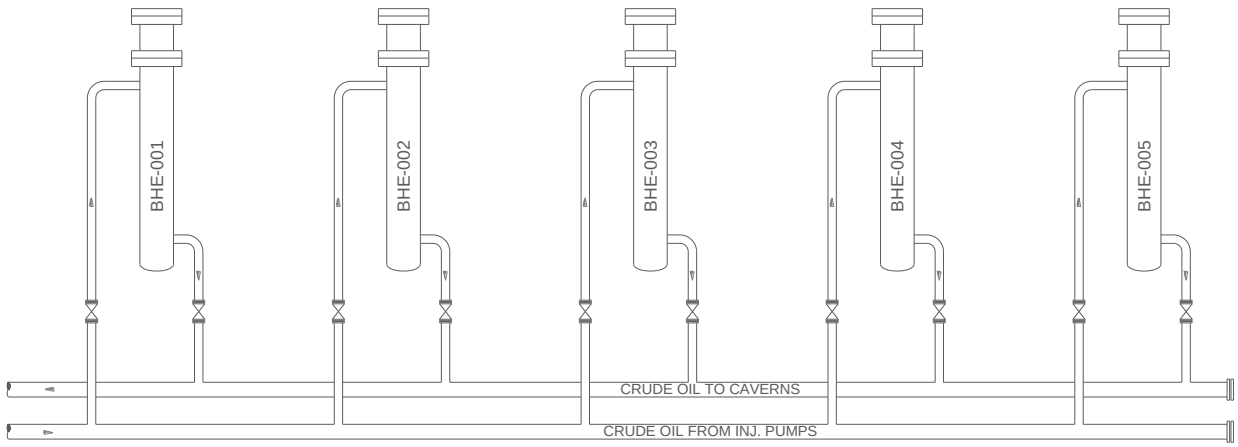

FIGURE 2.2 – Crude Oil Heat Exchanger Tube Bundles

1. Alternatives for Sparing Heat Exchanger Tube Bundles

The project scope of work is set by considering alternatives for how the existing Crude Oil Coolers are best spared.

A. Status Quo

The status quo is to maintain the existing system in place without providing spare tube bundles.

The existing SeaCure tube bundles have performed well over the last 10-16 years of service with little evidence of deterioration in performance. This alloy was specifically chosen for applications where localized corrosion in chloride-containing waters is an issue. However, insufficient data has been collected to project the remaining useful life of these exchangers to determine whether the SeaCure tube bundles will last another 25 years.

The existing heat exchangers are not equipped with isolation valves, which can provide positive shutoff on the crude oil and raw water (cooling water) sides to facilitate isolation of individual exchangers for repair of tube bundle leaks. With the current isolation block valve arrangement, the entire exchanger network must be taken off line on a tube bundle failure in any one of the exchangers before or during drawdown to repair or replace a single bundle. The time it takes to effect repairs in this way will delay drawdown to the detriment of the drawdown schedule. Given the nature of corrosion, the risk increases of jeopardizing the mission by

failing to plan a tube bundle sparing philosophy to address corrosion and preserve drawdown capability over the next 25 years.

Viability: No Further Analysis

B. New Isolation Valves Without Spare Tube Bundles

This alternative consists of maintaining the heat exchanger network in place without providing spare tube bundles. Instead, isolation valves will be provided in the appropriate numbers and placement for each exchanger on both the crude oil and water to permit isolation of any one exchanger which suffers a tube failure.

Installation of isolation valves facilitates isolation of individual exchangers before drawdown or on the run during a drawdown operation. Isolation from service allows for opening of the isolated exchanger to effect repairs and plug tubes should they fail a fitness for service test to more quickly repair and return an exchanger to service before drawdown. These isolation valves also provide the capability to identify and isolate an individual exchanger during drawdown to eliminate the leak and proceed with drawdown at a lower rate. Double block and bleed capability is provided with gate valves on the raw water inlets to each of the 5 exchangers. However, only single isolation valves are provided on the raw water outlet lines and the crude oil inlet and outlet lines. The single gate valves do not provide the positive shutoff to safely isolate and work each exchanger. Based on first look, 15 new isolation valves would have to be added to upgrade all 6 exchangers for safe, positive isolation of individual exchangers. The preferred configuration leads to installation of true double block and bleed capability upstream and downstream of each exchanger on both the crude oil and water sides.

Given the nature of corrosion and the increasing frequency of tube bundle failures over time, the risk increases of jeopardizing the mission by failing to actually stage spare bundles to replace tube bundles. This accumulates too many tube plugging repairs such that the available heat transfer area is no longer adequate to preserve cooling capacity for drawdown.

Viability: No Further Analysis

C. New Isolation Valves and Spare Tube Bundles

This alternative consists of maintaining the existing system in place and providing appropriate numbers and placement of valves for isolation of each exchanger. Also, a number of spare tube bundles will need to be provided so exchangers can be quickly repaired by plugging failed tubes or replacing tube bundles with spares on hand following the discovery of failures during fitness for service testing prior to drawdown.

The effectiveness of plugging individual tubes is limited in the face of progressive tube failures due to corrosion, leading to continued loss of effective heat transfer area in the exchanger and exchanger capacity. Having spare tube bundles available provides for full tube bundle replacement to restore heat transfer surface area to avoid reducing drawdown rates below the Level I Criteria. Purchase of 2 spare bundles for Big Hill is recommended for insurance against tube bundle leaks. This amounts to sparing 2 of 5 tube bundles or 40% of the single exchanger train. Purchase of 2 spare bundles provides insurance against leakage of a new bundle on initial installation. It also provides contingency against storage and handling damage to the new spare bundles. Two spares should also provide sufficient time to fabricate and deliver additional tube bundles to address any unforeseen increase in corrosion rate or bundle deterioration towards the end of LE 2.

Viability: Continue Analysis

D. Spare Tube Bundles Without New Isolation Valves

This alternative consists of maintaining the existing system in place and providing a number of spare tube bundles, so the tube bundles in an entire train of exchangers can be replaced with new bundles should failures be experienced preceding drawdown. The purchase of 2 spare tube bundles for Big Hill is recommended as noted in Alternative C above.

The ease and effectiveness with which individual heat exchanger tube leaks can be isolated and repaired prior to drawdown or during drawdown is compromised by failure to install the proper crude oil inlet and outlet isolation valves cited in Alternative C above.

Viability: No Further Analysis

2. Alternatives for Tube Bundle Materials Selection

The project scope of work is set by considering alternatives for materials of construction for the spare tube bundles.

A. Status Quo – SeaCure

Ferritic Stainless Steel (SeaCure) is a high performance stainless steel that can be used as an alternative to copper-nickel and titanium tubing. SeaCure is a high strength/low work material with good ductility. This alloy is specifically fabricated for applications where localized corrosion in chloride-containing water is an issue. While performance data is not widely available for SeaCure in similar applications, the installed SeaCure tube bundles have performed admirably in service at Big Hill relative to their failure prone carbon steel predecessors with little evidence of significant deterioration to date.

Viability: Continue Analysis

B. Austenitic Stainless AL-6XN

Austenitic Stainless AL-6XN is a low carbon, high purity austenitic stainless alloy, which is designed to be a seawater resistant material. High nickel and molybdenum contents make AL-6XN an answer to chloride ion stress corrosion cracking. Whereas, the nitrogen content allows AL-6XN to have a greater tensile strength, while retaining high ductility and impact strength. AL-6XN is a relatively new offering for this service with limited performance data with respect to the corrosion mechanisms witnessed at Big Hill.

Viability: No Further Analysis

C. Super Duplex Stainless 2507

Super Duplex Stainless 2507 is a chromium, molybdenum, and nickel based alloy, which has exceptional strength and corrosion resistance. Duplex 2507 exhibits excellent resistance to chloride stress corrosion cracking and pitting, making this material good for seawater application. Super Duplex Stainless 2507 is a relatively new offering for this service with limited performance data with respect to the corrosion mechanisms witnessed at Big Hill.

Viability: No Further Analysis

D. Titanium

Titanium (Grade 2) is a high titanium alloy that possesses good weldability, strength, ductility, and formability. Titanium (Grade 2) is typically used in applications where corrosion resistance is required for various aggressive materials. This material is resistant to high chloride content and service life may extend beyond the LE 2 25-year life requirement. Titanium may be more susceptible to flow induced vibration and failure for the wide variation in flow experienced at Big Hill without careful exchanger design. Nonetheless, titanium has a track record of successful application in high chloride service such as seawater dating back over 40 years.

The substitution of titanium for SeaCure requires repeating the Heat Transfer Research, Inc. (HTRI) software calculation to determine heat exchange rate, placement of baffles, tube wall thickness, and minimum bend radius for tubes. A material change would also require redesign of the tubesheet and the tube to tubesheet welding, currently designed for welding ferritic stainless tubes to the tubesheet. All would be required because the strength, elongation, minimum bend radius, and welding of Titanium is different from that of Ferritic Stainless steel.

Viability: Continue Analysis

E. Inconel

Inconel (Alloy 22) is a fully austenitic nickel based alloy, which exhibits excellent resistance to corrosive attacks by seawater, stress corrosion cracking, pitting, general corrosion, and crevice corrosion. Inconel is engineered to offer a combination of heat resistance, high temperature corrosion resistance, toughness, and strength. However, Inconel has limited performance data with respect to the corrosion mechanisms witnessed at Big Hill.

Viability: No Further Analysis

V. ALTERNATIVES ANALYSIS

Initial screening reduces the viable alternatives to providing new isolation valves and spare tube bundles with the bundles fabricated from SeaCure or titanium for further analysis. These alternatives are examined below as Alternatives A and B.

Assumptions & Constraints

- Even though the manufacturer reports that it has never experienced a failure in designed service of SeaCure material which has been around since 1978, there currently is insufficient data available to estimate the remaining life of the tube bundles currently in place to provide assurance of 100% reliability during drawdowns without bundle replacements over the next 25 years of service.
- SeaCure tube metallurgy is field proven in the current service to a life of 10-16 years, based on SPR experience with SeaCure tube bundles across sites.
- No data has been collected to date which justifies a change in tube bundle metallurgy from SeaCure.
- Even though Titanium metallurgy is field proven in the current service by 40+ years of industrial experience apart from the SPR, a level of unreliability is introduced for SPR service by having to repeat the HTRI calculation to determine heat exchange rate, placement of baffles, tube wall thickness, and minimum bend radius for tubes and by the redesign of the tubesheet and the tube to tubesheet welding.
- Lead times on fabrication of spare tube bundles are excessive such that replacement bundles must be inventoried to quickly address tube failures when discovered to initiate drawdown.
- Tube bundle and repair parts procurement and inventory must be managed effectively to provide the repair and replacement parts in time to initiate drawdowns.
- The purchase of 2 spare tube bundles provides sufficient insurance to spare the 5 exchangers on-site at Big Hill, following installation of isolation valves for each of the 5 exchangers.
- The existing tube bundles at Big Hill are not interchangeable with those at the other SPR sites (Bayou Choctaw, Bryan Mound, West Hackberry) given the differences in fabrication among shell & tube exchanger suppliers.
- Detailed design will request to have all HTRI calculations redone by the vendor in order to determine if any issues exist like vibration problems with the tubing. It is also recommended that a third party verify the accuracy of the calculations/findings.

Sparing Philosophy

The basic philosophy for sparing Crude Oil Cooler tube bundles against leaks follows the following logical progression of steps:

- Conduct periodic inspection and fitness for service testing to assess exchanger readiness for drawdown service and provide early indication and repair of potential tube failures.
- Monitor exchanger pressure drops in the field for an indication of increased pressure drop or tube failure to provide early indication and repair of potential tube failures.

- Isolate and test individual exchangers for leaks when leaks occur. Pull heads and plug up to 8-10% of tubes as leaks are discovered to repair leaks and return exchangers to service.
- Replace leaking tube bundles with spare bundles purchased for site if more than 8-10% of tubes require plugging in any one exchanger to address leaks. Recondition pulled bundles as spares, following replacement.
- Replace leaking tube bundles with spare bundles from other SPR sites if more than 2 spare bundles are required to address leaks. Recondition pulled bundles as spares, following replacement.
- Purchase additional replacement bundles for fabrication when inventory of spare bundles is depleted.

A. New Isolation Valves and Spare Tube Bundles (SeaCure)

This alternative would add isolation valves to provide proper isolation capability on the crude oil side and cooling water side isolation of individual exchangers to facilitate on-site repair and bundle replacement of tube bundles, which fail fitness for service testing prior to drawdown in timely fashion. This alternative would also provide a number of spare SeaCure tube bundles to replace leaking tube bundles should failures precede drawdown or during drawdown.

Benefits & Effectiveness

This alternative will allow for the effective management of Crude Oil Cooler tube bundle life in the face of progressive corrosion at an indeterminate rate over the next 25 years of operation based on the performance of SeaCure tube metallurgy observed on-site over the last 10 years of operation.

Installing crude oil side and water side isolation capability on each individual heat exchanger allows for quick isolation, opening, and repair of tube bundles when they fail the pressure step fitness for service testing conducted prior to each drawdown.

As discussed previously, purchasing and staging of 2 spare bundles for Big Hill provides sufficient insurance to quickly replace 2 of 5 tube bundles (40% of the exchangers at Big Hill) upon discovery of tube failure or one too many repairs by plugging tubes to preserve cooling capacity to the Level I drawdown criterion. The tube bundles installed at Big Hill are not interchangeable with those installed at Bayou Choctaw, Bryan Mound, and West Hackberry. Hence, Big Hill does not stand to benefit from sharing spare bundles among the SPR sites.

Specification of SeaCure metallurgy for the tubes in the bundle provides a service life greater than 10-16 years based upon SeaCure tube bundle performance witnessed to date across the SPR sites. This is expected to provide sufficient life to see Big Hill through the next 25 years with selective replacement of any failed tube bundles. In specifying the same metallurgy in use at Big Hill today, procurement, inventory, and maintenance procedures are simplified to working with familiar metallurgy.

The Big Hill site will be able to meet the required Level I drawdown rate of 1,100,000 barrels per day.

Risk & Mitigation Factors

There are associated risks with the installation of new isolation valves and spare SeaCure tube bundles option. The table below summarizes the risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for New Isolation Valves and Spare Tube Bundles (SeaCure)

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Existing SeaCure tube bundle remaining life is indeterminate.	Pursue more aggressive corrosion monitoring and fitness for service testing on-site at Big Hill to project remaining life of existing tube bundles.	High - High	High Risk Hazard
Existing SeaCure tube bundle life is shorter than expected.	Restrict life forecast to what has been observed in the field to date and proceed with collection of data to properly estimate remaining life as noted above.	Low - High	Low Risk Hazard
Existing or spare tube bundle life is shortened by mishandling of individual tube bundles.	Revisit special handling procedures to cope with size and weight of bundles during handling and with the effects of the thin tube wall design to avoid damaging a bundle, which may trigger additional bundle purchase.	High - High	High Risk Hazard
Spare tube bundle life is shortened by improper bundle storage.	Work with fabricator to specify proper bundle storage and handling practices in advance of purchase of spare bundles. Implement best practices.	Medium - High	Medium Risk Hazard

Risk and Mitigation Strategies for New Isolation Valves and Spare Tube Bundles (SeaCure) (Continued)			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Tube bundle sparing count is low.	Rework the exchanger bundle repair and sparing plan in greater detail as remaining life calculations are completed to assess spare bundle count. Work to expand sparing philosophy across SPR sites.	High - High	High Risk Hazard
Lead time on tube bundle fabrication is long.	Assume lead time is long and pursue procurement and proper layup of new bundles in storage within short order of approval of funds for project.	High - Low	Low Risk Hazard
Metals price for parts fabricated from SeaCure is highly variable over time.	Include allowance in cost estimate for future price increases. Request pricing for both SeaCure and titanium in requests for proposal for fabrication of spare exchanger tube bundles to ensure competitive pricing.	High - High	High Risk Hazard
Mix-up on tube bundle replacement parts in storage.	Risk mitigated by specifying and stocking only SeaCure plugs for exchanger tube bundle repairs.	Low - Low	Low Risk Hazard
Valves called out in SPR piping specs are no longer commercially available.	Verify commercial availability of valves called out in SPR piping standards before specifying valves for purchase.	High - High	High Risk Hazard
Lead time on isolation block valve delivery is long.	Procure isolation block valves within short order of approval of funds for project	High - High	High Risk Hazard
Safety Incidents during installation of isolation block valves.	Adhere to project safety guidelines in accord with the Federal & Industry Safety Standards during construction.	Medium - High	Medium Risk Hazard
Safety incidents during heat exchanger bundle repairs or bundle replacements.	Adhere to project safety guidelines in accord with the Federal & Industry Safety Standards during maintenance operations.	Medium - High	Medium Risk Hazard

B. New Isolation Valves and Spare Tube Bundles (Titanium)

This alternative would add isolation valves to provide proper isolation capability on the crude oil side and cooling water side isolation of individual exchangers to facilitate on-site repair and bundle replacement of tube bundles, which fail fitness for service testing prior to drawdown in timely fashion. This alternative would also provide a number of spare titanium tube bundles to replace leaking tube bundles should failures precede drawdown or during drawdown.

Benefits & Effectiveness

This alternative will allow for the effective management of Crude Oil Cooler tube bundle life in the face of progressive corrosion of indeterminate rate over the next 25 years of operation based on industrial performance of titanium tube metallurgy observed 40+ years of operation.

Installing crude oil side and water side isolation capability on each individual heat exchanger allows for quick isolation, opening, and repair of tube bundles when they fail the pressure step fitness for service testing conducted prior to each drawdown.

As discussed previously, purchasing and staging of 2 spare bundles for Big Hill provides sufficient insurance to quickly replace 2 of 5 tube bundles (40% of the exchangers at Big Hill) upon discovery of tube failure or one too many repairs by plugging tubes to preserve cooling capacity to the Level I drawdown criterion. The tube bundles installed at Big Hill are not interchangeable with those installed at Bayou Choctaw, Bryan Mound, and West Hackberry. Hence, Big Hill does not stand to benefit from sharing spare bundles among the SPR sites.

Specification of titanium metallurgy for the tubes in the bundle provides a service life of 15-20 years based upon similar industrial experience. This is believed to provide sufficient life to see Big Hill through the next 25 years with selective replacement of any failed tube bundles. Titanium is currently cheaper than SeaCure such that overall project cost is reduced in selecting titanium as the material of choice. However, selecting titanium complicates the storage and handling of replacement exchanger parts as this metallurgy is not familiar to Big Hill.

The Big Hill site will be able to meet the required Level I drawdown rate of 1,100,000 barrels per day.

Risk & Mitigation Factors

There are associated risks with the installation of new isolation valves and spare titanium tube bundles option. The table below summarizes the risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for New Isolation Valves and Spare Tube Bundles (Titanium)

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Existing SeaCure tube bundle remaining life at is indeterminate.	Pursue more aggressive corrosion monitoring and fitness for service testing on-site at Big Hill to project remaining life of existing tube bundles.	High - High	High Risk Hazard
Existing SeaCure tube bundle life is shorter than expected.	Restrict life forecast to what has been observed in the field to date and proceed with collection of data to properly estimate remaining life as noted above.	Medium - High	Medium Risk Hazard
Tube bundle life is shortened by mishandling of individual tube bundles.	Revisit special handling procedures to cope with size and weight of bundles during handling and with the effects of the thin tube wall design to avoid damaging a bundle, which may trigger additional bundle purchase.	High - High	High Risk Hazard
Spare tube bundle life is shortened by improper bundle storage.	Work with fabricator to specify proper bundle storage and handling practices in advance of purchase of spare bundles. Implement best practices.	High - High	High Risk Hazard

Risk and Mitigation Strategies for New Isolation Valves and Spare Tube Bundles (Titanium) (Continued)			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Tube bundle sparing count is low.	Rework the exchanger bundle repair and sparing plan in greater detail as remaining life calculations are completed to assess spare bundle count. Work to expand sparing philosophy across SPR sites.	Medium - High	Medium Risk Hazard
Lead time on tube bundle fabrication is long.	Assume lead time is long and pursue procurement and proper layup of new bundles in storage within short order of approval of funds for project.	High - Low	Low Risk Hazard
Metals price for parts fabricated from titanium is highly variable over time.	Include allowance in cost estimate for future price increases. Request pricing for both SeaCure and titanium in requests for proposal for fabrication of spare exchanger tube bundles to ensure competitive pricing.	High - High	High Risk Hazard
Mix-up on tube bundle replacement parts in storage.	Provide for segregation of SeaCure and titanium plugs for exchanger tube bundle repairs.	Low - Low	Low Risk Hazard
Valves called out in SPR piping specs are no longer commercially available.	Verify commercial availability of valves called out in SPR piping standards before specifying valves for purchase.	High - High	High Risk Hazard
Lead time on isolation block valve delivery is long.	Procure isolation block valves within short order of approval of funds for project.	High - High	High Risk Hazard
Safety Incidents during installation of isolation block valves.	Adhere to project safety guidelines in accord with the Federal & Industry Safety Standards during construction.	Medium - High	Medium Risk Hazard
Safety incidents during heat exchanger bundle repairs or bundle replacements.	Adhere to project safety guidelines in accord with the Federal & Industry Safety Standards during maintenance operations.	Medium - High	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. New Isolation Valves and Spare Tube Bundles (SeaCure)

This alternative would add isolation valves to provide proper isolation capability on the crude oil side and cooling water side isolation of individual exchangers to facilitate on-site repair and bundle replacement of tube bundles, which fail fitness for service testing prior to drawdown in timely fashion. This alternative would also provide a number of spare SeaCure tube bundles to replace leaking tube bundles should failures precede drawdown or during drawdown.

B. New Isolation Valves and Spare Tube Bundles (Titanium)

This alternative would add isolation valves to provide proper isolation capability on the crude oil side and cooling water side isolation of individual exchangers to facilitate on-site repair and bundle replacement of tube bundles, which fail fitness for service testing prior to drawdown in timely fashion. This alternative would also provide a number of spare titanium tube bundles to replace leaking tube bundles should failures precede drawdown or during drawdown.

Comparison of Alternatives

Core Team Member Ratings

	Safety During Construction	**Ease of Operations**	**Ease of Maintenance**	**Sustainability**
	Most Important	*Most Important*	*Important*	*Less Important*
Alternative A	*Excellent*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Excellent*
Alternative B	*Excellent*	*Excellent*	*Good*	*Excellent*
	Excellent	*Excellent*	*Good*	*Excellent*
	Excellent	*Excellent*	*Adequate*	*Excellent*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$2,007,630**	**$3,060,384**
Alternative B	**$1,794,616**	**$2,847,370**

Recommended Alternative

A. New Isolation Valves and Spare Tube Bundles (SeaCure)

Based on the technical evaluation of the Core Team Members, Alternative A was clearly rated equal or superior on all evaluation criteria, and in fact received the highest rating on every factor by all Core Team Members. Alternative B has a slightly lower investment cost and life cycle cost. The key deciding factor between alternatives consistency in materials with currently proven technology that is shown in the higher ratings on ease of maintenance. Therefore, Alternative A is the recommended preferred alternative, with the benefits of material and maintenance considerations outweighing the slightly higher investment and life cycle cost.

BH-MM-1429

Upgrade Outdoor Lighting

VCI Project Engineer: Corb Elsbury

Recommended Alternative:

Replace Designated Lights and Associated Cabling (LED)

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

Lighting at SPR sites is integral to providing increased security and safety of site personnel and facilities. The project intent is to provide more sustainable, reliable, and lower maintenance lighting service to the cavern and building areas as well as frequently used roadways. Specifically, this project looks at adding new lighting in areas that are under-lighted, replacing existing lights with energy efficient types, removing lights in areas that no longer need them, installing low-maintenance poles, and installing new wiring in conduit or duct banks.

Functional Requirements

Lighting levels to meet Design Level III Criteria and DOE Order 473.3 A. requirements.

- Perform a lighting survey to identify areas where lighting is inadequate or no longer needed; use light modeling programs using methods recommended by the Illuminating Engineering Society (IES).
- Adequately light each work area, parking area and walkway whenever an employee is present (OSHA 1915.82(a) (2).
- Compliment the lighting systems with the electro optical/closed circuit television (CCTV) assessment system.
- Allow for the rapid and reliable assessment of alarms from either the CCTV system or Protective Force (PF) personnel.
- Install maintenance with protected cabling.
- Consider energy efficient lighting.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer, Systems Engineering and Analysis Division
Corb Elsbury	VCI, Project Engineer
Marc Gross	FFPO, Manager Design Engineering

Team Members

Patrick Shepherd	DOE, Project Engineer
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Randy Bridges	FFPO, Process & Security Systems Control
John Guidry	FFPO, Site Director
Barton Smith	FFPO, Site Security Specialist

Stephen Crawford	FFPO, Site Mechanical Process Engineer
Paul Riegert	FFPO, Manager Site Construction
Danny Duff	FFPO, Manager Site Maintenance

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate alternatives and select a recommended preferred alternative.

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Most Important

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration. Maintenance operations will require less attention as new equipment replaces legacy equipment.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation. The site's ability to address Safety and Security concerns during implementation shall not be impacted. Safety is of the greatest importance.

Weight: Most Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Most Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan. Energy consumption shall be considered in all upgraded equipment criteria.

Weight: Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

The status quo consists of continuing to maintain the ~30-year old high pressure sodium (HPS) lighting systems and to use portable lighting, when needed, in areas not well lit. This alternative includes accepting the safety risks and unscheduled maintenance/repair costs; lighting at Big Hill is at the end of its useful life. Cabling associated with lighting is ~20-years old and will continue to be at risk of being severed and/or malfunctioning as ongoing major maintenance operations on the SPR continue.

Recent inspections from the Enterprise Assessment (EA) Team from DOE Headquarters found the SPR perimeter fence detection system lacked adequate scene illumination and was deficient in the number of light poles, fixtures, and light shielding. All of these issues negatively affect the PF's ability to assess and track intruder locations. The use of color cameras at nighttime, particularly when a scene is illuminated with HPS lamps, is problematic. The status quo will continue to provide for low visibility for night maintenance operations/security. Areas of the site deemed inadequately lighted hinder maintenance efforts as well as pose a safety risk for night shift employees. The degraded ability of the PF to assess intruder location and intent due to poor lighting conditions will continue.

Viability: No Further Analysis

B. Replace Designated Lights and Associated Cabling (LED)

The (LED) alternative consists of replacing lights and light fixtures with lights, along with the associated wiring/cabling. Under-lighted areas (i.e., main site, caverns, Raw Water Intake Structure (RWIS), Brine Disposal Wells, roadways, RPX pad, etc.) are to be identified, while considering light-emitting diodes (LED) lighting as a suitable replacement.

Viability: Continue Analysis

C. Replace Designated Lights and Associated Cabling (Induction)

The (Induction) alternative consists of replacing lights and light fixtures with lights, along with the associated wiring/cabling. Under-lighted areas (i.e., main site, caverns, RWIS, Brine Disposal Wells, roadways, RPX pad, etc.) are to be identified, while considering induction lighting as a suitable replacement.

Viability: Continue Analysis

D. Replace Designated Lights and Associated Cabling (High Intensity Discharge - HID)

The (HID) alternative consists of replacing lights and light fixtures with lights, along with the associated wiring/cabling. Under-lighted areas (i.e., main site, caverns, RWIS, Brine Disposal Wells, roadways, RPX pad, etc.) are to be identified, while considering high intensity discharge lighting as a suitable replacement.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternative A is eliminated from further consideration. The remaining alternatives, B, C, and D are examined below as alternatives A, B, and C, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Replace Designated Lights and Associated Cabling (LED)

The (LED) alternative consists of replacing all associated light fixtures and lights with LED technology, along with the associated wiring/cabling at Big Hill.

A recent lighting evaluation conducted at Big Hill determined there were ~13 light deficient areas, ~5 of those on roadways. A lighting survey will be performed to identify areas where lighting is inadequate or no longer needed (main site, RWIS, ESS, RWIPP, RPX, brine disposal well pads, roadways, employee parking lots, etc.). Methods recommended by the IES shall be used to model expected light levels and to assist in the design and layout of the replacement lighting. All light-deficient areas shall be replaced with energy efficient LED lighting. The DOE Design Level III Criteria for roadway ground level lighting is 0.2 foot candles (fc), 5.0 fc for process and maintenance areas, 0.1 fc for parking areas, and 1.0 for cavern areas.

Department of Energy modeled uniformity comparisons of LED, Induction and HPS produced results that suggested LED lighting displayed a 2:1 advantage in placement; this study was conducted using new luminaries, equal wattage, identical new utility poles and spaced for optimal performance. Visual uniformity comparisons of LED, Induction and HPS suggests that LED at maximum lux (luminous flux per unit area) of 27 lm/W (Lumens/Watt) characteristics performed better than Induction (11.2 lm/W) and HPS (24 lm/W). Negating obstacles such as above ground tanks and large buildings, it is a reasonable assumption that the previously identified light deficient areas ~13 to estimate for the half that number, ~7.

It is important to note that proposed camera replacements shall dictate the type of lighting (or vice versa) identified to replace existing HPS and Induction lighting; lighting systems must meet the requirements listed in DOE Order 473.3 A.

All roadway pole replacements (~5) shall be considered with hot dipped galvanized steel poles with extended hinged arms to allow for ease of maintenance. The remaining utility poles (~2) shall be replaced with a durable material such as hot-dipped galvanized poles (HDP) or an approved equal. Hinged poles shall only be used in situations where a man-lift is not feasible. Cabling replacement shall be addressed by pulling new lighting cabling through existing duct banks or conduit. If there is no existing duct bank or conduit, options of using existing cable trays or installing new duct bank or conduit shall be examined.

Assumptions & Constraints

Assumptions:

- A lighting evaluation shall be done prior to detailed design.
- LED lighting should reduce the need for poles and additional lighting fixtures by half.
- Lighting and new camera lighting requirements/engineering shall be de-conflicted during detailed design.
- Where possible, cabling shall be installed in existing cable trays vs installing new duct banks or conduit.
- Most cabling associated with lighting is located in duct bank.
- LED lighting at maximum burning hours (100K) retains 85% lumen output.
- LED fixtures are widely available with multiple light patterns and correlated color temperatures (CCT); available from 2000 to 10,000; eliminating light pollution (washout).

Constraints:

- Possible existing power sources for all new utility pole installation.
- Available/existing cable trays within a suitable distance for use.

Benefits & Effectiveness

Identifying site lighting deficiencies, old cabling, lights and fixture replacement with LED technology allows for multiple benefits and addresses current mission needs. Addressing the lighting deficiencies also allows for optimal security and safety, which best supports the requirements described in DOE 473.3 A.

- Improved visibility for night maintenance (safety) and security operations; LED lights are “instantly turned on with no warm up (DOE 473.3 A., Attachment 3, Section A 3-35 [3][b]).
- Allows for better PF intruder assessment capabilities due to the rapid and reliable assessment of alarms (DOE 473.3 A., Attachment 3, Section A 3-35 [3][a]).
- Improved lighting will complement the CCTV assessment system, allowing for improved security (DOE 473.3 A., Attachment 3, Section A 3-36 [3][g]).
- Cabling with duct banks or conduit is the industry standard and prevents inadvertent cutting of cables (provides for a 20-year life span), which prevents unscheduled maintenance repairs and personnel safety concerns (DOE 473.3 A., Attachment 3, Section A 3-36 [3][d]).
- Deficiencies found by the EA Team, DOE Headquarters are addressed and corrected (DOE 473.3 A., Attachment 3, Section A 3-36 [3][d]).
- Employees feel safer with more adequately lighted areas; allows for a safe work environment per OSHA guidelines (DOE 473.3 A., Attachment 3, Section A 3-36 [3][h]).
- LED provides the ability to focus on exact luminous areas, allowing for a safer work environment (DOE 473.3 A., Attachment 3, Section A 3-36 [3][f]).
- LED lighting is more energy efficient (~44%) than HPS, easier to maintain and has a longer life cycle than the existing high pressure sodium (HPS) lighting; meeting DOE sustainability mandates. (U.S. DOE Solid State Lighting Technology Demonstration, June 2010)
- LED fixtures are widely available with multiple light patterns and correlated color temperatures (CCT); available from 2000 to 10,000; eliminating light pollution (washout).
- Color Rendering Indexes (CRI) of 60-90.
- LED lighting provides higher lighting acuity value per lumen/watt; 135 Lumens/watt.
- Extremely long life span, 100K hours at 70 Watt hours.
- No toxic materials used in manufacturing; low to no recycling costs.

Risk & Mitigation Factors

With new LED lighting, cabling upgrades at the site come associated risks. Potential risks associated with replacing lights and cabling, as well as determining lighting deficiencies include reduced security capability during construction, failing to identify all inadequate lighting areas, maintaining a safe work environment, and having a loss of lighting. The table below summarizes the mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Determining Lighting Deficiencies and Replacing Outdoor Lighting (LED)

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Reduced security capability during construction.	Close coordination with NOLA, site security and contractor during work plan development and scheduling.	Medium - Medium	Medium Risk Hazard
Lighting survey does not identify all inadequately lighted areas.	Use a computer based program to confirm lighting survey results.	Low - Low	Low Risk Hazard
Safety while installing new lighting and cables.	Ensure a job hazard analysis is prepared by contractors and for anyone onsite near the installation of the lighting and/or cables.	Medium - Medium	Medium Risk Hazard
Lighting technology required to address both lighting and security (CCTV) needs.	Close coordination between maintenance and PF to determine the correct lighting technology.	Medium - Medium	High Risk Hazard

B. Replace Designated Outdoor Lights and Associated Cabling (Induction)

The (Induction) alternative consists of replacing all associated light fixtures and lights with Induction technology, along with the associated wiring/cabling at Big Hill. A lighting evaluation shall be performed to identify areas where lighting is inadequate or no longer needed (main site, caverns, RWIS, ESS, RWIPP, RPX, brine disposal well pads, roadways, employee parking lots, etc.). Methods recommended by the IES shall be used to model expected light levels and to assist in the design and layout of all replacement lighting.

A recent lighting evaluation conducted at Big Hill determined there were ~13 light deficient areas, ~5 of those on roadways. The DOE Design Level III Criteria for roadway ground level lighting is 0.2 foot candles (fc), 5.0 fc for process and maintenance areas, 0.1 fc for parking areas, and 1.0 for cavern areas.

A Department of Energy gateway study (June 2010) concluded Induction lighting used 6% less energy than HPS. HPS maintenance requires lamp replacement on average of every 5 years, ballasts every 15 years, igniters every 20 years, the housing every 25 years and photocell every 15 years. Induction lighting is nearly maintenance free for the rated bulb/ballast, exhibits a high color rendering index (CRI) of 80+ (HPS CRI is ~20-22) that produces vivid colors versus the yellowing (washout) associated with HPS and induction contains just slightly less amalgam (mercury). Induction lighting is found to operate much cooler (150F-180F than HPS (450-750F) presenting less environmental impact. Induction visual acuity (seeable lumens) is 191 lm/W while HPS has only 67 lm/W.

It is important to note that proposed camera replacements shall dictate the type of lighting (or vice versa) identified to replace existing lighting; lighting systems must meet the requirements listed in DOE Order 473.3 A.

All roadway pole replacements (~5) shall be considered with hot dipped galvanized steel poles with extended hinged arms to allow for ease of maintenance. The remaining utility poles (~8) shall be replaced with a durable material such as hot-dipped galvanized poles (HDP) or an approved equal. Hinged poles shall only be used in situations where a man-lift is not feasible. Cabling replacement shall be addressed by pulling new lighting cabling through existing duct banks or conduit. If there is no existing duct bank or conduit, options of using existing cable trays or installing new duct bank or conduit shall be examined.

Assumptions & Constraints

Assumptions:

- A lighting evaluation shall be done prior to detailed design.
- Lighting and security camera lighting requirements/engineering shall be de-conflicted during detailed design.
- Where possible, cabling shall be installed in existing cable trays vs installing new duct banks or conduit.
- Most cabling associated with lighting is located in duct bank or conduit.

Constraints:

- Possible existing power sources for all new utility pole installation.
- Available/existing cable trays within a suitable distance for use.
- Induction lighting is a mercury hazard; high recycling costs.
- Induction lighting is difficult to control optically.
- Very large fixture size compared to LED retrofit units.

Benefits & Effectiveness

The replacement of all cabling, existing lighting, and identifying site lighting deficiencies allows for multiple benefits and addresses current mission needs. Determining lighting deficiencies also allows for security and safety, which supports the requirements described in DOE 473.3 A.

- Improved lighting will complement the CCTV assessment system, allowing for improved security (DOE 473.3 A., Attachment 3, Section A 3-36 [3][g]).

- Cabling with duct banks or conduit is the industry standard and prevents inadvertent cutting of cables, which prevents unscheduled maintenance repairs and personnel safety concerns (DOE 473.3 A., Attachment 3, Section A 3-36 [3][d]).
- Requires relatively low maintenance efforts; Green Light Source.
- Rated life 60K hours (to 70% lumens, limited by ballast life); lamp and power supply are recommended as replaced at the same time.
- Color Rendering Index (CRI) of 80 and Correlated Color Temperature (CCT) of 3000K.

Risk & Mitigation Factors

With new induction lighting, cabling upgrades at the site come associated risks. Potential risks associated with replacing lights and cabling, as well as determining lighting deficiencies include reduced security capability during construction, failing to identify all inadequate lighting areas, maintaining a safe work environment, and having a loss of lighting in areas where poles are being replaced. The table below summarizes the mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing Utility Poles/Lighting and Determining Lighting Deficiencies (Induction)

Risks	Mitigation Strategy	Likelihood - Impact	Impact
Reduced security capability during construction.	Close coordination with NOLA, site security and contractor during work plan development and scheduling.	Medium - Medium	Medium Risk Hazard
Lighting survey does not identify all inadequately lighted areas.	Use a computer based program to confirm lighting survey results.	Low - Low	Low Risk Hazard
Safety while installing new lighting and cables.	Ensure a job hazard analysis is prepared by contractors and for anyone onsite near the installation of the lighting and/or cables.	Medium - Medium	Medium Risk Hazard
Lighting technology needed to address both lighting and security needs.	Close coordination between maintenance and PF to determine the correct lighting technology.	Medium - High	Medium Risk Hazard
Induction lighting contains mercury.	Maintenance on induction lighting should be conducted after complete cool down; address in an updated maintenance procedure.	Medium - High	Medium Risk Hazard

C. Replace Designated Outdoor Lighting and Associated Cabling (High Intensity Discharge)

The High Intensity Discharge (HID) alternative consists of replacing all lighting and fixtures with HID lighting technology and associated cabling at Big Hill. A recent lighting evaluation conducted at Big Hill determined there were ~13 light deficient areas, ~5 of those on roadways. A lighting evaluation shall be performed to confirm the light deficient areas and also determine where lighting is no longer needed (main site, caverns, RWIS, ESS, RWIPP, RPX, brine disposal well pads, roadways, employee parking lots, etc.). Methods recommended by the IES shall be used to model expected light levels and to assist in the design and layout of all replacement lighting; the DOE Design Level III Criteria for roadway ground level lighting is 0.2 foot candles (fc) 5.0 fc for process and maintenance areas, 0.1 fc for parking areas, and 1.0 for cavern areas.

The most common types of HID are mercury vapor lamps, metal halide lamps and HPS; HPS being the most common on the SPR. HID lighting lamps produce an arc for intense light, therefore requiring ballasts. HID ballast technology is old and highly inefficient, requiring time to establish the electric arc and is not easily controlled or dimmable while LED and Induction lighting can be integrated into a remote monitoring and dimming control system.

Mercury vapor lamps, the oldest types of high-intensity discharge lighting, were formerly used for street lighting, but are now only rarely used for that purpose. Nearly all new lamps sold in North America today for street lighting are either metal halide or LEDs, which have also displaced mercury vapor lamps in sports arenas and gymnasiums. Mercury vapor lamps provide about 50 lumens per watt, but ballast loss can reduce the system efficacy to about 30 lumens per watt, which is not competitive with LEDs.

Metal halide lamps produce a bright, white light with the best color rendition among high-intensity lighting types. They are used to light large indoor areas, such as gymnasiums and sports arenas, and outdoor areas, such as parking lots. Metal halide lamps are similar in construction and appearance to mercury vapor lamps. The addition of metal halide gases to mercury gas within the lamp results in higher light output, more lumens per watt, and better color rendition than from mercury gas alone.

High-pressure sodium (HPS) lighting is a type of HID lighting used for street and outdoor area lighting, parking garages, and some industrial applications. Although HPS lamps can be efficient and long-lasting, they typically have poor color rendering compared to other lamp types, and are being displaced by LEDs in many applications.

It is important to note that proposed camera replacements shall dictate the type of lighting (or vice versa) identified to replace existing lighting; lighting systems must meet the requirements listed in DOE Order 473.3 A.

All roadway pole replacements (~5) shall be considered with hot dipped galvanized steel poles with extended hinged arms to allow for ease of maintenance. The remaining utility poles (~8) shall be replaced with a durable material such as hot-dipped galvanized poles (HDP) or an approved equal. Hinged poles shall only be used in situations where a man-lift is not feasible. Cabling replacement shall be addressed by pulling new lighting cabling through existing duct banks or conduit. If there is no existing duct bank or conduit, options of using existing cable trays or installing new duct bank or conduit shall be examined.

Assumptions & Constraints

Assumptions:

- A lighting evaluation shall be done prior to detailed design.
- HID lighting is being replaced by LED technology for application in the studied alternatives.
- Lighting and new camera lighting requirements/engineering shall be de-conflicted during detailed design.
- Where possible, cabling shall be installed in existing cable trays vs installing new duct banks or conduit.
- Most cabling associated with lighting is located in duct bank or conduit.

Constraints:

- Possible existing power sources for all new utility pole installation.
- Available/existing cable trays within a suitable distance for use.
- Source efficiency is typically 120 lumens/watt or higher. However, losses from trapped light, protective covers and lenses, inefficient ballasts and unfavorable operating temperature typically result in a measured system efficiency of 30 lumens/watt or less.
- HID lights are more fragile and have a warm up (15-20 seconds) during ignition.
- Contains mercury; relatively higher recycling cost.

Benefits & Effectiveness

Determining lighting deficiencies also allows for optimal security and safety, which best supports the requirements described in DOE 473.3 A.

- Cabling with duct banks is the industry standard and prevents inadvertent cutting of cables, which prevents unscheduled maintenance repairs and personnel safety concerns (DOE 473.3 A., Attachment 3, Section A 3-36 [3][d]).
- Employees feel safer with more adequately lighted areas; allows for a safe work environment per OSHA guidelines (DOE 473.3 A., Attachment 3, Section A 3-36 [3][h]).

Risk & Mitigation Factors

With new upgrade at the site come associated risks. Some potential risks associated with replacing lights, cabling and determining lighting deficiencies include reduced security capability during construction, failing to identify all inadequate lighting areas, maintaining a safe work environment, and having a loss of lighting in areas during construction. The table below summarizes the mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Determining Lighting Deficiencies and Replacing All Outdoor Lighting (High-Intensity Discharge)

Risks	Mitigation Strategy	Likelihood - Impact	Impact
Reduced security capability during construction.	Close coordination with NOLA, site security and contractor during work plan development and scheduling.	Medium - Medium	Medium Risk Hazard
Lighting survey does not identify all inadequately lighted areas.	Use a computer based program to confirm lighting survey results.	Low - Low	Low Risk Hazard
Safety while installing new lighting and cables.	Ensure a job hazard analysis is prepared by contractors and for anyone onsite near the installation of the lighting and/or cables.	Medium - Medium	Medium Risk Hazard
Loss of lighting during construction/installation.	Prepare a strategic plan for minimizing the effects, and use portable lighting as necessary.	High - Medium	Medium Risk Hazard
Lighting technology needed to address both lighting and security (CCTV) needs.	Close coordination between maintenance and PF to determine the correct lighting technology.	Medium - High	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Replace Designated Lights and Associated Cabling (LED)

The LED alternative consists of replacing all associated light fixtures and lights with LED technology, along with the associated wiring/cabling on the site. This option will also consist of identifying lighting deficiencies and replacing with more energy efficient lighting on Big Hill.

B. Replace Designated Lights and Associated Cabling (Induction)

The Induction alternative consists of replacing all associated light fixtures and lights with Induction technology, along with the associated wiring/cabling on the site. This option will also consist of identifying lighting deficiencies and replacing with more energy efficient lighting on Big Hill.

C. Replace Designated Lights and Associated Cabling (High Intensity Discharge)

The HID alternative consists of replacing all associated light fixtures and lights with HID technology, along with the associated wiring/cabling on the site. This option will also consist of identifying lighting deficiencies and replacing with more energy efficient lighting on Big Hill.

Comparison of Alternatives

Core Team Member Ratings

	Constructability During Ongoing Oil Deliveries	**Ease of Operations**	**Ease of Maintenance**	**Safety During Construction**	**Security During Construction**	**Sustainability**
	Most Important	*Most Important*	*Most Important*	*Most Important*	*Most Important*	*Important*
Alternative A	*Excellent*	*Excellent*	*Excellent*	*Good*	*Good*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Good*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Good*	*Good*	*Excellent*
Alternative B	*Excellent*	*Excellent*	*Good*	*Good*	*Good*	*Good*
	Excellent	*Excellent*	*Good*	*Good*	*Excellent*	*Good*
	Excellent	*Excellent*	*Good*	*Good*	*Good*	*Good*
Alternative C	*Excellent*	*Good*	*Adequate*	*Good*	*Good*	*Good*
	Excellent	*Adequate*	*Adequate*	*Good*	*Excellent*	*Adequate*
	Excellent	*Excellent*	*Adequate*	*Good*	*Good*	*Adequate*

Cost Comparison

	Total Estimated Cost (TEC)	Life Cycle Cost (LCC)
Alternative A	**$1,030,633**	**$1,064,495**
Alternative B	**$1,008,759**	**$1,061,799**
Alternative C	**$1,019,562**	**$1,088,215**

Recommended Alternative

A. Replace Designated Lights and Associated Cabling (LED)

Based on the technical evaluation of the Core Team Members, Alternative A was clearly rated equal or superior on all evaluation criteria. The initial cost and life cycle cost of Alternatives A, B and C were essentially the same by comparison. Therefore, Alternative A is the recommended preferred alternative based on technical evaluation merits with cost factors that essentially provided no differentiation between alternatives.

BH-MM-1523

RWIS Infrastructure Upgrades

VCI Project Engineer: Jason McCrossen

Recommended Alternative:

Perform Overhaul of RWIS

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The level 1 Criteria for the Big Hill Strategic Petroleum Reserve Site is to be capable of drawing down 1.1 million barrels per day of oil. To accomplish this, 1.3 million barrels of raw water must be taken in at the Raw Water Intake Structure (RWIS) and injected into the caverns to displace the oil.

The RWIS consists of four raw water intake pumps and motors, five traveling screens, two flush water/firewater supply pumps, a pedestal crane, and the associated concrete, steel, and timber support structures.

It is mission critical for the Big Hill Site (BH) to have an operating, 24-hour ready, easy to use Raw Water Intake Structure (RWIS) for drawdown purposes.

Functional Requirements

A dependable, reliable, fully operating RWIS is mission critical. The RWIS will provide raw water to displace cavern oil during drawdown activities. The SPR system shall provide the capability to draw down and deliver crude oil from SPR storage sites to designated distribution terminals with further access to commercial pipeline distribution networks and marine docks. Each SPR site shall be capable of drawing down and delivering crude oil to the designated distribution terminals and pipelines for custody transfer at rates prescribed by the level 1 requirement.

I. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Jason McCrossen	VCI, Project Engineer
Marc Gross	FFPO, Manger Design Engineering

Team Members

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Levi Gabre	DOE, Lead General Engineer
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Steven Crawford	FFPO, Site Mechanical Process Engineer
Paul Riegert	FFPO, Manger Site Construction
Tony Deville	FFPO, Manager Site Operations
Danny Duff	FFPO, Manager Site Maintenance
Ken Swanson	FFPO, Manager Site Operations

II. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Most Important

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation.

Weight: Most Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Most Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan. SOW is mainly civil/structural repairs. It could potentially become important if there are required mechanical upgrades.

Weight: Less Important

III. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

Continue to operate as normal and perform normal maintenance as needed.

The RWIS currently meets the mission need but continued wear on equipment could hinder drawdown readiness going forward. Therefore, this alternative does not meet the life extension goal of providing a 25-year life expectancy for the RWIS.

Viability: No Further Analysis

B. Perform Overhaul of RWIS

Repair concrete, steel, and timber structures; install sump sparging system; refurbish traveling screens; rewind intake pumps and motors; upgrade flush water/firewater supply pumps and motors; replace pedestal crane; refurbish electrical system; add barge access to the east side of the intake; refurbish cathodic protection system. This will save the DOE SPR money in the long run vs continuing to repair as needed.

Viability: Continue Analysis

C. Eliminate RWIS and Use Portable Pumps When Drawdown Is Needed

Portable pumps can be used on as-need basis since drawdown is not a regular occurrence.

Viability: Continue Analysis

IV. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternative A is eliminated from further consideration. The remaining alternatives, B and C are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Perform Overhaul of RWIS

Repair concrete, steel, and timber structures; install sump sparging system; refurbish traveling screens; rewind intake pumps and motors; upgrade flush water/firewater supply pumps and motors; replace pedestal crane; refurbish electrical system; add barge access to the east side of the intake; refurbish cathodic protection system.

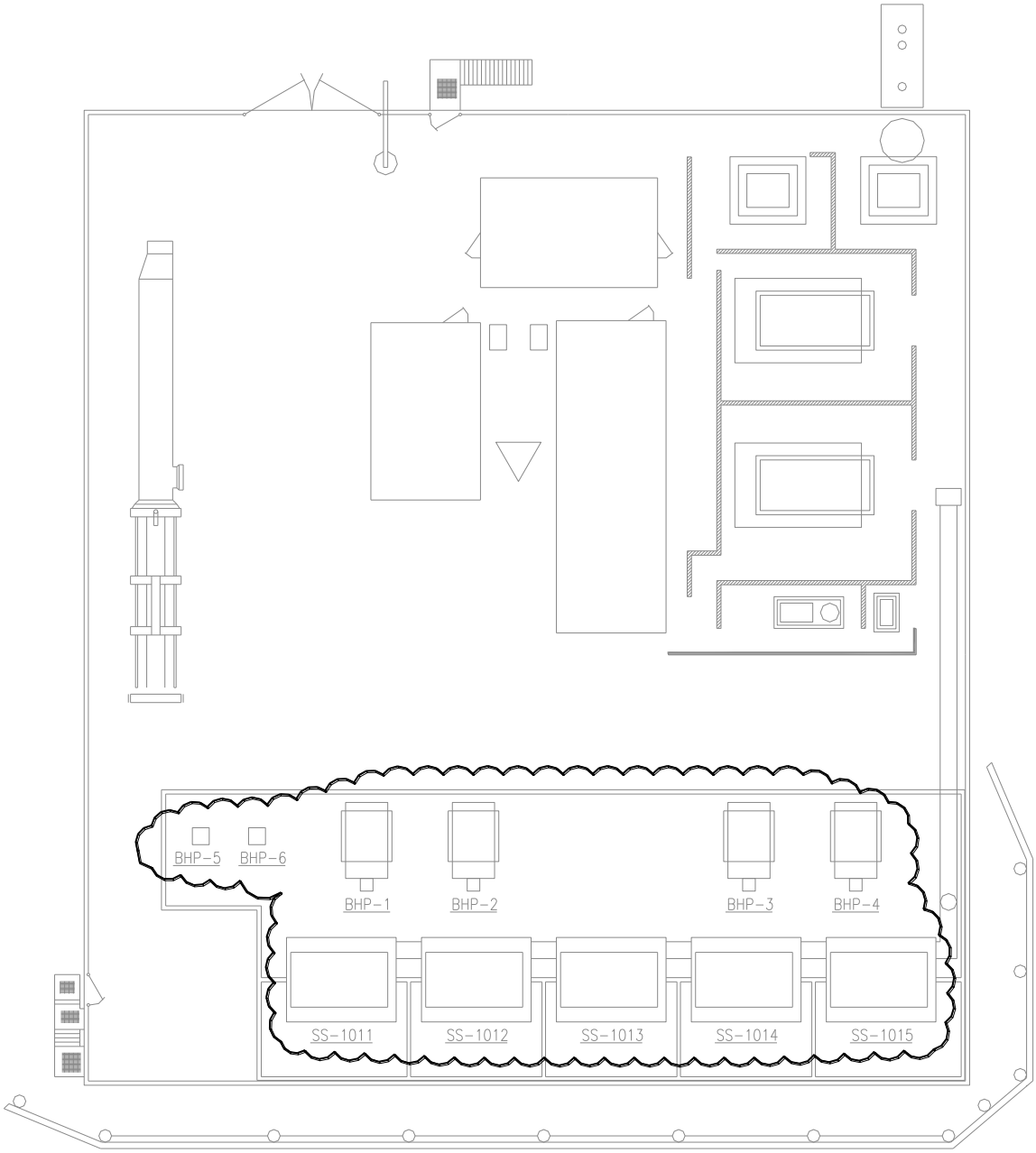

Figure 1 – Raw Water Intake Structure

Assumptions & Constraints

Site must maintain a level 1 drawdown rate. To accomplish this, only a limited portion of the structure can be down for maintenance at a time. In addition, the structure provides raw water for more than the Raw Water Injection Wells. String flush and pig runs for pipelines all require raw water from the structure.

Benefits & Effectiveness

A complete overhaul would support the mission by improving the functionality of a critical drawdown process for a 25-year period. Refurbishing the existing structure and equipment would reduce maintenance time and expense. Reworking the existing pumps and motors would result in improved performance and decreased energy costs needed for operation. There would be no additional training necessary for operation and no additional security measures due to the structure being located within the existing security perimeter.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Overhaul of RWIS

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
Large upfront expense.	Upfront expense offset by decreased maintenance costs over the life of the RWIS.	High – Low	Low Risk Hazard
Partial operating structure may not meet Level 1 Requirements.	Leave enough pumps in service to maintain Level 1 readiness.	High – Low	Low Risk Hazard
Safety concern for work over water.	Wear appropriate PPE to include an U.S. Coast Guard-approved Personal Floatation Device (PFD).	Low – High	Low Risk Hazard

B. Eliminate RWIS and Use Portable Pumps When Drawdown is Needed

Portable pumps can be used on as-need basis since drawdown is not a regular occurrence.

Assumptions & Constraints

Using portable pumps for drawdown would be functional but increase logistical challenges associated with performing the SPR's function in a timely manner. Pumps are used for more than just raw water to the Raw Water Injection pumps. The structure is used during quarterly exercises, string flushes, and pig runs in addition to drawdown. Construction of a portable pump system should not pose a significant construction obstacle to ongoing operations or cause a construction safety concern.

Benefits & Effectiveness

It would be beneficial to have an overall reduction in maintenance costs by eliminating the RWIS but the portable pumps would require regular maintenance and exercise to ensure preparedness for drawdown. The new system of portable pumps would require significant operational training. Security concerns would not change significantly as pumps would be operated within existing security perimeter. Use of diesel powered portable pumps would have a greater environmental impact than the existing RWIS pumps.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Eliminate RWIS and Use Portable Pumps When Drawdown is Needed

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
Drawdown delay due to portable pump procurement.	Store and maintain portable pumps for drawdown on site.	High – High	High Risk Hazard
Drawdown delay due to portable pump installation.	Develop installation procedures and regular testing of portable pumps on the system.	High – High	High Risk Hazard
Deterioration of Raw Water line to site if not in regular service.	Perform regular flushes of line.	High – High	High Risk Hazard
Barge with portable pumps might not be able to dock due to silting.	Dredge the area surrounding the RWIS	High – High	High Risk Hazard

V. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Perform Overhaul of RWIS

Repair concrete, steel, and timber structures; install sump sparging system; refurbish traveling screens; rewind intake pumps and motors; upgrade flush water/firewater supply pumps and motors; replace pedestal crane; refurbish electrical system; add barge access to the east side of the intake; refurbish cathodic protection system.

B. Eliminate RWIS and Use Portable Pumps When Drawdown is Needed

Portable pumps can be used on as-need basis since drawdown is not a regular occurrence.

Comparison of Alternatives

Core Team Member Ratings

	Constructability During Ongoing Oil Deliveries	**Ease of Operations**	**Ease of Maintenance**	**Safety During Construction**	**Security During Construction**	**Sustainability**
	Most Important	*Most Important*	*Most Important*	*Most Important*	*Most Important*	*Less Important*
Alternative A	*Adequate*	*Excellent*	*Excellent*	*Good*	*Good*	*Excellent*
	Adequate	*Excellent*	*Excellent*	*Good*	*Good*	*Excellent*
	Good	*Excellent*	*Good*	*Good*	*Excellent*	*Adequate*
Alternative B	*Marginal*	*Adequate*	*Adequate*	*Good*	*Adequate*	*Adequate*
	Marginal	*Adequate*	*Adequate*	*Good*	*Adequate*	*Adequate*
	Excellent	*Adequate*	*Adequate*	*Good*	*Good*	*Adequate*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$5,971,115**	**$6,347,469**
Alternative B	**$15,666,001**	**$20,406,978**

Recommended Alternative

A. Perform Overhaul of RWIS

Based on the technical evaluation of the Core Team Members, Alternative A was clearly rated equal or superior on all evaluation criteria. The initial cost and life cycle cost of Alternative A were both lowest of the alternatives. Therefore, Alternative A is the recommended preferred alternative based on both technical and cost factors studied in the alternative analysis.

BH-MM-1527

Replace Physical Security CCTV Assessment System

VCI Project Engineer: Corb Elsbury

Recommended Alternative:

Replace Existing Digital CCTV System (Cameras)

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

Replace/upgrade the existing physical security Closed Circuit Television (CCTV) assessment systems with the latest technology at Big Hill on the main site, Raw Water Intake Structure (RWIS), Electrical Sub-Station (ESS), and Raw Water Injection Pump Pad (RWIPP) consisting of perimeter and critical area fixed nose-to-tail cameras, Pan Tilt Zoom (PTZ) and Pan Tilt (PT) cameras for use as part of the surveillance and intrusion detection alarm assessment system.

Functional Requirements

The SPR assessment system must meet DOE Order 473.3 A. requirements and USNRC Intrusion Detection Systems and Subsystems Technical Information, March 2011, Office of Nuclear Security and Incident Response.

- Cameras and lighting must be effective in all weather conditions and all lighting conditions; lighting must compliment and not interfere with effectiveness of the assessment system.
- Central Alarm Station (CAS) monitors/screens shall be of sufficient size, picture quality and refresh rates to provide an accurate display of persons or animals without undue eye strain or inability to determine images.
- The CCTV assessment system shall be configured as an element of the total Intrusion Detection System (IDS) along with the required complimentary lighting.
- Lighting shall allow for the fast and reliable assessment of alarms from either the CCTV system or Protection Force (PF) personnel as defined in the Site Security Plan (SSP).
- The system must have the capability to automatically switch to the camera associated with the alarm event and clearly display the event for operator assessment.
- Video assessment coverage must be complete (e.g., no gaps between zones or areas that cannot be assessed due to shadows or objects blocking the camera's field of view).
- CCTV systems shall use real time signal or near real time transmission of camera views.
- Alarms shall be enabled to assess immediately by either the PF or by a remote central alarm monitoring station personnel using the CCTV management system; ergonomics shall be considered in design.
- CCTV assessment cameras used as primary assessment for alarms shall be fixed (i.e., not pan or tilt) with fixed focal length lenses or zoom capability.
- All cameras must be compatible with the existing Alarm Display and Annunciation System (ADAS) at the site. Close coordination with the ADAS system integrator is required as part of this study. It is understood that technical upgrades to the ADAS system may be required.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Corb Elsbury	VCI, Project Engineer
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Randy Bridges	FFPO, Process & Security Systems Control
John Guidry	FFPO, Site Director
Barton Smith	FFPO, Site Security Specialist
Steven Crawford	FFPO, Site Mechanical Process Engineer
Paul Riegert	FFPO, Manager Site Construction
Danny Duff	FFPO, Manager Site Maintenance

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Ease of Operation

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation. Safety is of the utmost concern.

Weight: Most Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Most Important

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

Continue to maintain existing digital CCTV system. The current digital technology residing on the site is not considered the latest technology and does not function at optimal capacity in its current configuration. Upcoming ADAS Upgrades (BH-MM-750) will address some shortcomings with technology but will not address the existing cameras (installed ~2010). Increased maintenance efforts and operational compatibility issues are expected to result from new components of ADAS connected with older technology cameras.

Assessment capabilities will eventually degrade if the technology gap is not addressed. Failure to meet DOE Order 473.3 A. and USNRC Intrusion Detection System requirements may result if the CCTV cameras are not upgraded along with the ADAS.

Viability: Continue Analysis

B. Replace Existing Digital CCTV System (Cameras)

Install the latest generation digital IP cameras. Replace all existing fixed, Pan-Tilt-Zoom (PTZ) and Pan Tilt (PT) physical security CCTV assessment system cameras (~88) on the main site, employee parking lot, Electrical Sub-Stations (ESS), Raw Water Injection Pump Pads (RWIPP), Raw Water Intake Structure (RWIS) and any additional identified areas of security coverage needed.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Status Quo

Continue to maintain all currently existing fixed, Pan-Tilt-Zoom (PTZ) and Pan Tilt (PT) physical security CCTV assessment system cameras at Big Hill.

Assumptions & Constraints

Assumptions:

- Camera types and lighting replacements shall be compatible (done during detailed design).
- The current digital cameras are operating in a satisfactory manner.
- Upcoming ADAS Upgrades will address any camera related software and/or hardware issues.
- Manufacturer's warranty is expired on the current cameras.

Constraints:

- Seamless integration of older existing digital cameras with latest technology (ADAS Upgrades).
- Maintenance on the existing cameras requires non-stock modifications by a subcontractor to install outdated parts.

Benefits & Effectiveness

Maintaining the current cameras at Big Hill will allow for effective security and safety measures. Maintenance procedures will streamline system upgrade to the ADAS. The information below summarizes the benefits and effectiveness of maintaining all currently existing cameras on site as well as addressing the mission needs of the site.

- Current camera equipment allows for requisite detection, classification and identification.
- The CCTV assessment system functions at an acceptable capacity, providing the PF response speeds fast enough to assess area and intruder incursions.
- Meets the DOE Protection Order 473.3 A. requirements.
- Allows for maintenance and operators to continue working with a familiar system, new equipment training is not required.

Risk & Mitigation Factors

With any new upgrade at the site comes associated risks. Some potential risks associated with maintaining all existing cameras on the site are the rapidly changing digital technology, maintaining equipment without a manufacturer's warranty and potential system conflicts with upcoming ADAS upgrades. The table below summarizes the above mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Continuing to Maintain Existing Cameras

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Site Security posture is degraded during installation.	Work closely with NOLA and site security to alleviate gaps in security, potentially compensatory PF options needed.	High - High	High Risk Hazard
Existing cabling infrastructure is not serviceable and needs to be replaced.	Must survey all existing camera locations and the existing cable for suitability for re-use.	Medium - High	Medium Risk Hazard

B. Replace Existing Digital CCTV System (Cameras)

Install the most current generation of digital IP cameras. Replace all existing fixed, Pan-Tilt-Zoom (PTZ) and Pan Tilt (PT) physical security CCTV assessment system cameras (~88) on the main site, employee parking lot, Electrical Sub-Stations (ESS), Raw Water Injection Pump Pads (RWIPP), Raw Water Intake Structure (RWIS) and any additional identified areas of security coverage needed.

This alternative proposes to replace the existing CCTV system cameras with the latest generation technology of Pelco cameras or approved equal on the Big Hill site. Replace all fixed cameras with (~67) the Pelco ExSite IP EHXME Series camera or approved equal. Replace all pan/tilt/zoom (PTZ) and Pan-Tilt (PT) cameras (~19) with the Pelco ExSite IP IPSXME Series camera or approved equal. Install these cameras on the main site, employee parking lots, Electrical Sub-Stations (ESS), Raw Water Injection Pump Pads (RWIPP), Raw Water Intake Structure (RWIS), and any additional identified areas of security coverage needed on Big Hill.

The Pelco ExSite IP Series cameras are the latest generation of explosion proof IP cameras designed to meet the rigorous requirements for hazardous locations with integrated camera/lens/receiver for safe and efficient installation. These cameras feature low-light technology, multiple compression formats and both upright and inverted operation for optimal image quality, performance, and reliability. The Pelco Exsite IP is capable of recording, managing, configuring, and viewing multiple live streams. These explosion proof camera systems shall include an optional programmable window wiper and washer/wipe sequence under a single command.

Dome cameras are not suggested replacements for two (2) important reasons. Fitting on camera illumination to a dome camera is more difficult (requiring significant additional lighting efforts) than fitting illumination to a fixed or PTZ system; lighting cannot be fitted to follow the movement of the camera. Therefore, it is assumed dome cameras lack optimal night-time performance requirements needed unless each dome camera is retrofitted with its own lighting assembly. Secondly, dome cameras are extremely sensitive; typically, they are outfitted with smoked domes, integral zoom lenses, and higher F-stop ratings (aperture speed) which reduce light transmission needed for optimal performance.

Cameras currently mounted on wooden utility poles shall be mounted on square tapered 7-gauge, steel hinged poles, 30’ in length. Each newly installed camera pole shall be properly grounded and have a lightning air terminal on top the pole.

Lighting is critical for optimal performance and shall be addressed in ongoing lighting upgrade efforts; white light is one of the critical essentials (illumination-white light, camera and lens) needed at the front end of every CCTV system.

Assumptions & Constraints

Assumptions:

- Camera types and lighting replacements shall be compatible (done during detailed design).
- A site modeling determination shall be held to establish detailed requirements and potentially gained efficiencies with new cameras.
- All new equipment shall be installed and accompanied with manufacturer warranties and product training.
- All hardware and cabling will have standard connectors and remain as originally supplied by their respective manufactures, requiring no modification prior to required maintenance installation.

Constraints:

- Construction dates of lighting projects (~2020 project); lighting and camera specifications must be compatible for optimal performance (CCTV replacement is tentatively scheduled for ~2023).

Benefits & Effectiveness

Replacing all cameras at Big Hill with the most current digital IP technology will allow for optimal security and safety measures while eliminating any difficulties with maintenance and operability. Maintenance

procedures will simplify once ADAS upgrades are installed. The information below summarizes the benefits and effectiveness of replacing all cameras on site with latest generation digital IP technology as well as addressing the mission needs of the site.

- Replaces cameras with the most current technology and camera equipment; detection, classification, and identification are achieved in the most expeditious and accurate manner.
- New high definition digital camera technology will allow for optimal compatibility with ADAS upgrades and can cover a much wider area than a standard definition IP camera.
- Up to date IP system installs require significantly less wiring than the older technology systems.
- New digital IP cameras can provide up to 25% more resolution and is especially better at capturing objects that are moving and running, even at high speed.
- Repetitive maintenance efforts are all but eliminated with new components as they shall come with manufacturer's warranties and new equipment training.
- The CCTV assessment system will function at optimal capacity, providing the PF response speeds fast enough to assess areas and intruder incursions without latency.
- The latest technology provides optimal viewing capacity and zoom capabilities, potentially reducing the total number of cameras and ancillary equipment needed to accomplish the DOE PF mission.
- Consistently meets the DOE Protection Order 473.3 A. requirements, reducing DOE Headquarters security assessment inspection shortcomings/findings.
- The possibility of the complete replacement of CCTV cameras across the SPR will enable much more efficient maintenance procedures, sparing and operator familiarity.

Risk & Mitigation Factors

With any new upgrade comes associated risks. Some potential risks associated with replacing all of the cameras at Big Hill include reduced security posture during construction, rapidly advancing technology and the lack of new equipment training for employees. The table below summarizes the above mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing All Cameras (Digital)

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Rapidly advancing digital CCTV technology renders current cameras obsolete if not replaced.	Implement a rigid 5-year life cycle replacement interval, sync possible camera upgrades with ADAS upgrades.	High - High	High Risk Hazard
Shall require training on the new equipment.	Minimize the length of training by making the training comprehensive, easy to follow and hands on.	High - Low	Low Risk Hazard
Site security posture is degraded during installation.	Work closely with NOLA and site security to alleviate gaps in security, potentially compensatory PF options.	High - Low	Low Risk Hazard
Existing cabling infrastructure is not serviceable and needs to be replaced.	Must survey all existing camera locations and the existing cable for suitability for re-use.	Medium - High	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Status Quo (Maintain Existing Digital Cameras)

Continue to maintain all currently existing fixed, Pan-Tilt-Zoom (PTZ) and Pan Tilt (PT) physical security CCTV assessment system cameras on Big Hill.

B. Replace Existing Digital CCTV System (Cameras)

Install the most current latest generation digital IP cameras. Replace all existing fixed, Pan-Tilt-Zoom (PTZ) and Pan Tilt (PT) physical security CCTV assessment system cameras (~88) on the main site, employee parking lots, Electrical Sub-Stations (ESS), Raw Water Injection Pump Pads (RWIPP), Raw Water Intake Structure (RWIS) and any additional identified areas of security coverage needed.

Comparison of Alternatives

Core Team Member Ratings

	Safety During Construction	**Security During Construction**	**Constructability During Ongoing Oil Deliveries**	**Ease of Operations**	**Ease of Maintenance**	**Sustainability**
	Most Important	*Most Important*	*Important*	*Most Important*	*Most Important*	*Less Important*
Alternative A	*Good*	*Good*	*Excellent*	*Good*	*Adequate*	*Good*
	Good	*Good*	*Excellent*	*Good*	*Adequate*	*Good*
	Excellent	*Good*	*Excellent*	*Excellent*	*Good*	*Adequate*
Alternative B	*Good*	*Good*	*Excellent*	*Excellent*	*Excellent*	*Excellent*
	Good	*Good*	*Excellent*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Good*	*Excellent*	*Excellent*	*Excellent*	*Excellent*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$000,000**	**$5,563,863**
Alternative B	**$5,846,579**	**$11,486,363**

Recommended Alternative

B. Replace Existing Digital CCTV System (Cameras)

Based on the technical evaluation of the Core Team Members, Alternative B was clearly rated equal or superior on all evaluation criteria. Alternative A, since it is the Status Quo, has no investment cost and life cycle cost that is roughly equivalent to the investment cost of Alternative B. The difference in both investment cost and life cycle cost between the two alternatives is simply about when the investment needs

to be made to replace the infrastructure, not when the investment needs to be made. Therefore, the benefits of performing the replacement in Alternative B are considered to outweigh what amounts to making the investment later in the status quo alternative. Keeping the status quo for a longer period of time also poses significant security risk that the technology becomes more obsolete, more difficult to maintain, and could result in unacceptable outages – all of which are captured in the ratings for operation and maintenance. Additionally, the upgrade of the CCTV systems across the four SPR sites at the same time provides better training, security, and consistency of operation and maintenance. Last, the ADAS project (which is a Go/No-Go project) and the Lighting Upgrades Project are better designed and installed in coordination with the upgraded CCTV infrastructure in Alternative B so that they function as an integrated system. Therefore, Alternative B is the recommended preferred alternative, with the benefits of operational considerations outweighing the earlier investment of cost required.

BH-MM-1530

Replace Perimeter Security Detection Systems

VCI Project Engineer: Corb Elsbury

Recommended Alternative:

FlexZone

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

Perimeter Security is provided at SPR sites to prevent undetected intrusion to the site facilities. This project is intended to provide a more reliable and maintainable intrusion detection system to replace the current aging system. The Big Hill existing Perimeter Security Detection System (PSDS) consists of ~18,500 feet of fence-mounted Intelli-Flex, Infrared Perimeter Intrusion Detection (IPID), traditional chain-link fencing, and unused, obsolete taut-wire.

Functional Requirements

The general requirements of the project are to meet DOE security parameters, ensure functionality of design (used as intrusion deterrent as intended), and provide a more reasonably maintainable system. The following are functional requirements for perimeter security detection on the SPR sites:

- Intrusion detection and assessment systems must function effectively in all environmental conditions and under all types of lighting conditions.
- Intrusion Detection Systems (IDS) alarms used for the protection of the SPR must be capable of immediate investigation by the Protection Force (PF), Central Alarm Station (CAS), and/or personnel via Closed Circuit Television (CCTV).
- Exterior IDS must be designed, where economically feasible, with independent redundant data communication paths for protecting DOE SPR interests. The conductors of the redundant data paths must not be installed in the same conduit, cable tray, or duct bank.
- The IDS system must be compatible with the existing Alarm Display and Annunciation System (ADAS) at the site. Close coordination with the ADAS system integrator is required. It is understood that upgrades to the ADAS system may be required.
- The IDS must be capable of being operated and maintained to ensure that the number of false and nuisance alarms do not reduce the effectiveness of the system, while meeting the nuisance alarm rates described in DOE Order 473.3 A.; each exterior intrusion detection sensor should not have a false or nuisance alarm rate of more than one alarm per 24 hours of operation.
- The IDS must be capable of detecting, with a probability of 90 percent and confidence level of 95 percent, an individual crossing the detection zone by walking, crawling, jumping, running, rolling, or climbing at any point in the detection zone.
- The system must deter adversaries from circumventing the detection system.
- The IDS must cover the entire perimeter without any gaps in detection, including the sides and tops of structures.
- The system must be located in such a manner that the length of each detection zone is consistent with the characteristics of the sensors used in that zone and the topography.
- The length of each detection zone must be within the optimal performance range of the sensor system and CCTV system.
- The system must be free of wires, piping, poles, and similar objects that could be used to assist an intruder traversing the isolation zone or that could assist in the undetected ingress or egress of an adversary or matter.
- An isolation zone must be at least 20 feet (6 meters) wide and clear of fabricated or natural objects that would interfere with operation of the detection systems or effective assessment.
- The system must incorporate a stabilized apron of ~3 feet on both sides of perimeter fencing to deter rodent burrows and rain erosion underneath the existing fencing.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Corb Elsbury	VCI, Project Engineer
Marc Gross	FFPO, Manager Design Engineering

Team Members

Patrick Shepherd	DOE, Project Engineer
Jerry Packard	DOE, Security Officer
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Hernaldo Carpio	DOE, Site General Engineer
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Todd Demaris	FFPO, Sr. Protection Physical Security
Randy Bridges	FFPO, Process & Security Systems Control
John Guidry	FFPO, Site Director
Barton Smith	FFPO, Site Security Specialist
Stephen Crawford	FFPO, Site Mechanical Process Engineer
Paul Riegert	FFPO, Manager Site Construction
Danny Duff	FFPO, Manager Site Maintenance

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Constructability during On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations. Close coordination with the Site Security Specialist and site/maintenance operations will allow for minimal impact on oil delivery operations.

Weight: Most Important

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment. Upgrades to existing technology and equipment will allow for optimal operation.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment, resulting in commonality of similar systems for future maintenance and sparing consideration. Maintenance operations will require less attention as new equipment replaces legacy equipment; all new equipment shall come with a service warranty.

Weight: Most Important

Safety during Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation. Safety is of the greatest importance.

Weight: Most Important

Security during Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to site security detection systems, as the Site Security Specialist shall coordinate to accommodate for down time to particular assessment systems during construction.

Weight: Most Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan. Energy consumption shall be considered in all upgraded equipment criteria.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

Allow the current PSDS system to remain in place and continue to repair fencing and obsolete taut-wire as needed. Allow for degraded fence areas and increasingly difficult parts procurement and maintenance efforts.

Senstar informed its customers of the planned retirement of the Intelli-FLEX fence-mounted intrusion detection sensor, and at a future date, they will no longer provide repair services for the Intelli-FLEX.

Viability: No Further Analysis

B. FlexZone w/Chain Link Fencing

Replace with a single sensor system consisting of the latest-generation of fence-mounted microphonic fence disturbance sensor systems such as Senstar FlexZone (Senstar suggested product replacement for Intelli-Flex) and IPID or an approved equal with associated software packages. Stabilize the fence to reduce erosion, deter rodents/animals, control weeds in support the PSDS. Replace fencing and posts where degradation has occurred; replace all barbed wire atop fencing with razor wire mounted on dual outriggers.

Viability: Continue Analysis

C. REDSCAN

REDSCAN is an analog system that can be pole or building mounted to provide an infrared laser wall that is installed inside the perimeter fence. The laser watches the fence area and monitors for any movement. REDSCAN does not meet DOE requirements as a standalone system for climbing, cutting, and bridging, as additional perimeter detection systems must be incorporated to meet functional requirements; REDSCAN vertical detection applications are in test stages. The REDSCAN alternative does not accomplish a single system install solution such as Intelli-Flex or its approved equal.

Viability: No Further Analysis

D. AgilFence

AgilFence uses advanced fiber optic, fence mounted sensors. Sensors are embedded in the optical fiber cable to form an array of sensors for perimeter fence intrusion detection. These extremely responsive sensors are used to detect incidents in various scenarios. A slight disturbance to the physical perimeter will trigger a response in the nearest optical fiber sensor that translates to an intrusion alert. This alternative requires replacing the current traditional chain-link fence in its entirety. Used in Southeast Asia and Eastern Europe, AgilFence is not used in the U.S. to date.

Viability: No Further Analysis

E. IMPASSE II and Infrared Perimeter Intrusion Detection

Replace the current components of the PSDS system (Intelli-Flex, IPID and fencing) with a combination of FlexZone and Impasse II. Impasse II is a steel palisade fence with an installed internal raceway for detection sensor systems, video cabling and arresting cables. Stabilize the fencing system to reduce erosion, deter rodents/animals, weed control in support the PSDS.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A, C, and D are eliminated from further consideration. The remaining alternatives, B and E are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. FlexZone with Chain Link Fencing

The Big Hill perimeter intrusion is experiencing obsolescence and maintenance related issues. Installed ~2006 and ~1997 respectively, the existing Intelli-Flex and IPID is not meeting the requirements of DOE 437.3 A. High nuisance alarm rates, maintenance difficulties, weather effects, and overall performance requires attention. FlexZone provides an alternative to address mentioned shortcomings of the Big Hill PSDS, but also introduces a system very much like other systems used across the SPR. FlexZone is the manufacturer suggested replacement of the currently used Intelli-Flex; Intelli-Flex is now a legacy system and soon will be phased completely out from the Senstar inventory (correspondence Dated 23 December 2014).

Replacing the existing perimeter detection system (~18,500') with the latest-generation of a fence-mounted microphonic fence disturbance sensor system such as FlexZone or an approved equal with associated software retains the proven performance of the current Intelli-Flex while introducing a similar system. Replacing the existing IPID (~1) with an ECSI International, Inc. product or approved equal shall address the aging and faulty IPID system. New equipment fielding and training, maintenance, and overall performance is similar and therefore provides a substantial advantage when associated with ease of operation/maintenance.

FlexZone is Senstar's latest generation ranging fence-mounted sensor. FlexZone detects and locates any attempt to cut, climb or otherwise break through the fence. It accurately locates intrusions even when there are multiple simultaneous intrusions and in the presence of background environmental noise.

FlexZone can detect and locate perimeter intrusions over a distance of up to 1,968 feet per sensor processor, and within 10 feet of accuracy. One processor can support up to 60 distinct, customizable zones. Both power and data can run over the sensor cables, minimizing infrastructure requirements. Advanced Digital Signal Processing (DSP) enables FlexZone to adapt to a wide variety of fence types including traditional chain-link fence currently in place on the site. Networking capability for remote configurations and alarm reporting is available and the product works reliably in the harsh environments. Current FlexZone warranties provide for a minimum of 2 years from installation and the manufacturer ensures replacement parts are available for a minimum of 10 years from purchase. Training of operators and maintenance personnel on calibration and system maintenance is provided.

The Architectural IPID system from ESCI International, Inc. provides a dependable security barrier of pulsed infrared technology to create multiple detection zones, each with a range of up to 1000 feet. Solid state electronics are not affected by environmental conditions such as birds, small animals, puddles, leaves, grass or mechanical vibrations. It works in rain and fog instantly pinpointing the intrusion zone via normally opened or closed dry contacts that can be interfaced with any annunciator or data communication system. IPID does not false alarm. The system will only alarm if an object breaks the 3.54" diameter beam more than 98.5%. Easy to use, extremely low nuisance alarm rates and widely used by Government entities, the product is accompanied by a 10-year warranty.

The fencing on the site consists of traditional chain-link fence that has experienced degradation due to sag and rusting from the salt/humid environment over the past 20+ years. Many sections of the fence have been subjected to flooding subsequently contributing to rust damaged fence posts and fabric. As fencing and gates are replaced, particular attention should be paid to the existing (~18) Balanced Magnetic Sensors (BMS) on gates. Replace the BMS as necessary to address HQ DOE findings 2015 of correcting deficiencies regarding to a lack of end of line sensors.

This alternative shall replace all fencing and posts (~18,500') with new, galvanized before weave (GBW) chain-link fencing fabric and posts. It shall also raise fencing in areas affected by consistent flooding and install ~6' (~3' on either side of outer perimeter fence bottom) of aggregate or concrete under fencing system to reduce erosion, deter rodents/animals, control weeds and obscuration, and support the overall Perimeter Security Detection System (PSDS).

The installation of concrete or aggregate under the fence will alleviate grass cutters from getting near the fence and prevent weed control chemicals from degrading the sensor tie material, resulting in sagging sensor cables as these ties break. Replace all barbed wire with razor wire mounted on dual outriggers atop all perimeter fencing and critical area fencing (~ 19,200'). In an attempt to reduce sagging over time, remove unused gates (~2) on the outer perimeter and any unused obsolete taut-wire systems on site.

Assumptions & Constraints

Assumptions:

- FlexZone and fencing replacement includes main site, Raw Water Intake Structure and required pump pads.
- Work requires minor adjustments to an already existing DOE approved Task Specification (Intelli-Flex).
- Most, if not all fencing shall be replaced.

Constraints:

- Protection Force (PF) compensatory involvement during construction.
- Chain-link fencing is not considered adequate security to meet today's asymmetric threats.

Benefits & Effectiveness

Replacing the PSDS system will allow for improved security measures on site, which is more cost effective and best meets requirements described in DOE 473.3 A. Repairs to the fencing system and replacements of sensors will allow for expedited response and deterrence of unauthorized entry on site. The items below summarize the benefits/effectiveness and mission need items addressed by replacing the existing PSDS on site with FlexZone.

- Familiar, new equipment and software will provide for improved maintenance and significantly enhanced performance (DOE 473.3 A., Attachment 3, Section A 3-44 [2][a][1]).
- Allows for increased security measures on site, providing optimal security protection (DOE 473.3 A., Attachment 3, Section A 3-45 [3][b][2]).
- FlexZone allows for precision sensitivity leveling/adjustments.
- Removes unserviceable fencing where degradation has occurred (DOE 473.3 A., Attachment 3, Section A 3-45 [3][b][2]).
- Communications path redundancy ensures continued perimeter protection in the event of a cable cut.
- Provides better fencing in areas affected by consistent flooding (DOE 473.3 A., Attachment 3, Section A 3-45 [3][b][2]).
- Prevent access onto site through removal of un-used gates, further strengthens security measures (DOE 473.3 A., Attachment 3, Section A 3-44 [2][a][1]).
- Will allow for better protection against ladder/pole assisted climbing intrusion once all razor ribbon on top of perimeter and critical area fencing is installed (DOE 473.3 A., Attachment 3, Section A 3-45 [3][b][1]).
- Concrete or aggregate will allow for better erosion, animal/rodent control, weed control and protect against potential under wire intrusion (DOE 473.3 A., Attachment 3, Section A 3-44 [2][a][1]).
- Replacement of the degrading and now legacy PSDS system, upgrading to a current industry standard system (DOE 473.3 A., Attachment 3, Section A 3-44 [2][a][1]).
- FlexZone is noted for low power consumption.
- Optional Ethernet card with Power over Ethernet (PoE) capability.
- Sensors are calibrated with Windows-based point and click utility (over the network or locally by USB).

Risk & Mitigation Factors

Some potential risks associated with replacing the current PSDS with FlexZone include potentially reduced security posture during construction, training employees on a new system, and potential safety issues while updating and installing equipment. The table below summarizes mentioned risks with a correlating

mitigation strategy. The table describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for FlexZone with Chain-Link Fencing

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Reduced security posture during construction.	Close coordination between NOLA, site security and contractor work scheduling and sequence.	High - High	High Risk Hazard
Will require training on the new system.	Minimize the length of training by making the training comprehensive, hands on and repetitive.	Medium - Low	Low Risk Hazard
Potential safety hazards involved when updating or installing equipment on site.	The contractors shall prepare a Job Hazard Analysis and the site shall brief employees on site near the system update or installation.	Medium - Low	Low Risk Hazard

B. IMPASSE II with FlexZone

The Big Hill perimeter intrusion is experiencing obsolescence and maintenance related issues. Installed ~2006, the existing Intelli-Flex and IPID is not meeting the requirements of DOE 437.3 A. High nuisance alarm rates, maintenance difficulties, weather effects and overall performance requires immediate attention. Senstar informed its customers of the planned retirement of the Intelli-FLEX fence-mounted intrusion detection sensor, and at a future date, they will no longer provide repair services for the Intelli-FLEX.

This alternative is a high security fence, combined with installing a new perimeter security detection system such as FlexZone or an approved equal; a single perimeter detection system, arrayed in depth by design including new IPID. A recent Fluor physical security system evaluation (dated March 2016) of the Ameristar Impasse II system yielded familiarity and an overall positive evaluation. The Impasse II is widely used for military sites, government facilities, petroleum and chemical facilities, and airports.

A high security fence, IMPASSE II, is a vertical (~8' in height), palisade steel fencing made of pre-galvanized steel, test-based to ASTM B117 standards, with tamper-proof fastenings and an installed internal raceway for detection systems, video cabling and up to 3 arresting cables. The raceway eliminates the need for any trenching, boring, fastening ties, or degradation from fence sag. The Impasse II security fence panels employ a bracketless design using tamper proof fasteners; are installed with heavier posts (I-beam); includes a 15-year warranty. The panels are constructed of heavy duty steel, eliminating fence sag. The Impasse II does not require the use of razor wire atop its fencing panels – a choice of trident, stronghold or gauntlet style options are available.

Replacing the existing perimeter detection system (~18,500') with the latest-generation of a fence-mounted microphonic fence disturbance sensor system such as FlexZone or an approved equal with associated software retains the proven performance and familiarity of the currently installed Intelli-Flex system.

This alternative shall replace all fencing and posts (~18,500') with the pre-galvanized Ameristar fencing system, Impasse II. It shall also raise areas affected by consistent flooding and install ~6' (~3' on either side of outer perimeter fence bottom) of aggregate or concrete under fencing system to reduce erosion, deter rodents/animals, control weeds and obscuration, and support the overall Perimeter Security Detection System (PSDS). As fencing and gates are replaced, particular attention should be paid to the existing (~18) Balanced Magnetic Sensors (BMS) on gates. Replace the BMS as necessary to address HQ DOE findings 2015 of correcting deficiencies regarding to a lack of end of line sensors.

The installation of concrete or aggregate under the fence will alleviate grass cutters from getting near the fence and prevent weed control chemicals from degrading the sensor tie material, resulting in sagging sensor cables as these ties break. Remove unused gates (~2) on the outer perimeter and any unused obsolete taut-wire systems on site.

Assumptions & Constraints

Assumptions:

- Impasse II and FlexZone installation includes main site, Raw Water Intake Structure and required pump pads.
- The IPID is at the main entrance.

Constraints:

- Protection Force compensatory activity during installation/construction.

Benefits & Effectiveness

Replacing the fencing and installing FlexZone with IMPASSE II will allow for the optimal security posture on site as described in DOE 473.3 A. This alternative of the PSDS replacement will allow for stricter deterrence of unauthorized entry and improve degrading systems. The items below summarize the benefits and effectiveness of adding the IMPASSE II as the PSDS on site.

- Will replace the degrading fence and allow for replacement of the now legacy PSDS system (DOE 473.3 A., Attachment 3, Section A 3-45 [3][b][2]).

- Allows for higher security measures on site, negates the need for razor wire and enables an improved platform for installation of a selected intrusion system (DOE 473.3 A., Attachment 3, Section A 3-44 [2][a][1]).
- Capable of being an all-inclusive PSDS system in one installation, allowing for shorter duration installation and disruption to site security posture (DOE 473.3 A., Attachment 3, Section A 3-45 [3][b][2]).
- Allows for easier detection probability calculations.
- The Impasse rail system is designed to house all peripherals required to complete a perimeter security system without the expense of trenching and boring typically used in these applications (DOE 473.3 A., Attachment 3, Section A 3-45 [3][b][2]).
- The Impasse rail can accommodate crash barrier components such as arresting cables (DOE 473.3 A., Attachment 3, Section A 3-45 [3][b][2]).
- Impasse II is made from 96% recycled steel.
- Permacoat process gives Impasse II distinct advantage over chain link fencing - a corrosion resistant, polyester top coat (test based on ASTM B117 Standard).

Risk & Mitigation Factors

With any new upgrade at the site come associated risks. Some potential risks associated with IMPASSE II on site is reduced security posture during construction, training employees on a new system, and generating potential safety issues while updating and installing equipment. The table below summarizes the above mentioned risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for IMPASSE II with FlexZone

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Reduced security posture during construction.	Close coordination between NOLA, site security and contractor work scheduling and sequence.	Medium - High	Medium Risk Hazard
May require extensive training on a new system.	Minimize the length of training by making the training comprehensive, hands on, and repetitive.	Medium - Medium	Medium Risk Hazard
Potential safety hazards involved when updating or installing equipment on-site.	The contractors shall prepare a Job Hazard Analysis (JHA) and the site shall brief employees near the system update or installation.	Medium - Low	Low Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. FlexZone

Replace with the latest-generation of fence-mounted microphonic fence disturbance sensor systems such as Senstar FlexZone (Senstar suggested product replacement for Intelli-Flex) and IPID or an approved equal with associated software packages. Stabilize under fencing with aggregate or concrete to reduce erosion, deter rodents/animals, and control weeds to support the Perimeter Security Detection System (PSDS). Replace fencing and posts where degradation has occurred. Replace barbed wire with razor wire mounted on dual outriggers on top of perimeter and critical area fencing. Remove unused gates and any obsolete taut-wire on the site.

B. IMPASSE II with FlexZone

Install the IMPASSE II, is a vertical metal, palisade fencing combined with the latest-generation of fence-mounted microphonic fence disturbance sensor systems such as Senstar FlexZone (Senstar suggested product replacement for Intelli-Flex) and IPID or an approved equal with associated software packages. Stabilize under fencing with aggregate or concrete to reduce erosion, deter rodents/animals, and control weeds to support the Perimeter Security Detection System (PSDS). Remove unused gates and any obsolete taut-wire on the site.

Comparison of Alternatives

Core Team Member Ratings

	Constructability During Ongoing Oil Deliveries	**Ease of Operations**	**Ease of Maintenance**	**Safety During Construction**	**Security During Construction**	**Sustainability**
	Most Important	*Most Important*	*Most Important*	*Most Important*	*Most Important*	*Less Important*
Alternative A	*Excellent*	*Excellent*	*Excellent*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Excellent*	*Good*	*Excellent*
	Good	*Excellent*	*Excellent*	*Excellent*	*Good*	*Good*
Alternative B	*Excellent*	*Good*	*Good*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Good*	*Good*	*Excellent*
	Good	*Good*	*Excellent*	*Good*	*Good*	*Good*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$7,398,830**	**$7,523,442**
Alternative B	**$10,646,487**	**$10,789,127**

Recommended Alternative

A. FlexZone

Based on the technical evaluation of the Core Team Members, Alternative A was clearly rated equal or superior on all evaluation criteria. The initial cost and life cycle cost of Alternative A were both lowest of the alternatives. Therefore, Alternative A is the recommended preferred alternative based on both technical and cost factors studied in the alternative analysis.

BH-MM-1552

Replace Oil-in-Water Monitor

VCI Project Engineer: Lorna Madison

Recommended Alternative:

New UV Fluorescence Monitors

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The Oil-in-Water Monitor Instrumentation installed in the Brine Return Line at Big Hill (BH) must be replaced in order to detect and eliminate oil breakthrough into the Brine Pond and subsequent oil carryover into the remainder of the brine handling system in order to address environmental and safety standards.

Functional Requirements

The following are the functional requirements for the replacement of the Oil-in-Water Monitor at Big Hill:

- Monitors must be installed farther upstream than the current monitor in cavern header piping for individual wellheads to provide early warning and timely response to oil breakthrough due to wellhead string failure in order to minimize site environmental impact.
- Monitor selection shall provide the sensitivity required to detect initial oil breakthrough from any one cavern wellhead.
- Monitor selection shall provide for robust, reliable operation with minimum inspection, calibration, and repair activity over the estimated 25-year life of the Life Extension 2 (LE 2).
- Monitor installation plans shall consider providing alternative means of cavern depressurization/fill in a safe manner during installation.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Lorna Madison	VCI, Project Engineer
Stephen Brothers	FFPO, Principal Operations System Engineering

Team Members

Anthony Bonadona	VCI, Project Engineer
Ed Orloski	VCI, Process Engineer
William Leet	VCI, Process Engineer
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Buddy Delaune	FFPO, Principal Mechanical Engineer
Paul Riegert	FFPO, Manager Site Construction
Steven Crawford	FFPO, Site Mechanical Process Engineer
Randy Bridges	FFPO, Process and Security Systems Control
Bob Sevcik	FFPO, Director - Environmental Department

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as necessary to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate alternatives and select a recommendation.

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment. Monitors must be installed farther upstream than the current monitor in cavern header piping at the individual wellheads to provide early warning and timely response to oil breakthrough to minimize environmental impact. Monitor selection shall provide the sensitivity required to detect initial oil breakthrough from any one cavern wellhead.

Weight: Most Important

Ease of Maintenance

The selected alternative features technology which exhibits the necessary detector sensitivity and compatibility with existing controls' hardware and which can be readily serviced and maintained on-site alongside existing equipment. Monitor selection shall provide for robust, reliable operation with minimum inspection, calibration, and repair activity over the estimated 25-year life of LE 2.

Weight: Most Important

Safety during Construction

The selected alternative when implemented will be able to be constructed and operated safely and have the ability to address Safety and Security concerns during implementation. A robust contractor work plan shall be vetted by the Government for all safety concerns that might be of note during construction.

Weight: Most Important

Constructability during Ongoing Oil Deliveries

The selected alternative is able to be implemented with little or no impact to ongoing oil delivery operations. Close coordination with the Site Security Specialist and site/maintenance operations will allow for minimal impact on oil delivery operations. Monitor installation plans shall consider providing alternative means of cavern depressurization/fill in a safe manner during installation.

Weight: Important

Sustainability

The selected alternative when implemented will be able to achieve the Department of Energy (DOE) sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan. Water monitors/interface instrumentation installed in the brine return line at the Big Hill site shall be replaced in order to ensure that the required oil/hydrocarbon content criteria in the brine pond are met.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

The status quo consists of continuing to use the existing Oil-in-Water Monitor at Big Hill.

Current practice for detecting oil breakthrough to the brine side on cavern wellhead string failure in time to prevent significant oil contamination of the brine system is not effective. Operators are trained to successfully to check for pressure equalization across the wellhead to detect a string break in a blocked-in, no-flow scenario. However, the currently installed instrumentation for detection of oil breakthrough under flowing conditions is not effective. The currently installed system has failed to detect entrained oil content in the header system multiple times due to issues with monitor type, monitor installation, monitor

maintenance, and installed location of the monitor. Based on experience to date, the single monitor is currently installed too close to the end of the line into the brine pond to protect the brine piping from accumulating significant quantities of oil with breakthrough of that oil into the brine pond where it registers as an environmental excursion. Continuing to operate the existing Oil-in-Water Monitor does nothing to reduce the incidence of environmental excursion with oil breakthrough into the brine pond and downstream brine systems.

Viability: No Further Analysis

B. Flowmeters

This alternative consists of conducting a pilot study using the existing flowmeters on site to see if they can detect oil in water. This pilot study would be conducted before any other alternative being pursued to monitor oil in water. The flowmeters are already installed on-site. The pilot study is pending.

Should the pilot study determine that the flowmeters are not capable of detecting oil in water, then an alternative technology would be selected from the list below to pursue reliable detection of oil in water. Alternate technology selection necessitates a second pilot test to prove the capabilities of the alternate technology in the field.

Viability: Continue Analysis

C. New UV Fluorescence Monitors

This alternative consists of installing new ultraviolet (UV) fluorescence based monitors at individual wellheads to provide for early detection and response to oil breakthrough into the brine header at each wellhead. Brine quality, line velocity, temperature, suspended solids, and organic matter do not affect measurement by UV fluorescence based monitors. These monitors are highly accurate, providing instantaneous and continuous measurement. They have the required sensitivity with range of detection from 0–10 parts per million (ppm) to 0–150 ppm Oil-in-Water. They are self-cleaning and require low maintenance. They are available for an in-line and a loop/side stream type installation.

Viability: Continue Analysis

D. New UV Absorption Monitors

This alternative consists of installing new ultraviolet absorption based monitors at individual wellheads to provide for early detection and response to oil breakthrough into the brine header at each wellhead. The presence of organic materials including bacteria, yeast, and algae will interfere with the performance of these meters. Compensation, filtering, or frequent zeroing is required to successfully operate these monitors. This monitor type cannot be recommended as a reliable Oil-in-Water Monitor for Big Hill brine operations on account of these potential interferences and the extra care required to maintain performance of this instrument in service.

Viability: No Further Analysis

E. New Calorimetry Monitors

This alternative consists of replacing the existing monitor/system with calorimetry based monitors at individual wellheads to provide for early detection and response to oil breakthrough into the brine header at each wellhead. The presence of solids will interfere with the performance of these meters. Compensation, filtering, or frequent zeroing is required to successfully operate these meters. Catalyst addition is required for color transformation/recognition, and a database of standards of colors must be collected and defined for each different hydrocarbon and application. Moreover, this does not provide the user with the ppm oil detection sensitivity required. This monitor type cannot be recommended as a reliable Oil-in-Water Monitor for Big Hill brine operations.

Viability: No Further Analysis

F. New Light Scatter Monitors

This alternative consists of replacing the existing monitor/system with nephelometry (light scatter) based monitors at individual wellheads to provide for early detection and response to oil breakthrough into the brine header at each wellhead. The presence of solids, trace chemicals, and color bodies will interfere with the performance of these meters in the absence of sample stabilization to give a false high hydrocarbon reading. Compensation and filtering techniques are required to offset potential interferences. This monitor type cannot be recommended as a reliable Oil-in-Water Monitor for Big Hill brine operations.

Viability: No Further Analysis

G. New Microscopy Monitors

This alternative consists of replacing the existing monitor/system with microscopy (imaging) based monitors at individual wellheads to provide for early detection and response to oil breakthrough into the brine header at each wellhead. Brine quality, line velocity, temperature, suspended solids, and organic matter do not affect measurement of these monitors. These monitors are highly accurate, providing instantaneous and continuous measurement. They have the required sensitivity with range of detection of up to 1000 ppm oil-in-water and the ability to detect particle and droplet size information e.g. Dv10, Dv50, and Dv90 data. The above features can be combined with other analyses like florescence and spectral analyses for the best available reliability in measurement techniques.

Viability: Continue Analysis

H. New Radar, Acoustic, Capacitance, or Energy Absorption Monitors

This alternative focuses on alternative technology selection from a list of options which are typically characteristic of interface level control and not oil-in-water measurement. This includes options such as radar, microwave, acoustic, and capacitance, energy absorption, etc. The monitor of choice among these would be installed at each individual wellhead to provide for early detection and response to oil breakthrough into the brine header at each wellhead. The presence of solids and organics will interfere with the performance of these meters. Compensation, filtering, recalibration, or frequent zeroing is required to successfully operate these meters. These meters lack the required sensitivity for gaging oil breakthrough. They typically measure oil concentrations on the percent level rather than the ppm level desired for detecting oil breakthrough. These meters are better suited to gaging oil water interface levels than for detecting oil entrainment into system flows. These monitor types cannot be recommended for reliable oil-in-water monitoring service for Big Hill brine operations.

Viability: No Further Analysis

I. New Technology

This alternative consists of replacing the existing monitor/system with new technology that is still in its testing phase such as laser-based monitors. Although newer technology may be available, insufficient field testing has been performed and communicated to establish such technology as commercially reliable and robust options for application here. Therefore, new technology lacking full proving in the field is not considered a viable alternative here.

Viability: No Further Analysis

V. ALTERNATIVES ANALYSIS

Based on the initial analysis of the alternatives, Alternatives A, D, E, F, H and I are eliminated from further consideration as unacceptable or infeasible for replacing the Oil-in-Water Monitors. The remaining Alternatives, B, C, and G, are examined below as Alternatives A, B, and C, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

Common Assumptions & Constraints

- Monitor selection will provide for robust, reliable operation with minimum inspection, calibration, and repair activity over the estimated 25-year life of the Life Extension 2 (LE 2).
- Monitors will be installed farther upstream than the current monitor in cavern header piping at the individual wellheads to provide early warning and timely response to oil breakthrough due to wellhead string failure to minimize site environmental impact.
- Monitor selection will provide the sensitivity required to detect initial oil breakthrough from any one cavern wellhead.
- Monitor installation plans will consider providing alternative means of cavern depressurization/fill in a safe manner during installation.
- Monitors will meet the required environmental and safety standards.

A. Flowmeters

This alternative will evaluate the existing installed flowmeters to detect oil in water under flowing conditions.

Assumptions & Constraints

- The flowmeters are installed and fully operational.
- The flowmeters will be performance tested in the field to confirm whether they can reliably detect oil breakthrough into water.
- The flowmeter pilot study will be conducted first before any alternative technology is considered.
- If the flowmeter fails to detect oil in water, the next best alternative from the list of alternatives below will be selected, and a pilot test will be performed to determine its viability.

Benefits & Effectiveness

The use of the current flowmeters installed at the site allows for multiple benefits and addresses current mission needs. The items below summarize the benefits and effectiveness of conducting a pilot test and using the current flowmeters.

- The pilot test will allow the site to test whether current equipment installed on-site is able to detect oil in water.
- If the pilot test shows that the flowmeters are adequate, no new equipment will need to be purchased.

Risk & Mitigation Factors

Conducting a pilot test on the currently installed flowmeters will come with associated risks. The table below describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Using the Flowmeters/Conducting a Pilot Test

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Safety while conducting the pilot test.	Ensure a job hazard analysis is prepared by contractors and for anyone on-site in the area of replacement.	Medium - Medium	Medium Risk Hazard
Flowmeters do not reliably detect oil in water.	Conduct performance test in the field to establish whether they work. If they don't provide the desired results, proceed with selection and testing of alternative technology.	Medium - Medium	Medium Risk Hazard

B. New UV Fluorescence Monitors

This alternative will replace the existing monitors/system with ultraviolet fluorescence based monitors/system.

Assumptions & Constraints

Assumptions:

- New ultraviolet UV fluorescence monitors are installed at each individual wellhead.
- The monitors can detect from 0–10 parts per million (ppm) to 0–150 ppm oil-in-water.
- UV florescence monitors are self-cleaning and low maintenance.

Constraints:

- Meter recalibration may be required from time to time for changes in ratios of Aliphatic/Aromatic vs. Total Hydrocarbon (HC).
- Performance testing of a single monitor installed in the field is required to confirm this technology selection before committing to purchase of additional monitors.
- Monitor life requires periodic field servicing and periodic replacement over the estimated 25-year life of the Life Extension 2 (LE 2).

Benefits & Effectiveness

The replacement of the existing monitors/system with UV fluorescence based monitors/system allows for multiple benefits and addresses current mission needs. The items below summarize the benefits and effectiveness of installing new monitors/system on-site.

- The UV fluorescence based monitors/system will eliminate the risk of getting oil into the brine pond.
- Process Parameters, Total Suspended Solids (TSS), and Organic Matter cannot influence or affect the measurement of UV fluorescence based monitors.
- The monitors/system are highly accurate, providing instantaneous and continuous measurement.
- The monitor/system have a good range of detection from 0–10 parts per million (ppm) to 0–150 ppm oil-in-water.

Risk & Mitigation Factors

Replacing the existing monitors/system with UV fluorescence based monitors/system will come with associated risks. The table below describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing the Existing Monitors/System with UV Fluorescence Monitors

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Safety while removing and installing the new monitors/system.	Ensure a job hazard analysis is prepared by contractors and for anyone on-site in the area of replacement.	Medium - Medium	Medium Risk Hazard
UV florescence monitors not compatible with oil.	Supply analyzer vendors adequate information on the chemical/physical properties of the oil and brine.	Medium - High	Medium Risk Hazard
UV florescence monitors incorrectly calibrated.	Ensure the monitors are calibrated for the correct ratios of Aliphatic/ Aromatic vs. Total Hydrocarbon.	Medium - High	Medium Risk Hazard
UV florescence monitors installed too far from wellheads.	Ensure location of the monitors will provide adequate oil detection and response time from site personnel.	Medium - High	Medium Risk Hazard

C. New Microscopy Monitors

This alternative will replace the existing monitors/system with microscopy based monitors/system.

Assumptions & Constraints

Assumptions:

- New Microscopy monitors are installed at each individual wellhead.
- Microscopy monitors are the best technology available.
- The detection is up to 1000 ppm oil-in-water and particle and droplet size information e.g. Dv10, Dv50, and Dv90 data.

Constraints:

- Microscopy monitors are more suitable for water injection type work.
- Microscopy monitors analyses side stream only.
- Performance testing of a single monitor installed in the field is required to confirm this technology selection before committing to purchase of additional monitors.
- Monitor life requires periodic field servicing and periodic replacement over the estimated 25-year life of the Life Extension 2 (LE 2).

Benefits & Effectiveness

- The microscopy based monitors/system will eliminate the risk of getting oil into the brine pond.
- Process Parameters, Total Suspended Solids (TSS), and Organic Matter cannot influence or affect the measurement of UV fluorescence based monitors.
- The monitors/system are highly accurate, providing instantaneous and continuous measurement.
- The monitors/system have a good range of detection of up to 1000 ppm oil-in-water, and the ability to detect particle and droplet size information e.g. Dv10, Dv50, and Dv90 data.
- The microscopy based monitors/system can be combined with other analyses like florescence and spectral analyses for the best available reliability in measurement techniques.

Risk & Mitigation Factors

Replacing the existing monitors/system with microscopy based monitors/system will come with associated risks. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing the Existing Monitors/System with Microscopy Based Monitors

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Safety while removing and installing the new monitors/system.	Ensure a job hazard analysis is prepared by contractors and for anyone on-site in the area of replacement.	Medium - Medium	Medium Risk Hazard
Microscopy monitors not compatible with oil.	Supply analyzer vendors adequate information on the chemical/physical properties of the oil and brine.	Medium - High	Medium Risk Hazard
Microscopy monitors incorrectly calibrated.	Ensure the monitors are calibrated for the correct concentration (ppm) and particle/droplet size.	Medium - High	Medium Risk Hazard
Microscopy monitors installed too far from wellheads.	Ensure location of the monitors will provide adequate oil detection and response time from site personnel.	Medium - High	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Flowmeters

This alternative will utilize the existing flowmeters currently installed to monitor oil in water.

B. New UV Fluorescence Monitors

This alternative will replace the existing monitors/system with ultraviolet fluorescence based monitors/system.

C. New Microscopy Monitors

This alternative will replace the existing monitors/system with microscopy based monitors/system.

Comparison of Alternatives

Core Team Member Ratings

	Safety During Construction	**Ease of Operations**	**Ease of Maintenance**	**Constructability During Ongoing Oil Deliveries**	**Sustainability**
	Most Important	*Most Important*	*Most Important*	*Important*	*Less Important*
Alternative A	*Excellent*	*Good*	*Adequate*	*Excellent*	*Good*
	Excellent	*Good*	*Good*	*Excellent*	*Good*
	Excellent	*Good*	*Excellent*	*Excellent*	*Excellent*
Alternative B	*Good*	*Excellent*	*Excellent*	*Good*	*Excellent*
	Excellent	*Good*	*Excellent*	*Good*	*Excellent*
	Good	*Excellent*	*Excellent*	*Good*	*Excellent*
Alternative C	*Good*	*Adequate*	*Good*	*Good*	*Excellent*
	Excellent	*Good*	*Adequate*	*Good*	*Excellent*
	Good	*Adequate*	*Good*	*Good*	*Excellent*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$299,648**	**$000,000**
Alternative B	**$6,790,838**	**$7,894,745**
Alternative C	**$6,763,688**	**$7,867,595**

Recommended Alternative

B. New UV Fluorescence Monitors

Based on the technical evaluation of the Core Team Members, Alternative B was rated overall higher on the evaluation criteria. Alternative A has a significantly lower investment cost and life cycle cost followed by Alternative C and Alternative B. Alternative A has a significant risk of technically not meeting the mission need and functional requirements and therefore is not recommended. Alternative B was rated significantly higher overall than Alternative C on the evaluation criteria. Therefore, Alternative B is the recommended preferred alternative, with the significant benefits of operational considerations outweighing the higher investment and life cycle cost.

BH-MM-523

Replace 5 KV Outdoor Bus Ducts

VCI Project Engineer: Lorna Madison

Recommended Alternative:

Cable Bus

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The existing 5 KV Bus Duct is painted steel construction. The integrity of some sections of the existing bus duct is being compromised by corrosion. Other sections of the bus duct are rusting significantly and the entire bus duct assembly could be considered a high maintenance item. The existing bus duct is over 25 years old and is approaching the end of its original service life. Replacing the existing bus duct with new modular, corrosion resistant units will reduce site maintenance manpower requirements and material costs. If this task is not implemented there is a higher risk of bus duct failure due to moisture intrusion into the housing and possible electrical faults that would shut down or damage additional equipment. Electrical faults of this type could affect the ability to fill or drawdown the site.

Functional Requirements

- Install one new modular, 5 KV, 3,000-amp bus duct between the outdoor brine disposal, transformer (BHTX-9) and the 5 KV switchgear in the load center building.
- Install one new modular, 5 KV, 3,000-amp bus duct between the outdoor Raw Water Injection, transformer (BHTX-6) and the 5 KV switchgear in the load center building.
- Install one new modular, 5 KV, 3,000-amp bus duct between the outdoor Crude Oil Injection, transformer (BHTX-29) and the 5 KV switchgear in the load center building.
- Install two new modular, 5 KV, 2,000-amp bus ducts between the two outdoor step-down transformers (BHTX-14 and BHTX-15) and the 5 KV switchgear in the Raw Water Intake Structure (RWIS) load center building.
- New modular bus ducts will accommodate the requirements for wind loading per ASCE-7 and will be constructed of corrosion resistant materials requiring less maintenance.
- Include space heaters to prevent moisture intrusion, as applicable.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for Projects has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
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Marc Gross	FFPO, Manager Design Engineering

Team Members

Anthony Bonadona	VCI, Project Engineer
William Leet	VCI, Process Engineer
Eric Schlosser	VCI, Instrument Engineer
Lisa Eldredge	FFPO, Principal Operations System Engineer
Buddy Delaune	FFPO, Principal Mechanical Engineer
Paul Riegert	FFPO, Manager Site Construction
Scott Salter	FFPO, Electrical Engineer

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as necessary to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate alternatives and select a recommendation.

Constructability during On-going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations. Outdoor Bus Duct replacement activity should not compromise drawdown readiness.

Weight: Most Important

Safety during Construction

The selected alternative when implemented will be able to be constructed and operated safely. Ability to address Safety and Security concerns during implementation.

Weight: Most Important

Ease of Operations

The selected alternative when implemented will result in an Outdoor Bus Duct system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Important

Ease of Maintenance

The selected alternative is similar in nature to existing Bus Duct equipment resulting in commonality of similar systems for future maintenance and sparing consideration. The Outdoor Bus Duct needs to provide 100% operating reliability for an estimated 25-year service life. Outdoor Bus Duct design should ensure that in-place inspection and repair techniques can be minimized or eliminated.

Weight: Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

Maintain and operate the existing system in place. Continue to paint and repair the existing bus duct. This bus duct will require increasing maintenance effort and cost as it approaches the end of its expected service life. Along with this increased maintenance effort is the risk of higher failure rates and equipment outages. Electrical failures and faults of this type could affect the ability to fill or drawdown the site.

Viability: No Further Analysis

B. Bus Duct, Segregated Bus Duct

Bus duct is a rigid sheet metal duct containing either copper or aluminum bus bars for the purpose of conducting large currents. Similar to cable tray, bus duct has thick, steel side rails and thinner sheet metal coverings. Individual current carrying bus bars within the bus duct are evenly separated and electrically insulated. Bus duct conductors are not continuous from end to end and require multiple joints which are susceptible to loose connections and possible failure. Bus duct installation is very rigid, requires very accurate placement, and field adjustments are not possible as is possible with cable bus. Because bus duct is rigid, additional cost is incurred due to the required flex braid for connecting bus duct to switchgear, transformers and switches. Bus duct is assembled in large segments with both mechanical and electrical connections. Each section of bus duct has substantial weight, requires heavy lift equipment, is physically bolted together, and requires physical supports. Outdoor bus duct must be totally enclosed and requires bus bar derating which results in larger bus bars and extra cost. Breathers, drains, and space heaters will likely be required to prevent condensation in the enclosed outdoor bus duct. When transitioning from outside bus duct to inside bus duct, the indoor bus bar will also need to be oversized to physically match the outdoor section. The oversized indoor bus bar sections result in increased cost. Bus duct requires high cost routine maintenance including repainting/recoating, annual torque of all physical connections, and IR scanning of terminations and joints. Phasing of conductors is less efficient than Cable Bus phasing with resultant higher losses and higher operating costs.

Bus duct is hard to install, measurements must be precise, and bus duct does not provide all of the many benefits obtained from a cable bus installation.

Viability: No Further Analysis

C. Cable Tray with Cable Clamps

Cable tray is a cable support system constructed from two side rails connected with individual rungs, solid bottom sections, or ventilated bottom sections depending on the application. Cable tray is useful in situations where changes to a wiring system are anticipated, since new cables can be installed by laying them in the tray, instead of pulling them through existing conduit. It is available in a variety of materials including aluminum, fiberglass, galvanized steel, hot-dipped galvanized steel, and stainless steel. A solid bottom cable tray provides good protection to cables, but requires cutting the tray or using fittings to enter or exit cables. Ventilated tray has openings in the bottom of the tray, allowing some air circulation around the cables, water drainage, and allowing some dust to fall through the tray. Smaller cables exit the tray through the ventilation openings, which may be either slots or holes punched in the bottom. A ladder tray has the cables supported by a bar spaced at regular intervals, similar to the rungs of a ladder. Both ladder and ventilated trays may have solid covers to protect cables from falling objects, dust, and water. Large power cables laid in the tray may require support blocks to maintain spacing between conductors, to prevent overheating of the wires. To maintain support of cables at changes of elevation or direction of a tray, a large number of specialized cable tray fittings are made which are specific to each style and manufacturer. It is important that thermal contraction and expansion be considered when installing cable tray systems. The length of the straight cable tray runs and the temperature differential govern the number of expansion splice plates required. Cable tray should be anchored at the support nearest to its midpoint between the expansion splice plates and secured by expansion guides at all other support locations. The weight of an aluminum cable tray is approximately half that of a comparable steel tray, which will affect cost of shipping, material cost, handling, project weight and the strength/cost of support members. Cable tray is easier to modify, cut, and drill than Bus Duct, Isolated Phase Bus, and Cable Bus. Hot dip galvanized and painted steel cable tray finishes must be repaired when field cutting or drilling. Failure to repair coatings will impair the cable tray's corrosion resistance. 2000A and 3000A require many cables per phase. Multiple cables in tray require derating and take up a lot of space.

Viability: No Further Analysis

D. Cable Bus

Cable Bus is an electrical busway assembly that consists of fully insulated, shielded conductors mounted in a ventilated metal housing with polymer cable supports that maintain cable phasing, spacing, and short circuit protection. Use of shielded cables cancels the external magnetic field generated by phase currents.

Shielded cables along with the use of proper cable supports work together to withstand forces due to short circuits. The cables are run in parallel through the entire bus housing. More than one parallel cable per phase can be used where large conductor sizes are required. Several smaller parallel conductors are more flexible during installation and benefit from greater current carrying capacity than fewer, larger conductors. The ventilated cable bus enclosure is made from welded aluminum alloy, with each piece sized to fit each specific project installation. The lightweight, welded rigid enclosures are usually able to be lifted by two men without the need for special heavy lifting equipment. Cable bus systems consist of continuous length conductors from termination to termination, eliminating splices which can be a source of faults. The insulated conductors used are designed to withstand harsh outdoor environments, are not affected by moisture, and do not require heaters, filter breathers, or thermostats, reducing the number of possible failure points. Free air rating is achieved with ventilated enclosure covers for optimum conductor cooling, and greater ampacity is achieved with less copper. In most applications over 1000 amps, cable bus costs significantly less that bus duct, cable tray, or other systems. Since Cable Bus is continuous there are no power losses from splices and connections. It has lower impedance and lower voltage drop due to proper phasing, spacing and support if the conductors. Unlike rigid bus duct systems which must be exact to make equipment terminations, cable bus is easily adjusted to account for equipment misalignment and unforeseen obstacles during construction. Tap boxes, transformer termination boxes, and switchgear/MCC top hats are available to provide the necessary space to complete the installation. No special finishes are required with housings available in aluminum and stainless steel. Cable bus is a smart alternative to running multiple cables per phase in cable tray.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A, B, and C are eliminated from further consideration. Alternative A - Status Quo will result in increased maintenance and higher failure risk and is not a viable option. Alternative B - Segregated Bus Duct is a viable option but it is difficult to install and requires precise measurements. It does not provide the benefits of cable bus. Alternative C – Cable Tray with Cable Clamps requires ampacity derating and cable separation and takes up a lot of space and is not a viable option.

The remaining alternative D is examined below as alternative A.

The below analyses provide the research and technical information gathered by the AoA Team. This analysis is not evaluative or comparative.

A. Cable Bus

The site will replace the 5KV Outdoor Bus Ducts with Cable Bus.

Assumptions & Constraints

- Approximate length of each cable bus is 25'.

Benefits & Effectiveness

The replacement of the 5 KV Outdoor Bus Ducts with Cable Bus allows for multiple benefits and addresses current mission needs.

- Cable Bus are easily adjusted to account for equipment misalignment and unforeseen obstacles during construction.
- No special finishes are required with housings available in aluminum and stainless steel.
- Shielded cables along with the use of proper cable supports work together to withstand forces due to short circuits.
- Use of shielded cables cancels the external magnetic field generated by phase currents.
- The lightweight, welded rigid enclosures are able to be lifted by two men without the need for special heavy lifting equipment.
- The insulated conductors used are designed to withstand harsh outdoor environments, are not affected by moisture, and do not require heaters, filter breathers, or thermostats.
- Since Cable Bus are continuous, there are no power losses from splices and connections.
- Cable Bus have lower impedance and lower voltage drop due to proper phasing, spacing, and support if the conductors.

Risk & Mitigation Factors

There are associated risks with replacing the 5 KV Outdoor Bus Ducts with Cable Bus, which are summarized in the table below. The table also describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Installing the Cable Bus Ducts

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Safety incidents during the installation of the Cable Bus Ducts.	Adhere to project safety guidelines in accordance with the Federal & Industry Safety Standards during construction.	Medium - Medium	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Cable Bus

Cable Bus is an electrical busway assembly that consists of fully insulated, shielded conductors mounted in a ventilated metal housing with polymer cable supports that maintain cable phasing, spacing and short circuit protection.

Comparison of Alternatives

Core Team Member Ratings

	Safety During Construction	**Constructability During Ongoing Oil Deliveries**	**Ease of Operations**	**Ease of Maintenance**	**Sustainability**
	Most Important	*Most Important*	*Important*	*Important*	*Less Important*
Alternative A	*Excellent*	*Excellent*	*Excellent*	*Excellent*	*Good*
	Excellent	*Excellent*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Excellent*	*Good*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$901,784**	**$912,648**

Recommended Alternative

A. Cable Bus

Based on the screening process led by the Core Team Members that reviewed four possible alternatives, Alternative A was the only viable alternative selected to be studied that would meet the mission need and functional requirements. Therefore, Alternative A is the recommended preferred alternative.

BH-MM-596

Replace Onshore Section of Brine Disposal Pipeline

VCI Project Engineer: Brian Tuminello

Recommended Alternative:

Construct a New Appropriate Diameter On-Shore Portion of the Pipeline; Optimize New Line Size with New Brine Disposal Pumps and Motors

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The current mission requirement for Big Hill to meet the SPR Level I Brine Disposal rate is 225,000 barrels per day (225 MBD). The achieve this, the Brine Disposal pumps transfer brine to the Gulf of Mexico through a 14-mile-long, 48-inch diameter, steel pipeline.

Functional Requirements

The functional requirements for this Project is to assure that the Brine Disposal Pipeline will continue to support the Crude Oil Fill and Operational Mission of Big Hill Brine Disposal. The Pipeline must be able to be cleaned and inspected to determine its integrity.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Brian Tuminello	VCI, Project Engineer
Chris Vedros	FFPO, Manger Pipeline and Equipment Integrity

Team Members

Reza Zinolabedini	DOE, Lead General Engineer
Levi Gabre	DOE, Lead General Engineer
Laren Tushim	VCI, Mechanical Engineer
John Walker	VCI, Mechanical Engineer
Dave Wilkins	VCI, Lead Process Engineer
Janet Robert	FFPO, Director Facilities Design and Integrity
Lisa Eldredge	FFPO, Principal Operations Systems Engineer
John Guidry	FFPO, Site Director
Steven Crawford	FFPO, Site Mechanical Process Engineer
Danny Duff	FFPO, Site Maintenance Manager
Paul Riegert	FFPO, Site Construction Manager
Tony Deville	FFPO, Site Operations Manager

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation.

Weight: Most Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Important

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Less Important

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Less Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

This alternative would continue to operate the existing pipeline and conducting the same type of periodic testing and inspections to determine the integrity of the pipeline. Future inspections would indicate the trend data of localized areas of inspection and necessary repairs. The current program cannot assess nor assure the condition of the pipeline. This alternative is not recommended for further evaluation.

Viability: No Further Analysis

B. Construct a New Appropriate Diameter On-Shore Portion of the Pipeline

This alternative would include a new on-shore portion of the brine disposal pipeline and would assure a long term, high integrity on-shore portion of the brine disposal pipeline. Several considerations to be addressed are route, Gulf Intracoastal Waterway (GIWW) crossing, land acquisition, and tie-in at the beach. The mission requirements have significantly decreased from the original design of the existing pipeline. (The brine disposal pipeline was originally sized for 1,400,000 barrels per day.) The replacement would provide several different options regarding the material of construction including new steel, new alloy steel, non-metallic (HDPE), or internally lined piping.

This alternative is to replace the on-shore portion of the brine pipeline. Hydraulic analysis would dictate the pipeline size requirements and the replacement option would most likely result in a smaller line size. Various materials of construction and/or internal coatings could be analyzed, potentially providing superior corrosion resistance to that of the existing steel pipeline. Depending on the size of the new pipeline, it may

be possible to construct a new, appropriate diameter pipeline in the existing Right of Way (ROW) thus avoiding the requirement for land acquisition.

Viability: Continue Analysis

C. Construct a New Appropriate Diameter On-Shore Portion of the Pipeline; Optimize New Line Size with New Brine Disposal Pumps and Motors

This alternative would be the same as alternative B but it would optimize the new line size with new, appropriately sized brine disposal pumps, motors, and associated discharge valves and piping. The existing pumps and motors were designed for a very different mission and should be considered for replacement due to age and size / horsepower requirements.

This alternative would most likely be the costliest approach; however, it would assure the brine disposal system equipment meets the project functional requirements and assures the long term reliability and dependability of the new equipment. The existing brine disposal pumps are capable of much greater flow and pressure than what is required for the brine disposal mission. The existing 2,500 horsepower motors are reaching the end of their useful life and should be considered for replacement.

Viability: Continue Analysis

D. Clean and Inspect the Existing Pipeline to Determine Extent of Condition and Extent of Required Repairs and / or Replacement

This alternative would involve the use of an inspection “smart” pig to determine the condition of the pipeline. Significant cleaning would be required due to the anticipated amount of rust scale on the inside of the pipe. This would involve sending numerous pigs down the pipeline. A pig receiving tray would be required either at the beach crossing or the end of the pipeline in the Gulf of Mexico. Depending on the results of the pig run and pig data evaluation, the required extent of repairs and or replacement could be identified.

This alternative is feasible to determine the extent of condition of the existing pipeline and only address those areas needing attention. This inspection would most likely include the off-shore portion of the pipeline. This would involve the use of offshore marine equipment and underwater diver operations. There would be considerable expense in preparing the pipeline for an adequate inspection with no certainty of obtaining useful inspection results. If inspection data was deemed to be of good quality for integrity determination, verification efforts would be appropriate to validate the inspection results. The inspection data may necessitate some emergency based repairs if integrity data indicated pending failure or leak especially in the first 10 miles (on-shore portion) of the pipeline. SPR experience in a pipeline in this service and age has indicated that this line is near the useful end of life. Several repairs have already been made in certain sections of this pipeline.

Viability: No Further Analysis

E. Develop Brine Injection Wells for Brine Disposal

This alternative would require the feasibility analysis of drilling underground injection wells into an appropriate aquifer for disposal of brine. This approach would be similar to those used at the West Hackberry and Bayou Choctaw sites. Since the brine disposal requirements at Big Hill are currently only at 225 MBD, this approach may be viable. The facility for brine disposal wells would need to include the necessary piping, valving, lighting, well-pads, and acquisition of the required real estate.

This alternative would involve drilling and operating brine disposal wells similar to West Hackberry and Bayou Choctaw. The number of injection wells, depth, size, and location would need to be determined. By comparison to West Hackberry and Bayou Choctaw, it is anticipated that 12 – 15 wells would be required in order to achieve the design disposal rates. The expense of drilling this many wells alone would potentially make this alternative not cost effective. The Big Hill site is approximately 10 miles to the Gulf of Mexico and because of this proximity, it doesn’t make Brine Disposal Wells very desirable. Due to the intermittent nature and volumes of brine disposal requirements, i.e. batch mode, brine disposal wells become difficult to maintain and operate. The viability of this alternative is very dependent on obtaining information as to where

the disposal wells could be located. This would most likely result in the need to acquire the necessary property and permits for deep injection of brine.

Viability: No Further Analysis

F. Transfer Brine to 3rd Party for Disposal/Underground Injection

This alternative would be to contract with a 3rd party to provide assurance of the capability to dispose of brine at the required rates to support DOE Mission requirements. This would put the life cycle expense of operating disposal facilities onto a 3rd party but would also put the DOE in a position of being dependent on a 3rd party to support the on-going operational and mission requirements for brine disposal.

This alternative may be viable if DOE can reach agreement with a nearby disposal facility. This would create a dependence on a 3rd party for the capability and availability to support DOEs brine disposal requirements. Additionally, this alternative does not provide the reliability of brine disposal and introduces a concern of lack of competition for someone to sell brine to.

Viability: No Further Analysis

G. Construct a New Appropriate Diameter On-Shore Portion of the Pipeline using the existing 48-inch Pipeline as a Sleeve; Optimize New Line Size with New Brine Disposal Pumps and Motors.

This alternative is the same as Alternative **C** except the new line would be constructed using appropriately sized HDPE pipe installed inside of the existing 48-inch brine line which would be used as a casing. Additionally, new pumps, motors, and associated discharge valves and piping would be installed. Hydraulic analysis would dictate the pipeline size requirements and the replacement option would most likely result in a smaller line size. Based on the hydraulics the size of the new pipeline will be able to utilize the existing brine line as a casing and would eliminate the need for any new Right of Way (ROW) thus avoiding the requirement for land acquisition.

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A, D, E, and F are eliminated from further consideration. The remaining alternatives, B, C, and G are examined below as alternatives A, B, and C, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Construct a New Appropriate Diameter On-Shore Portion of the Pipeline

This alternative would include a new onshore portion of the brine disposal pipeline and would assure a long term, high integrity portion of the brine disposal pipeline. Several considerations to be addressed are route, Gulf Intracoastal Water Way (GIWW) crossing, land acquisition, and tie-in at the beach. The current mission requirements are significantly different from the original design of the existing pipeline. The replacement would provide several different options regarding the material of construction including new steel, new alloy steel, non-metallic (HDPE), or internally lined, steel piping. For this alternative, a new pipeline would be constructed and installed in a trench or directionally drilled adjacent to the existing pipeline presumably in the existing right of way while the existing pipeline remains in service.

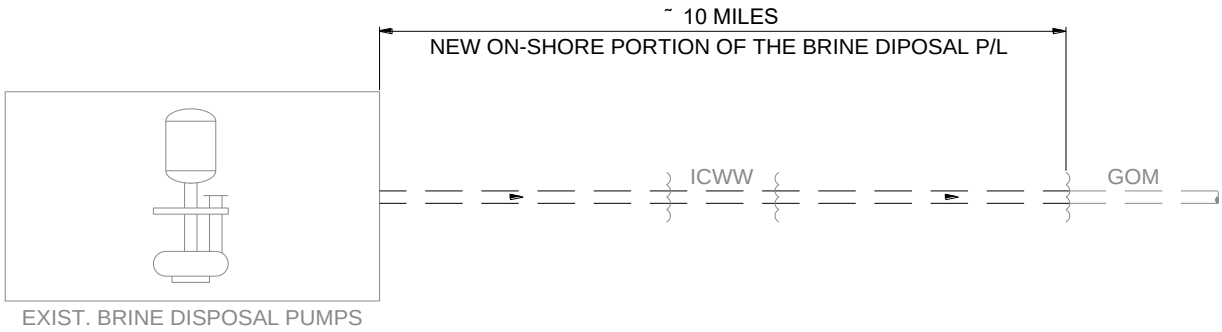

Figure 1 – New On-Shore Portion of Pipeline

Assumptions & Constraints

There is an assumption that the pipeline will be able to be excavated at the beach and an appropriate transition can be made to continue the use of the existing offshore portion of the pipeline. It is assumed that the pipeline from the point of tie-in to the end of diffuser section offshore has integrity. It is further assumed that the necessary construction equipment can be mobilized through-out the length of the pipeline route including the beach tie-in location. An important constraint for this and all alternatives is the amount of time that the Big Hill Site can manage cavern pressures within the design parameters and be without brine disposal capability. Preliminary design concept would suggest a 26-inch diameter, DR 13.5, High Density Polyethylene (HDPE) pipeline or a 24-inch lined, externally coated, carbon steel pipeline. Additionally, while the use of HDPE offers excellent corrosion resistance, there is currently no known method of conducting an integrity assessment.

Benefits & Effectiveness

This alternative provides an appropriately designed brine disposal system meeting the required 225,000 barrel per day brine disposal requirement. The replacement pipeline made of HDPE or lined, externally coated, carbon steel would offer excellent corrosion resistance and meet pressure requirements. The current brine disposal mission is very different from the mission of the original pipeline allowing the new pipeline to be a much smaller diameter pipeline.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Constructing New On-Shore Portion of the Brine Disposal Pipeline			
Risks	**Mitigation Strategy**	**Likelihood – Impact**	**Risk Code**
Delays in obtaining necessary right of way and permits to construct new pipeline.	Determine the best alternative and proceed with necessary approvals at earliest possible date.	Low – High	Low Risk Hazard
Existing pipeline and brine disposal system would be out of service for an extended period of time depending on route and final tie-ins.	Detail engineering design would optimize the pipeline routing from the main Big Hill Site to the beach.	High - Medium	Medium Risk Hazard

B. Construct a New Appropriate Diameter, On-Shore Portion of the Pipeline; Optimize New Line Size with New Brine Disposal Pumps and Motors

This alternative would be the same as alternative A but it would optimize the new line size with new, appropriately sized brine disposal pumps and motors. The existing pumps, motors, and associated discharge valves and piping were designed for a very different mission and should be considered for replacement due to age and size / horsepower requirements. For this alternative, a new pipeline would be constructed and installed in a trench or directionally drilled adjacent to the existing pipeline. Preliminary design concept would suggest a 26-inch, DR 13.5 HDPE pipeline or a 24-inch lined carbon steel pipeline with approximately 500 horsepower electric motor driven, vertical turbine pumps.

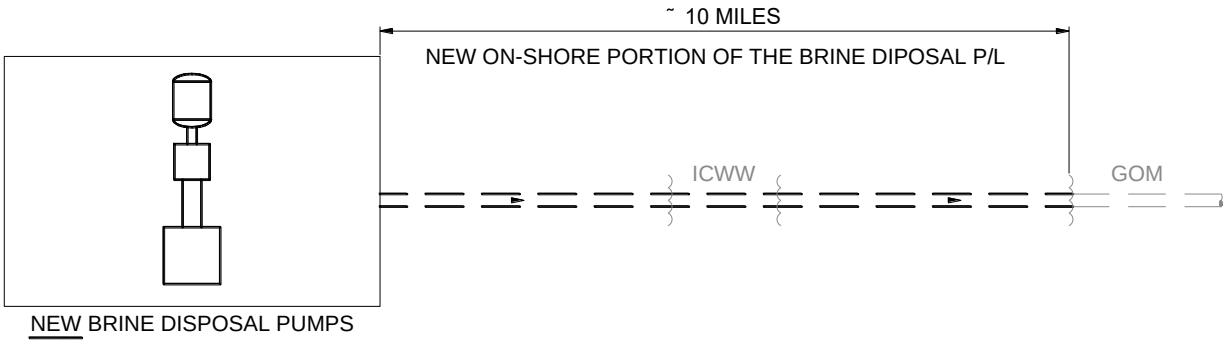

Figure 2 – New On-Shore Portion of Pipeline and New Brine Disposal Pumps

Assumptions & Constraints

There is an assumption that the pipeline will presumably be installed in the existing right of way while the existing pipeline remains in service; the pipeline will be able to be excavated at the beach and an appropriate transition can be made to continue the use of the existing offshore portion of the pipeline. It is assumed that the pipeline from the point of tie-in to the end of diffuser section offshore has integrity. It is further assumed that the necessary construction equipment can be mobilized through-out the length of the pipeline route including the beach tie-in location. The existing motors (2,500 HP) would most likely be replaced with much lower horsepower motors. The new piping and pump/motors would be purchased as Long Lead Equipment. An important constraint for this and all alternatives is the amount of time that the Big Hill Site can manage cavern pressures within the design parameters and be without brine disposal capability. Additionally, while the use of HDPE offers excellent corrosion resistance, there is currently no known method of conducting an integrity assessment.

Benefits & Effectiveness

This alternative provides an appropriately designed brine disposal system meeting the required 225,000 barrel per day brine disposal requirement. The replacement pipeline made of HDPE would offer excellent corrosion resistance and meet pressure and temperature requirements. The current brine disposal mission is very different from the mission of the original pipeline allowing the new pipeline and pumps to be a much smaller diameter pipeline.

Optimizing the brine disposal pumps and motors will result in reduced power requirements and cost and will assure the pump and motors are meeting the 25-year life expectancy requirements.

The new motors, pumps, and pipeline will be sized to meet the project functional requirements and the equipment and operating expense should be significantly smaller with lower operating costs. The new motors could be installed on the existing brine disposal platform and the electrical system reconfigured to support the new, smaller motors.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Constructing a New Appropriate Diameter On-Shore Portion of the Pipeline; Optimize New Line Size with New Brine Disposal Pumps and Motors			
Risks	**Mitigation Strategy**	**Likelihood – Impact**	**Risk Code**
Delays in obtaining necessary right of way and permits to construct new pipeline.	Determine the best alternative and proceed with necessary approvals at earliest possible date.	Low – High	Low Risk Hazard
Existing pipeline and brine disposal system (pipeline and pumps) would be out of service for an extended period of time depending on route and final tie-ins.	Detail engineering design would optimize the pipeline routing from the main Big Hill Site to the beach. Purchase of new pump/motors and piping as Long lead equipment.	High – Medium	Medium Risk Hazard

C. Construct a New Appropriate Diameter On-Shore Portion of the Pipeline using the existing 48-inch Pipeline as a Sleeve; Optimize New Line Size with New Brine Disposal Pumps and Motors

This alternative would be the same as alternative B but it would utilize the existing 48-inch brine disposal pipeline as a sleeve in which to install a new, smaller diameter pipeline and with new, appropriately sized (smaller) brine disposal pumps and motors. The existing pumps, motors, and associated discharge valves and piping were designed for a very different mission and should be considered for replacement due to age and size / horsepower requirements. Preliminary design concept would suggest a 26-inch, DR 13.5, HDPE pipeline with approximately 500 horsepower electric motor driven, vertical turbine pumps. Additionally, this diameter pipe could be installed (pulled) in 5,000 + foot sections at a time resulting in approximately 10 to 11 pull points for the 10 mile on-shore segment.

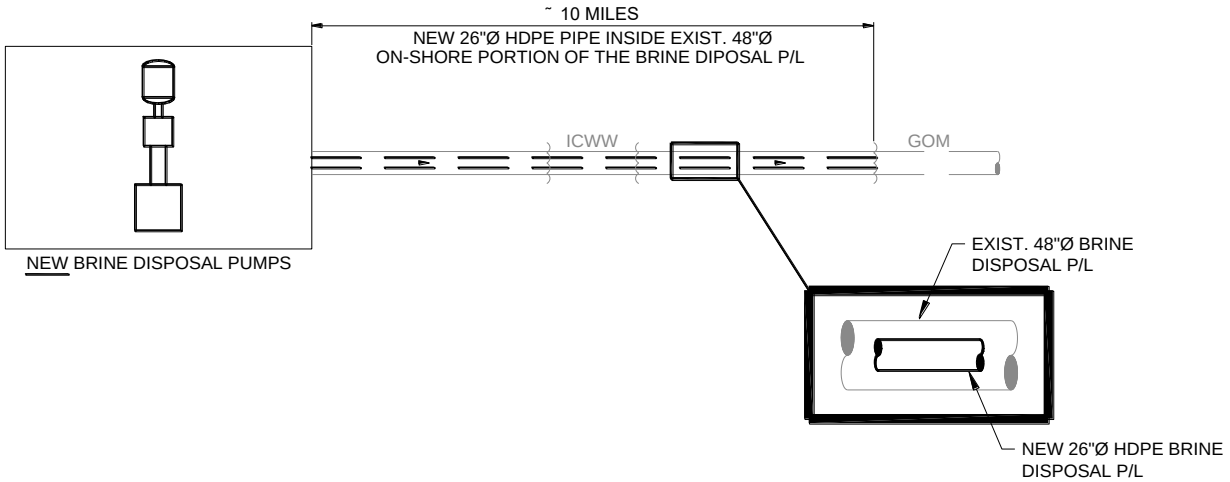

Figure 3 – New On-Shore Portion of Pipeline Inside of Existing Pipeline and New Brine Disposal Pumps

Assumptions & Constraints

There is an assumption that the pipeline will be able to be excavated at the beach and an appropriate transition can be made to continue the use of the existing offshore portion of the pipeline. It is assumed that the pipeline from the point of tie-in to the end of diffuser section offshore has integrity. It is further assumed that the necessary construction equipment can be mobilized through-out the length of the pipeline route including the beach tie-in location. The existing motors (2,500 HP) would most likely be replaced with much lower horsepower motors. The new piping and pump/motors would be purchased as Long Lead Equipment. An important constraint for this and all alternatives is the amount of time that the Big Hill Site can manage cavern pressures within the design parameters and be without brine disposal capability. Additionally, while the use of HDPE offers excellent corrosion resistance, there is currently no known method of conducting an integrity assessment.

Benefits & Effectiveness

This alternative provides an appropriately designed brine disposal system meeting the required 225,000 barrel per day brine disposal requirement. The replacement pipeline made of HDPE pipe would offer excellent corrosion resistance and can meet the flow and pressure requirements. This alternative has the added benefit of the avoidance of acquisition of any new land for new pipeline right of way and with the anticipated 5000-foot-long pull segments, the impact in the marsh area would be minimal.

Optimizing the brine disposal pumps and motors will result in reduced power requirements and cost and will assure the pump and motors are meeting the 25-year life expectancy requirements.

The new motors, pumps and pipeline will be sized to meet the project functional requirements and the equipment and operating expense should be significantly smaller with lower operating costs. The new pump

/ motors could be installed on the existing brine disposal platform and the electrical system reconfigured to support the new, smaller motors.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Constructing a New Appropriate Diameter On-Shore Portion of the Pipeline using the existing 48" Pipeline as a Sleeve; Optimize New Line Size with New Brine Disposal Pumps and Motors.

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
Difficulty in preparing excavated pits to install (pull) 5,000 foot sections of new HDPE pipeline.	Detailed Engineering Design will determine the best location for pull points of the new HDPE pipeline	Low - Medium	Low Risk Hazard
Existing pipeline and brine disposal system (pipeline and pumps) would be out of service for an extended period of time depending on actual pull lengths and final tie-ins.	Detail engineering design would optimize the pipeline pull segments from the main Big Hill Site to the beach. Purchase new pump/motors and piping as Long lead equipment. A construction strategy would need to be developed to conduct as many segment pulls concurrently as possible.	High – Low	Low Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Construct a New Appropriate Diameter On-Shore Portion of the Pipeline

This alternative would include a new onshore portion of the brine disposal pipeline and would assure a long term, high integrity portion of the brine disposal pipeline. Several considerations to be addressed are route, ICWW crossing, land acquisition and tie-in at the beach. The mission requirements are significantly different from the original design of the existing pipeline. The replacement would provide several different options regarding the material of construction including new steel, new alloy steel, non-metallic (HDPE) or internally lined piping.

B. Construct a New Appropriate Diameter On-Shore Portion of the Pipeline; Optimize New Line Size with New Brine Disposal Pumps and Motors

This alternative would be the same as alternative A but it would optimize the new line size with new, appropriately sized brine disposal pumps and motors. The existing pumps, motors and associated discharge valves and piping were designed for a very different mission and should be considered for replacement due to age and size / horsepower requirements.

C. Construct a New Appropriate Diameter On-Shore Portion of the Pipeline using the existing 48-inch Pipeline as a Sleeve; Optimize New Line Size with New Brine Disposal Pumps and Motors

This alternative would be the same as alternative B but it would utilize the existing 48-inch brine disposal pipeline as a sleeve in which to install a new, smaller diameter pipeline and with new, appropriately sized (smaller) brine disposal pumps and motors. The existing pumps and motors were designed for a very different mission and should be considered for replacement due to age and size / horsepower requirements. Early engineering analysis has indicated that 26-inch HDPE DR13.5 Pipe would meet the flow and pressure requirements and that this diameter pipe could be installed (pulled) in 5,000 + foot sections at a time.

Comparison of Alternatives

Core Team Member Ratings

	Ease of Maintenance	**Safety During Construction**	**Sustainability**	**Constructability During Ongoing Oil Deliveries**	**Ease of Operations**	**Security During Construction**
	Most Important	*Most Important*	*Important*	*Less Important*	*Less Important*	*Less Important*
Alternative A	*Good*	*Good*	*Marginal*	*Excellent*	*Good*	*Excellent*
	Good	*Good*	*Marginal*	*Excellent*	*Good*	*Excellent*
	Good	*Good*	*Good*	*Excellent*	*Good*	*Good*
Alternative B	*Excellent*	*Good*	*Marginal*	*Excellent*	*Good*	*Excellent*
	Excellent	*Good*	*Marginal*	*Excellent*	*Good*	*Excellent*
	Good	*Good*	*Good*	*Good*	*Good*	*Good*
Alternative C	*Good*	*Good*	*Good*	*Marginal*	*Good*	*Excellent*
	Excellent	*Good*	*Excellent*	*Adequate*	*Good*	*Excellent*
	Marginal	*Good*	*Good*	*Marginal*	*Good*	*Good*

Cost Comparison

	Total Estimated Cost (TEC)	Life Cycle Cost (LCC)
Alternative A	**$55,717,662**	**$56,631,958**
Alternative B	**$81,520,527**	**$81,752,659**
Alternative C	**$66,349,382**	**$66,581,514**

Recommended Alternative

B. Construct a New Appropriate Diameter On-Shore Portion of the Pipeline; Optimize New Line Size with New Brine Disposal Pumps and Motors

Based on the technical evaluation of the Core Team Members, Alternative B was rated overall higher on the evaluation criteria than Alternatives A and C. Alternative A has the lowest investment cost and life cycle cost while Alternative B has the highest. The key benefits to Alternative B over alternative A is the additional scope of replacing the aged pumps and motors along with the pipeline to ensure more sustainable operation of the brine disposal pipeline while providing the best solution to the system obtaining a 25-year design life. The key benefit to Alternative B over Alternative C is that the installation of the pipeline occurs without taking the existing pipeline out of service. Therefore, Alternative B is the recommended preferred alternative, with the benefits of the pumps and motors replacement and lack of impact to site operations outweighing the higher investment and life cycle cost.

BH-MM-597

Replace Raw Water Intake Pipeline

VCI Project Engineer: Brian Tuminello

Recommended Alternative:

Construct New Raw Water Pipeline that Extends Beyond the Raw Water Injection Pumps and Install New Pig Receiver

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I. PROJECT CONCEPT

Mission Need

The current mission requirement for Big Hill to meet the SPR Level I Drawdown rate is 1,100,000 barrels per day (1.1 MMBD). The achieve this, the Raw Water Intake pumps and pipeline are sized to meet the design point of 1.20 MMBD.

Functional Requirements

The functional requirements for this Project is to assure that the 5-mile-long Raw Water Pipeline will continue to support the Drawdown and Operational Mission of Big Hill. The Pipeline must be able to be cleaned and inspected to determine its integrity.

This Project is one component of a series of Projects to Assure the Drawdown Rate at Big Hill is in accordance with SPR Level I Criteria. Other projects that are part of the completed Drawdown System that are affected by this BH-MM-597 project are: BH-MM-611, BH-MM-1356, BH-MM-1357 and BH-MM-1338, 793.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Brian Tuminello	VCI, Project Engineer
Chris Vedros	FFPO, Manager Pipeline Equipment and Integrity

Team Members

Reza Zinolabedini	DOE, Lead General Engineer
Levi Gabre	DOE, Lead General Engineer
Laren Tushim	VCI, Mechanical Engineer
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Lisa Eldredge	FFPO, Principal Operations Systems Engineer
Tony Deville	FFPO, Manager Site Operations
John Guidry	FFPO, Site Director
Steven Crawford	FFPO, Mechanical Process Engineer
Danny Duff	FFPO, Manager Site Maintenance
Paul Riegert	FFPO, Manager Site Construction

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Most Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Most Important

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation.

Weight: Most Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

This alternative would continue to operate the existing pipeline and conduct periodic testing and inspections to determine the integrity of the pipeline. Future inspections would dictate the extent of pipeline repairs and / or replacement. The current inspection program cannot assure that pending failures would be detected in a timely manner to prevent an actual failure from occurring. This approach does not meet the project functional requirements.

Viability: No Further Analysis

B. Construct New Raw Water Pipeline

This alternative would replace the existing five-mile-long, 48-inch diameter raw water pipeline with a new, appropriate diameter pipeline connecting the raw water intake structure to the main site and would assure a long term, high integrity raw water pipeline. The route of the pipeline needs to be considered. The mission

need and functional requirements would be assured for the next 25 – 30 years in that a new pipeline is anticipated to last that length of time as the original pipeline. The replacement would provide several different options regarding the material of construction including new externally coated steel, new alloy steel, non-metallic (HDPE), or internally lined piping in order to provide corrosion protection. Depending on the size selected, a new pig launcher and receiver may be required. A new pipeline would need to be constructed parallel to the existing pipeline in order to conduct on-going operations (oil sales) during the construction period. This may result in the need for additional right of way acquisition.

This alternative is to replace the existing raw water pipeline. Hydraulic analysis would dictate the pipeline size requirements and may result in a smaller line size. Various materials of construction and / or internal coatings could be analyzed, potentially providing superior corrosion resistance to that of the existing steel pipeline. Depending on the size of the new pipeline, it may be possible to construct a new, appropriate diameter pipeline in the existing Right of Way (ROW) thus avoiding the requirement for land acquisition. If a new line size is recommended, a new pig launcher and receiver would be required also.

Viability: Continue Analysis

C. Clean and Inspect Existing Pipeline

This alternative would clean and inspect the existing pipeline to determine the condition of the pipeline and perform required repairs and/or replacement. This alternative would involve the use of an inspection “smart” pig to determine the condition of the pipeline. Significant cleaning would be required due to the anticipated amount of rust scale on the inside of the pipe. This would involve sending numerous cleaning pigs down the pipeline. Depending on the results of the inspection pig run and the inspection pig data evaluation, the required extent of repairs and or replacement could be identified.

This alternative is viable to determine the condition of the existing pipeline and only address those areas needing attention. There would be expense in preparing the pipeline for an adequate inspection and then addressing the repairs (if required). The inspection may necessitate some emergency based repairs if integrity data indicated pending failure or leak. If the line can be shown to have integrity for 20 or more years to come, the cost of replacing the pig launcher and receiver could be avoided.

Viability: Continue Analysis

D. Construct New Raw Water Pipeline that Extends Beyond the Raw Water Injection Pumps and Install New Pig Receiver

This alternative would replace the existing 5-mile-long, 48-inch diameter raw water pipeline and extend the pipeline an additional approximately 800 feet such that it extends beyond the end of the Raw Water Injection Pumps. This would result in a new, appropriate diameter pipeline connecting the raw water intake structure to the main site and would assure a long term, high integrity raw water pipeline. This alternative also installs a new Raw Water Pig Receiver beyond the last branch connection to the Raw Water Injection pumps. The route of the pipeline needs to be considered. The mission need and functional requirements are assured for the next 25 – 30 years. The replacement would provide several different options regarding the material of construction including new externally coated steel, new alloy steel, non-metallic (HDPE), or internally lined piping in order to provide superior corrosion protection. This configuration assures that all piping up to and beyond the last injection pump is periodically cleaned such that no sediment is allowed to build up and affect the integrity of the pipe with particular interest in the piping between the existing pig trap and the R/W Injection pump. A new pipeline would need to be constructed parallel to the existing pipeline in order to conduct on-going operations (oil sales) during the construction period. This may result in the need for additional right of way acquisition.

This alternative allows all Raw Water piping upstream of the Raw Water Injection pumps to be periodically cleaned via pigging and able to be inspected. A reconfiguration of the branch connections to the 7 Raw Water Injection pumps and any other process equipment would be required so that the connections do not come off the bottom of the header. Moving the branch connections to the top would prevent debris from pigging activities from entering the suction piping to the individual injection pumps.

Viability: Continue Analysis

E. Construct New Raw Water Pipeline that is Routed Through a Large Diameter Vessel

This alternative would replace the existing 5-mile-long, 48-inch diameter raw water pipeline and route the piping through a large diameter horizontal settling tank such that the velocity of the raw water could be reduced to less than 1.0 ft./sec to allow suspended solid material to settle out. The vessel would resemble a 10-foot diameter, 50 feet long section of pipe (settling tank) and would be located between the new Pig Receiver and the suction header to the R/W Injection Pumps. The settling tank would be equipped with a low point nozzle(s) and piping to the Brine disposal pond for periodic flushing and cleaning of the settling tank. The pipeline would be replaced with a new, appropriate diameter pipeline connecting the raw water intake structure to the main site and would assure a long term, high integrity raw water pipeline. The route of the pipeline needs to be considered. The mission need and functional requirements are assured for the next 25 – 30 years. The replacement would provide several different options regarding the material of construction including new steel, new alloy steel, non-metallic (HDPE), or internally lined piping in order to provide superior corrosion protection. Depending on the size selected, a new pig launcher and receiver may be required. A new pipeline would need to be constructed parallel to the existing pipeline in order to conduct on-going operations (oil sales) during the construction period. This may result in the need for additional right of way acquisition.

This alternative would maintain the similar configuration of the current system except the addition of the settling tank to trap the suspended sediment and debris that are in the raw water stream that is flowing to the injection pumps during pipeline pigging activities. Flow velocities in the piping to the injection pumps varies but may be as low as 1.13 feet per second. It has been observed that the sediment will settle out and stay inside the piping because of the low velocities. The settling tank would “trap” this sediment and the sediment could be forced to the brine disposal pond by way of appropriately sized piping in lieu of staying inside the R/W Injection suction pipe.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternative A is eliminated from further consideration. The remaining alternatives, B, C, D, and E are examined below as alternatives A, B, C, and D, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Construct New Raw Water Pipeline

This alternative would replace the existing 5-mile-long, 48-inch diameter raw water pipeline with a new, appropriate diameter pipeline connecting the raw water intake structure to the main site and would assure a long term, high integrity raw water pipeline. The route of the pipeline needs to be considered. The mission need and functional requirements would be assured for the next 25 – 30 years in that a new pipeline is anticipated to last that length of time as did the original pipeline. The replacement would provide several different options regarding the material of construction including new externally coated steel, new alloy steel, non-metallic (HDPE), or internally lined piping in order to provide superior corrosion protection. Depending on the size selected, a new pig launcher and receiver may be required. A new pipeline would need to be constructed parallel to the existing pipeline in order to conduct on-going operations (oil sales) during the construction period. This may result in the need for additional right of way acquisition. Preliminary Engineering analysis has suggested that a 42-inch diameter, externally coated steel pipeline with a new pipeline Pig Launcher and Receiver will provide the necessary flow and pressure requirements to the suction side of the Raw Water Injection Pumps.

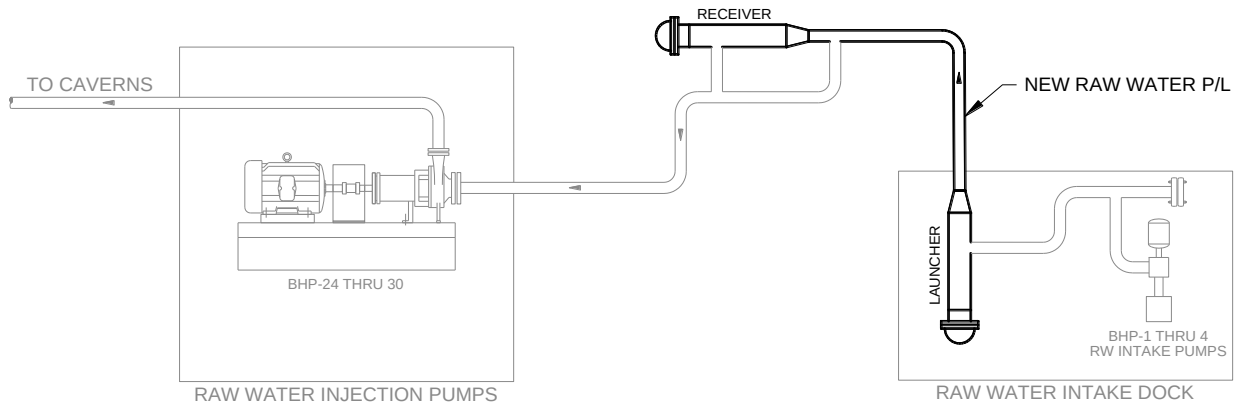

Figure 1 – New Raw Water Pipeline

Assumptions & Constraints

The primary assumptions for this alternative are that the necessary right of way and environmental permitting for the construction of the new pipeline are attainable. It is further assumed that new steel or other material is available to construct this pipeline and that sufficient labor is available to build this pipeline. It is recommended that the piping to construct this pipeline and new Pig Launcher / Receiver be procured as a long lead items. An issue or constraint associated with this alternative is that the debris that is removed from inside of the pipeline during pigging episodes needs to be disposed of in a manner that is not detrimental to the existing Big Hill Brine disposal ponds.

Benefits & Effectiveness

This alternative would meet the mission need and functional requirements and would assure the integrity of the pipeline for the next 25 years.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Constructing New Raw Water Pipeline			
Risks	**Mitigation Strategy**	**Likelihood – Impact**	**Risk Code**
Delays in obtaining necessary right of way and permits to construct new pipeline.	Determine the best alternative and proceed with necessary approvals at earliest possible date.	Low – High	Low Risk Hazard
Existing pipeline and raw water system would be out of service for an extended period of time depending on route and final tie-ins.	Detail engineering design would optimize the pig receiver location and pipe routing at the main Big Hill Site.	High – High	High Risk Hazard

B. Clean and Inspect Existing Pipeline

This alternative would clean and inspect the existing pipeline to determine the condition of the pipe and perform required repairs and/or replacement. This alternative would involve the use of an inspection “smart” pig to determine the condition of the pipeline. Significant cleaning would be required due to the anticipated amount of rust scale on the inside of the pipe. This would involve sending numerous cleaning pigs down the pipeline. Depending on the results of the inspection pig run and the inspection pig data evaluation, the required extent of repairs and or replacement could be identified.

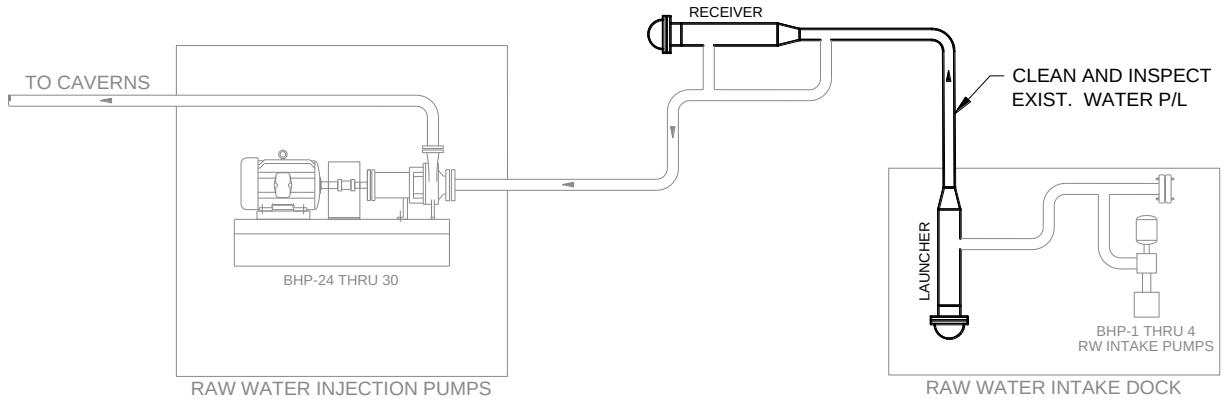

Figure 2 – Clean and Inspect Existing Pipeline

Assumptions & Constraints

One significant assumption is that the pipeline can be adequately cleaned and inspected in order to assure a thorough inspection to determine the condition. Additionally, an assumption of this proposal is that the integrity of the existing pipeline is found to be such that any required repairs would be minimal. Most of the 5 miles of the pipeline are in a marsh area and access to any affected areas is possible. Depending on the condition of the pipe, either repairs (sleeves) or short replacement pipe sections could address the defective area.

Benefits & Effectiveness

The potential benefits of this approach is the avoidance of a complete pipeline replacement cost and the least amount of time to repair. There is a certain level of uncertainty regarding the avoidance of replacement cost if the inspection reveals significant corrosion.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Cleaning and Inspecting Existing Pipeline

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
Inspection determines that pipeline requires replacement due to extent of condition.	In advance of inspection, perform detailed engineering for an AFC Design package to replace the pipeline.	High – High	High Risk Hazard
High water condition from seasonal weather events could delay repair efforts and increase repair costs.	If feasible, schedule any required repairs during stable weather months, ex. May, June, July.	High – High	High Risk Hazard

C. Construct New Raw Water Pipeline that Extends Beyond the Raw Water Injection Pumps and Install New Pig Receiver

This alternative would replace the existing 5-mile-long, 48-inch diameter raw water pipeline and extend the pipeline an additional approximately 800 feet such that it extends beyond the end of the Raw Water Injection Pumps. This would result in a new, appropriate diameter pipeline connecting the raw water intake structure to the main site and would assure a long term, high integrity raw water pipeline. This alternative also installs a new Raw Water Pig Receiver beyond the last branch connection to the Raw Water Injection pumps. The route of the pipeline needs to be considered. The mission need and functional requirements are assured for the next 25 – 30 years. The replacement would provide several different options regarding the material of construction including new externally coated steel, new alloy steel, non-metallic (HDPE), or internally lined piping in order to provide superior corrosion protection. This configuration assures that all piping up to and beyond the last injection pump is periodically cleaned such that no sediment is allowed to build up and affect the integrity of the pipe with particular interest in the piping between the existing pig trap and the R/W Injection pump. Preliminary Engineering analysis has suggested that a 42-inch diameter, externally coated, steel pipeline with a new pipeline Pig Launcher and Receiver will provide the necessary flow and pressure requirements to the suction side of the Raw Water Injection Pumps.

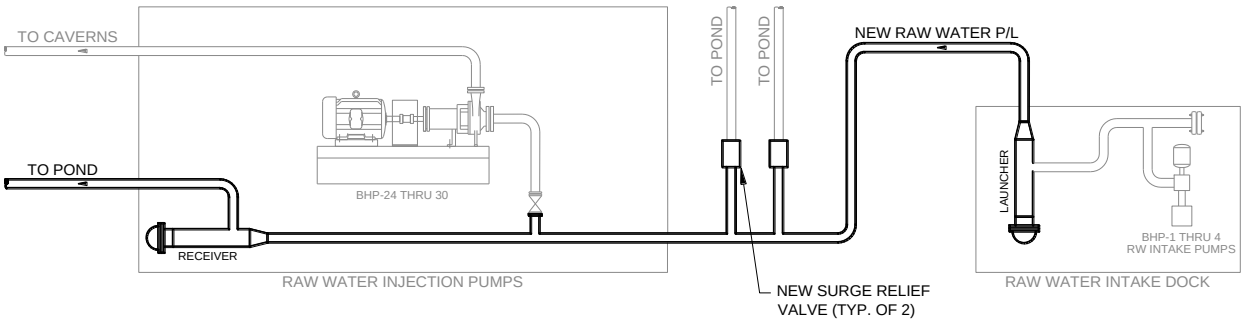

Figure 3 – New Raw Water Pipeline, New Pig Receiver

Assumptions & Constraints

The assumptions for this alternative include those as identified in Alternative A and that detail engineering can select an optimal location for the pig receiver and necessary piping for pipeline pigging water to the Big Hill Pond. It is recommended that the piping to construct this pipeline and new Pig Launcher / Receiver be procured as a long lead items. An issue or constraint associated with this alternative is that the debris that is removed from inside of the pipeline during pipeline cleaning / pigging episodes needs to be disposed of in a manner that is not detrimental to the existing Big Hill Brine disposal ponds. Pushing the pigging water / debris into the brine ponds would almost certainly necessitate brine pond cleaning in the future.

Benefits & Effectiveness

This alternative would meet the mission need and functional requirements and would assure the integrity of the pipeline for the next 25 years. Additionally, this alternative allows for periodic cleaning of the Raw Water Injection Pump suction manifold which has been shown to be a desired capability.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Constructing New Raw Water Pipeline that Extends Beyond the Raw Water Injection Pumps and Install New Pig Receiver			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Delays in obtaining necessary right of way and permits to construct new pipeline.	Determine the best alternative and proceed with necessary approvals at earliest possible date.	Low – High	Low Risk Hazard
Existing pipeline and raw water system would be out of service for an extended period of time depending on route and final tie-ins.	Detail engineering design would optimize the pig receiver location and pipe routing at the main Big Hill Site.	High – High	High Risk Hazard

D. Construct New Raw Water Pipeline that Includes Water Flow Routed Through a Large Diameter Vessel

This alternative replaces the existing 48-inch diameter raw water pipeline and routes the piping through a large diameter horizontal settling tank such that the velocity of the raw water could be reduced to less than 1.0 ft./sec allowing suspended solid material to settle out. The vessel would resemble a 10-foot diameter, 50-foot long section of pipe (settling tank) and would be located between the Pig Receiver and the suction header to the Raw Water Injection Pumps. The settling tank would be equipped with a low point nozzle(s) and piping to the Brine disposal pond for periodic flushing and cleaning of the settling tank. Preliminary Engineering analysis suggests a 42-inch externally coated steel pipeline with a new pipeline Pig Launcher and Receiver provide necessary flow and pressure to the suction side of the Raw Water Injection Pumps.

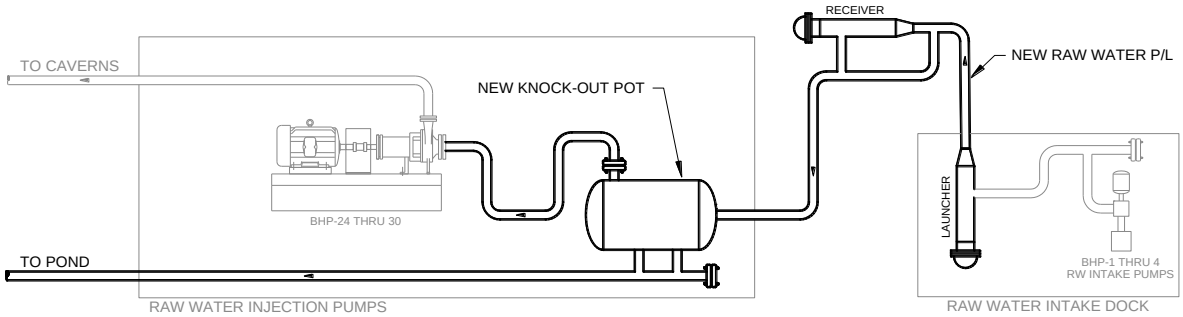

Figure 4 – New Raw Water Pipeline and New Knock-Out Pot

Assumptions & Constraints

The assumptions for this alternative include those as identified in Alternatives A and B and that detail engineering can select an optimal location for the settling tank and low point nozzle piping for water to the Big Hill Pond. It is recommended that the piping, Pig Launcher / Receiver to construct this pipeline, and new settling tank be procured as long lead items.

Benefits & Effectiveness

This alternative would meet the mission need and functional requirements and would assure the integrity of the pipeline for the next 25 years. Additionally, this alternative provides the benefit to settle out or capture any debris created during pipeline pigging activities to get to the suction header of the raw water injection pumps which has been shown to be a desired capability. This alternative would maintain the existing piping configuration to the Raw Water Injection pump pad and avoid any requirement to replace that piping.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Constructing New Raw Water Pipeline that Includes Water Flow Routed Through a Large Diameter Vessel

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Delays in obtaining necessary right of way and permits to construct new pipeline.	Determine the best alternative and proceed with necessary approvals at earliest possible date.	Low – High	Low Risk Hazard
Existing pipeline and raw water system would be out of service for an extended period of time depending on route and final tie-ins.	Detail engineering design would optimize the pig receiver location and settling tank location and pipe routing at the main Big Hill Site.	High – High	High Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Construct New Raw Water Pipeline

This alternative would replace the existing 48-inch diameter raw water pipeline with a new, appropriate diameter pipeline connecting the raw water intake structure to the main site and would assure a long term, high integrity raw water pipeline. Several considerations to be addressed are route. The mission requirements are assured for the next 25 – 30 years. The replacement would provide several different options regarding the material of construction including new steel, new alloy steel, non-metallic (HDPE), or internally lined piping in order to provide superior corrosion protection. Depending on the size selected, a new pig launcher and receiver may be required. A new pipeline would need to be constructed parallel to the existing pipeline in order to conduct on-going operations (oil sales) during the construction period. This may result in the need for additional right of way acquisition.

B. Clean and Inspect Existing Pipeline

Clean and inspect the existing pipeline to determine the extent of condition and perform required Repairs and/or Replacement. This alternative would involve the use of an inspection "smart" pig to determine the condition of the pipeline. Significant cleaning would be required due to the anticipated amount of rust scale on the inside of the pipe. This would involve sending numerous cleaning pigs down the pipeline. Depending on the results of the pig run and the smart pig data evaluation, the required extent of repairs and or replacement could be identified

C. Construct New Raw Water Pipeline that Extends Beyond the Raw Water Injection Pumps and Install New Pig Receiver

This alternative would replace the existing 48-inch diameter raw water pipeline and extend the pipeline beyond the end of the Raw Water Injection Pumps with a new, appropriate diameter pipeline connecting the raw water intake structure to the main site and would assure a long term, high integrity raw water pipeline. This alternative also installs a new Raw Water Pig Receiver beyond the last branch connection to the Raw Water Injection pumps. Several considerations to be addressed are route. The mission requirements are assured for the next 25 – 30 years. The replacement would provide several different options regarding the material of construction including new steel, new alloy steel, non-metallic (HDPE), or internally lined piping in order to provide superior corrosion protection. This configuration assures that all piping up to and beyond the last injection pump is periodically cleaned such that no sediment is allowed to build up and affect the integrity of the pipe with particular interest in the piping between the existing pig trap and the R/W Injection pump.

D. Construct New Raw Water Pipeline that is Routed Through a Settling Tank

This alternative would replace the existing 48-inch diameter raw water pipeline and route the piping through a large diameter horizontal settling tank such that the velocity of the raw water could be reduced to less than 1.0 ft. / sec. to allow suspended solid material to settle out. The vessel would resemble a 10-foot diameter by approximately 50-feet long section of pipe and would be located between a new, relocated Pig Receiver and the suction header to the R/W Injection Pumps. The settling tank would be equipped with a low point nozzle(s) and piping routed to the Brine disposal pond for periodic flushing and cleaning of the knock out pot. The piping would be replaced with a new, appropriate diameter pipeline connecting the raw water intake structure to the main site and would assure a long term, high integrity raw water pipeline.

Comparison of Alternatives

Core Team Member Ratings

	Constructability During Ongoing Oil Deliveries	Sustainability	Ease of Operations	Ease of Maintenance	Safety During Construction	Security During Construction
	Most Important	*Most Important*	*Most Important*	*Most Important*	*Most Important*	*Important*
Alternative A	*Excellent*	*Adequate*	*Excellent*	*Excellent*	*Good*	*Good*
	Excellent	*Adequate*	*Good*	*Excellent*	*Good*	*Good*
	Excellent	*Excellent*	*Excellent*	*Good*	*Good*	*Good*
Alternative B	*Marginal*	*Good*	*Excellent*	*Good*	*Good*	*Good*
	Good	*Good*	*Good*	*Good*	*Good*	*Good*
	Marginal	*Marginal*	*Marginal*	*Marginal*	*Marginal*	*Marginal*
Alternative C	*Excellent*	*Adequate*	*Excellent*	*Excellent*	*Good*	*Good*
	Excellent	*Good*	*Excellent*	*Excellent*	*Good*	*Good*
	Good	*Excellent*	*Excellent*	*Excellent*	*Good*	*Good*
Alternative D	*Excellent*	*Adequate*	*Excellent*	*Excellent*	*Good*	*Good*
	Excellent	*Good*	*Excellent*	*Excellent*	*Good*	*Good*
	Excellent	*Excellent*	*Excellent*	*Good*	*Good*	*Good*

Cost Comparison

	Total Estimated Cost (TEC)	Life Cycle Cost (LCC)
Alternative A	**$162,977,521**	**$163,163,842**
Alternative B	**$3,110,177**	**$3,648,216**
Alternative C	**$167,098,827**	**$167,329,693**
Alternative D	**$167,082,031**	**$167,747,964**

Recommended Alternative

C. Construct New Raw Water Pipeline that Extends Beyond the Raw Water Injection Pumps and Install New Pig Receiver

Based on the technical evaluation of the Core Team Members, Alternative B was rated so low with several marginal ratings, that it should have been eliminated from contention as non-viable during the screening process in the identification of alternatives phase based on its high potential not to meet mission needs and functional requirements. Therefore, the selection of the recommended preferred alternative is made from the remaining Alternatives A, C and D.

Based on the technical evaluation of the Core Team Members, Alternative C and D were rated essentially equally and both of these higher than Alternative A. Alternative A had slightly lower initial and life cycle cost because Alternatives C and D include additional scope that provides a more systematic solution to the mission need and functional requirements given recent issues with integrity of the raw water intake pipeline. Alternative C and D have essentially the same investment costs, while Alternative C has the lower life cycle cost. Therefore, based on the roughly equal ratings and investment costs but lower life cycle costs, Alternative C is the recommended preferred alternative.

BH-MM-611

Replace Crude Oil Injection Pump Motors and Skids

VCI Project Engineer: Brian Tuminello

Recommended Alternative:

Replace Pump and Motor on New Skid Base; Repair/Revise Concrete Base

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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B. Replace Pump and Motor on New Skid Base; Repair/Revise Concrete Base 5

VI. ALTERNATIVE SELECTION 6

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Core Team Member Ratings 6

Cost Comparison 6

Recommended Alternative 7

I. PROJECT CONCEPT

Mission Need

The Big Hill Crude Oil Injection Pumps/Motors are critical equipment for crude oil fill, cavern to cavern transfers and Drawdown Operations. The Big Hill Site mission is to deliver 1,100,000 barrels per day of oil through a 36-inch crude oil pipeline to Sun terminal. The Big Hill SPR site is equipped with 6 crude oil pumps each capable of providing 280,000 barrels per day of crude oil.

Functional Requirements

The functional requirement of this project is to assure the reliability and readiness of the 6 crude oil pumps and electric motor drivers. The electric motor driver of each of these pumps has had a history of high maintenance costs and frequent rebuilds. Additionally, the original manufacturer of the motors (Louis-Allis) is no longer in business. Previous attempts to replace similar motors have been unsuccessful without major pump/motor skid modifications or the use of a massive adaptor plate. This project is to evaluate the alternatives available to assure dependable, reliable motors and skid bases are available for the Big Hill Crude oil pumps. Modified or new pump/motor bases shall assure that the proposed design allows for safe installation and ease of maintenance.

This Project is one component of a series of Projects to Assure the Drawdown Rate at Big Hill is in accordance with SPR Level I Criteria. Other projects that are part of the completed Drawdown System that are affected by this BH-MM-611 project are: BH-MM-597, BH-MM-1356, BH-MM-1357 and BH-MM-1338, 793.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Brian Tuminello	VCI, Project Engineer
Lisa Eldredge	FFPO, Principal Operations Systems Engineer

Team Members

Reza Zinolabedini	DOE, Lead General Engineer
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Tony Deville	FFPO, Site Operations Manager
Steven Crawford	FFPO, Site Mechanical Process Engineer
Marty Loftin	FFPO, Site Maintenance Supervisor
Paul Riegert	FFPO, Site Construction Manager
Paul Bonin	FFPO, Site Maintenance Supervisor

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations.

Weight: Most Important

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Most Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration.

Weight: Most Important

Safety During Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation.

Weight: Most Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Important

Security During Construction

The selected alternative when implemented will be able to be constructed with minimal to zero impacts to Site Security detection systems.

Weight: Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

This alternative would continue to maintain the existing motors and skid bases through appropriate vendors and repairs. This alternative does not meet the projects functional requirements and is not recommended for further evaluation.

Viability: No Further Analysis

B. Replace Electric Motor and Steel Skid Base

Replace the existing electric motor driver and steel frame skid base with a new electric motor driver and new steel skid base. This alternative would provide new, current technology, efficient motors that would be designed for a 25-year life. The electric motor horsepower (and associated power cables) would need to be evaluated but is expected to be nearly the same as the existing motor. Cable testing would need to determine if the existing cables need replacement.

This alternative meets the mission need and functional requirements providing dependable, reliable equipment. This alternative is recommended for further evaluation.

Viability: Continue Analysis

C. Replace Electric Motor Driven Pumps with Diesel Engine Driven Pumps

This alternative would replace the six existing pumps with new, skid mounted, diesel engine driven pumps. The diesel engine drivers would need a fuel source and maintenance requirements.

This alternative would require extensive infrastructure revisions including electric utility revision, fuel storage considerations, emission permit considerations and several others considerations. This alternative is not recommended for further evaluation.

Viability: No Further Analysis

D. Replace Pump and Motor on New Skid Base; Repair/Revise Concrete Base

This alternative assures that the entire pump / motor / skid base and concrete foundation will be dependable and reliable for a 25-year service life. This alternative is an enhancement to alternative **B** and would be the most prudent approach to assuring the long term reliability of the crude oil pumps.

This alternative would be meet the mission need and functional requirements and would provide the 25-year service life that is desired. Depending on revisions to the pump, electric service revisions may be required including cable replacement and / or motor service (MCC) revision. This alternative may result in the costliest approach but provides the longest term dependability and reliability. This alternative is recommended for further evaluation.

Viability: Continue Analysis

E. Replace Motor Only; Re-Use Skid Base and Pump

This alternative would replace the electric motor driver with a new, current design, efficient electric motor and would most likely require modifications to the existing skid base. This alternative would not achieve the projects functional requirements as it could not be determined if the existing skid base for the pumps would be dependable for 25 years of service life.

This alternative would not assure the reliability of the skid base and would most likely result in excessively high maintenance cost to maintain the operational condition of the crude oil pumps and motors. Additionally, the existing skid base may not be dependable for a 25-year service life. Consequently, this alternative does not meet the project functional requirement. This alternative is not recommended for further evaluation.

Viability: No Further Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A, C, and E are eliminated from further consideration. The remaining alternatives, B and D are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Replace Electric Motor and Steel Skid Base

This alternative would provide new, current technology, efficient motors that would be designed for a 25-year life. The electric motor horsepower (and associated power cables) would need to be evaluated but is expected to be nearly the same as the existing motor. Cable testing would need to determine if the existing cables need replacement. A hydraulic analysis of the Big Hill site crude oil and Raw Water system had indicated that the current specification for the crude oil pumps is adequate to support the mission requirements.

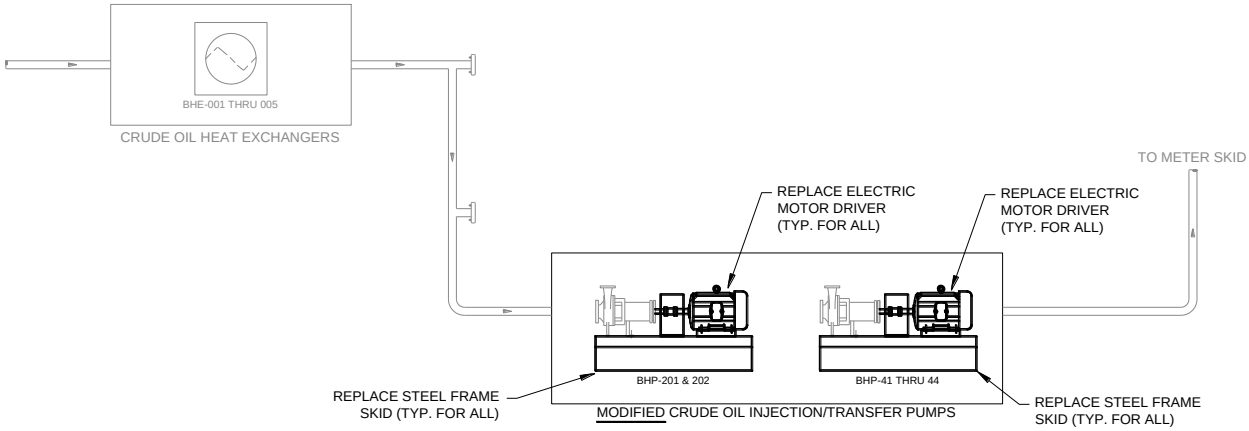

Figure 1 – Replace Electric Motor and Steel Skid Base

Assumptions & Constraints

The key assumption for this alternative is that the concrete base that the steel skid base is attached to will only need to be minimally repaired during the new skid base installation. If actual conditions are found to be different, significant time would be required to determine the extent of concrete repair requirements.

Benefits & Effectiveness

This alternative would most likely result in the least cost option of all alternatives identified. Motor and skid base replacement could be performed one pump at a time while not impacting the remaining pumps or drawdown capability.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing Electric Motor and Steel Skid Base

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
New motor and skid base will require extensive pump / piping modification.	Motor and skid base design will need to be coordinated with existing piping configuration.	Medium – High	Medium Risk Hazard
Existing concrete base will require extensive repair during steel skid base installation resulting in construction schedule delays.	Evaluate concrete condition and amend construction scope accordingly.	High – High	High Risk Hazard

B. Replace Pump and Motor on New Skid Base; Repair/Revise Concrete Base

This alternative assures that the entire pump / motor / skid base and concrete foundation will be dependable and reliable for a 25-year service life. This alternative is an enhancement to alternative A and would be the most prudent approach to assuring the long term reliability of the 6 crude oil pumps. A hydraulic analysis of the Big Hill site crude oil and Raw Water system had indicated that the current specification for the crude oil pumps is adequate to support the mission requirements.

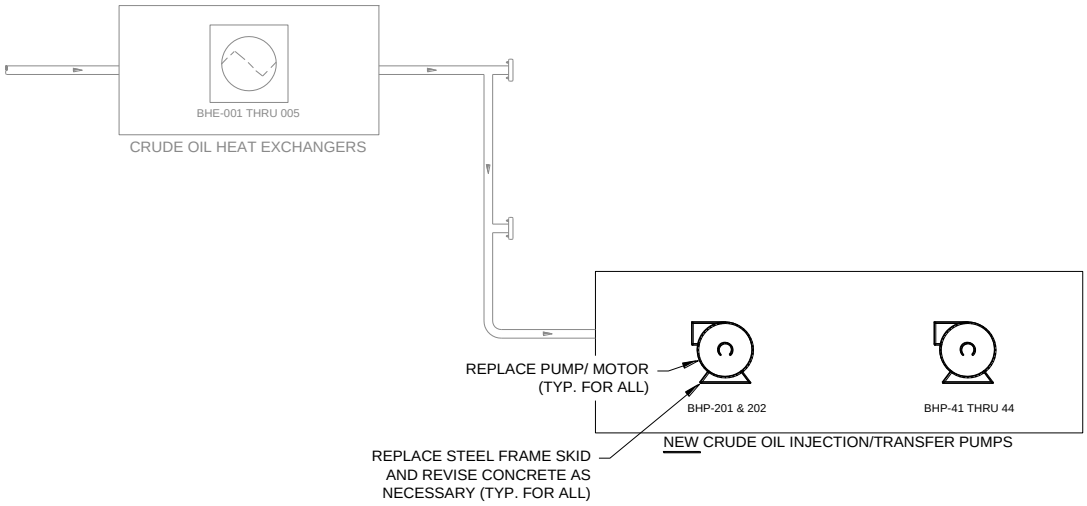

Figure 1 – Replace Pump, Motor, and Steel Skit Base

Assumptions & Constraints

The key assumption to this alternative is that a new pump / motor meeting the existing hydraulic requirements will physically fit in existing space provided on the High Pressure Pump pad without any interference from existing structures or peripheral equipment. Additionally, it is assumed that the concrete base that the steel skid base is attached to will only need to be minimally repaired during the new skid base installation. The new pump / motor sets would be procured as Long Lead Equipment.

Benefits & Effectiveness

This alternative would result in a planned, well defined, pump / motor replacement and concrete foundation design meeting the 25-year design life.

Risk & Mitigation Factors

There are associated risks with this alternative which are summarized in the table below. The table describes the likelihood of occurrence at the site, along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies Replacing Pump and Motor on New Skid Base; Repair/Revise Concrete Base

Risks	Mitigation Strategy	Likelihood – Impact	Risk Code
Replacement of existing pumps with new pumps will result in longer “Out-of-Service” period	The new crude oil pumps and motors could be planned to be replaced one at a time to mitigate any drawdown impairments.	High – High	High Risk Hazard
New pumps will result in larger motor H.P. resulting in larger starter capability	Evaluate / determine largest H.P. capability from existing starters and change or modify as required.	Medium – High	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Replace Electric Motor and Steel Skid Base

This alternative would provide new, current technology, efficient motor that would be designed for a 25-year life. A hydraulic analysis of the Big Hill site crude oil and Raw Water system had indicated that the performance of the crude oil pumps is adequate to support the mission requirements.

B. Replace Pump and Motor on New Skid Base; Repair/Revise Concrete Base

This alternative assures that the entire pump / motor / skid base and concrete foundation will be dependable and reliable for a 25-year service life. This alternative is an enhancement to alternative A and would be the most prudent approach to assuring the long term reliability of the crude oil pumps. A hydraulic analysis of the Big Hill site crude oil and Raw Water system had indicated that the crude oil pumps are adequate to support the mission requirements and thus the new motors would be nearly equal to that of the existing motors.

Comparison of Alternatives

Core Team Member Ratings

	Constructability During Ongoing Oil Deliveries	**Ease of Operations**	**Ease of Maintenance**	**Safety During Construction**	**Sustainability**	**Security During Construction**
	Most Important	*Most Important*	*Most Important*	*Most Important*	*Important*	*Important*
Alternative A	*Excellent*	*Good*	*Adequate*	*Excellent*	*Good*	*Good*
	Excellent	*Good*	*Adequate*	*Excellent*	*Good*	*Good*
	Marginal	*Good*	*Adequate*	*Good*	*Good*	*Good*
Alternative B	*Excellent*	*Excellent*	*Excellent*	*Excellent*	*Good*	*Good*
	Excellent	*Good*	*Adequate*	*Excellent*	*Good*	*Good*
	Marginal	*Excellent*	*Excellent*	*Good*	*Excellent*	*Good*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$10,598,051**	**$11,400,944**
Alternative B	**$13,051,535**	**$13,333,781**

Recommended Alternative

B. Replace Pump and Motor on New Skid Base; Repair/Revise Concrete Base

Based on the technical evaluation of the Core Team Members, Alternative B was clearly rated equal or superior on all evaluation criteria. Alternative A has a lower investment cost and life cycle cost. The differential in cost is the increased initial cost to replace the pump and repair the foundation in Alternative B, which provides a better long-term solution. This is evidenced by the increased maintenance costs in Alternative A and the higher sustainability, maintenance, and operations ratings for Alternative B. Therefore, Alternative B is the recommended preferred alternative, with the benefits of sustainability, operability and maintainability outweighing the higher investment cost.

BH-MM-670

Site Building Upgrades (Phase 2) (E2P2)

VCI Project Engineer: Corb Elsbury

Recommended Alternative:

This project has been issued as Approved for Construction (AFC)

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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VI. ALTERNATIVE SELECTION 3

AFC Cost 3

I. PROJECT CONCEPT

Mission Need

Several of the Big Hill site structure components are beyond life cycle replacement; these upgrades will keep them in good repair and protect them from moisture intrusion. The current Approved for Construction (AFC) engineering package developed is suitable for a contractor to perform the removal, installation, construction, and/or repair of various wall panels, siding, windows, and roofs.

Functional Requirements

SPR Level 1 Criteria requires the maintenance program to ensure facilities meet or exceed their design life requirements. The following DOE approved specifications provide the functional requirements for each design detail of this Approved for Construction project:

- 02050 Demolition of Facilities
- 09901 Painting for Buildings
- 13121 Pre-Fabricated Industrial/Commercial Metal Buildings
- 16030 Field Testing of Systems
- 16111 Conduit
- 16450 Grounding
- 16670 Lightning Protection Systems
- DOE Cool Roof methods/guidance

II. PROCESS

Alternatives Analysis Plan

The Analysis of Alternatives (AoA) Process Plan is not applicable to projects with detailed design packages issued to DOE as Approved for Construction.

This document outlines completed design Scope of Work for BH-MM-670

III. SELECTION CRITERIA

Formal selection criteria are not applicable to projects with detailed design packages issued as AFC.

IV. ALTERNATIVES IDENTIFICATION

Alternative Identification is not applicable to projects with detailed design packages issued as AFC.

V. ALTERNATIVES ANALYSIS

Alternative Analysis is not applicable to projects with detailed design packages issued as AFC. The AFC detailed design identified and outlined the following scope of work:

<u>Administration Building No. 800</u>: Furnish and install 3M Ultra 8mm S800 film, or approved equal, impact resistant film on interior face of existing glazing of all windows, doors, and side lites, in accordance with the manufacturer's instructions. Materials to meet Missile Level C. Reseal all exterior louver frames and flashing.

Control Center Building No. 801: Furnish and install 3M Ultra 8mm S800 film, or approved equal, impact resistant film on interior face of existing glazing of all windows, doors, and side lites, in accordance with the manufacturer's instructions. Materials to meet Missile Level C.

Maintenance/Warehouse Building No. 802: Replace designated existing corroded steel wall panels and all existing translucent fiberglass wall panels with new components to match the existing panels in profile, gauge and color. All new screws shall be stainless steel self-drilling type with neoprene washers. Materials shall carry a 20-year warranty against panel failure. Furnish and install 3M Ultra 8mm S800 film, or approved equal, impact resistant film on interior face of exterior and interior glazing of windows, doors, and side lites of the building, in accordance with the manufacturer's instructions. Materials to meet Missile Level C.

Tool Room Building No. 803: Prime and coat entire roof, including roof vent curbs, and ridge caps, along with all miscellaneous flashing with reflective coating system that meets the "cool roof" requirements. Coating system shall meet DOE Specifications. Apply in accordance with the coating manufacturer's instructions. Reseal all roof penetrations including but not limited to exhaust fan curbs and ridge caps with sealant compatible with roof coating system.

Fire Water Pump Building No. 810: Replace the bottom 3 feet of designated wall panels and screws with panels of the same gauge and profile as the existing panels. Include all associated trim and flashing materials. Match the existing building panel color. Screws shall be stainless steel self-drilling type with neoprene washers.

Laydown Storage Building No. 812: Replace designated wall, roof panels and screws with panels of the same gauge and profile as the existing components. Match the existing building panel color. Screws shall be stainless steel self-drilling type with neoprene washers. Replace designated roof panels and associated trim and flashing. Replaced roof components shall meet "cool roof" requirements.

Security Operations Center (SOC) Building No. 815: Remove all existing exterior finish insulating system (EFIS) down to the existing concrete masonry units.

Prepare existing CMU wall, furnish and install rubberized damp proofing for CMU walls. Furnish and install new closed cell pre-insulated metal wall panels. Panel exterior finish shall be Centria, Versacor Ultra finish, or approved equal. All replacement insulated pre-finished metal panels shall carry a 20 year "no dollar limit" NDL warranty.

Furnish and install 3M Ultra 8mm, S800 film, or approved equal, impact resistant film on interior face of the exterior glazing of all windows, doors, and side lites, in accordance with the manufacturer's instructions. Replace damaged/cracked glazing "in-kind" on front door. Materials to meet Missile Level C. Clean existing main roof with a cleaning system approved by the roof coating manufacturer for this particular roofing system. Replace front canopy roof system down to the metal deck and furnish and install new Duro-last PVC, single ply roofing system "white" over new rigid tapered insulation system. New roofing system to meet 152 mph wind load. Insulation shall be fastened with screws recommended by the roofing manufacturer for the wind load specified. Roof system shall meet "cool roof" requirements. Also replace all scupper flashing systems and cant strips. All new flashing and fasteners shall be stainless steel.

Grade the north side of the building and slope area to drain to existing ditch. Finish grade all disturbed areas and reuse/reinstall St. Augustine sod, with full coverage. Grade new swale at a minimum of 1/8" per foot slope.

Communications Building at RWIS No. 819: Furnish and install new concealed fastener type stainless steel roof and wall panel system, including furring channels and stainless steel self-drilling screws over existing fiberglass wall and roof system. Seal any holes in fiberglass prior to installing new stainless steel systems. New roof system shall meet "cool roof" requirements. Refer to new drawing details.

FIB Building No. 8: Furnish and install 3" thick isocyanurate closed cell insulation in areas of conduit penetrations and rectangular non-insulated areas under the structural floor.

VI. ALTERNATIVE SELECTION

Alternative Selection is not applicable to projects with detailed design packages issued as AFC.

BH-MM-670 Scope of Work is outlined in Section V.: Alternatives Analysis of this document.

AFC Cost

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
BH-MM-670	**$899,059**	**$1,013,027**

BH-MM-750

Upgrade ADAS System Servers and Workstations

VCI Project Engineer: Corb Elsbury

Recommended Go Project:

Upgrade/Replace Existing ADAS Servers and Workstations

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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VI. ALTERNATIVE SELECTION 7

Recommended Go Project 7
Cost 7

I. PROJECT CONCEPT

Mission Need

The servers, workstations and other hardware components that comprise the ADAS system on the SPR must be replaced every 4-5 years in order to maintain hardware and operating capability Upgrading the applicable Alarm Display and Annunciation System (ADAS) servers and workstations at the Big Hill, Texas SPR site is recommended.

Functional Requirements

The SPR ADAS assessment system must meet the Department of Energy (DOE) Order 473.3 A. and SPR Level III Criteria, Section 13.12 requirements (Intrusion Detection and Assessment Systems). Additionally, the system upgrade must meet DOE Program Cyber Security Plan (PCSP) and NIST-800-53, Security and Privacy Controls for Federal Information Systems and Organizations.

- Upgrades to the latest generation applicable servers and workstations; ergonmics shall be considered in detailed design.
- Shall augment perimeter protection.
- Shall allow for rapid assessment of nuisance alarms to reduce response degradation by PF.
- Upgrades to the ADAS shall include the new ARINC Advanced Information Management (AIM) systems.
- Computer systems shall be capable of continuous patching.
- Required to have auxiliary or uninterrupted power.
- Upgrades to the ADAS shall include workstation hardware compatible with the new operating system.
- Replace the NICE audio logger with a comparable system that will operate on currently-supported Microsoft operating systems.
- System must interface with DOE current badging system.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for Go/No Go Projects has been standardized for all Go/No Go AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Corb Elsbury	VCI, Project Engineer
Marc Gross	FFPO, Manager Design Engineering

Team Members

Jerry Packard	DOE, Security Officer, Security and Emergency Division
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Hernaldo Carpio	DOE, Site Engineer
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Randy Bridges	FFPO, Director – Process and Security
Todd Demaris	FFPO, Sr. Protection and Physical Security
John Guidry	FFPO, Big Hill Site Site Director
Steven Crawford	FFPO, Site Mechanical Process Engineer
Barton Smith	FFPO, Site Security Specialist
Paul Riegert	FFPO, Manager Site Construction

III. SELECTION CRITERIA

Formal selection criteria will not be applicable in a Go/No Go Project.

IV. ALTERNATIVES IDENTIFICATION

Alternatives Identification is not applicable in a Go/No-Go Project.

V. ALTERNATIVES ANALYSIS

The current ADAS system components were procured in 2010. Servers, hardware, and workstation components that comprise the ADAS system must be upgraded every four to five years to maintain system capacity. Assessment capabilities will continue to degrade to the point of SPR failure to meet the DOE Order 473.3 A. requirements.

Failure to replace these systems will result in obsolete systems that are providing physical security measures on the SPR. Use of servers and workstations beyond their life cycle will result in the lack of available security patches and upgrades; creating significant risk to the ADAS system, a DOE Risk Management Implementation Plan Requirement (RMAIP) violation.

The below analyses provide the research and technical information gathered by the AoA Team.

A. Upgrade/Replace Existing ADAS Servers and Workstations

The servers, workstations and other hardware components that comprise the ADAS system must be replaced every 4-5 years in order to maintain hardware and operating capability; the current ADAS system components were purchased in ~2010. Current version levels of the ARINC AIM System, components, and Microsoft Operating Systems shall be upgraded concurrently to ensure maintainability and support from current system integrators and warranties. Incorporate system enhancement features determined appropriate for ARINC AIM software upgrades.

The work covered by this alternative consists of furnishing all equipment and software required to perform the work in connection with the front-end upgrade of the Alarm Detection and Annunciation Systems (ADAS) servers, workstations, and associated software at the site.

All furnished servers must be Energy Star rated. All workstations and LCD displays furnished must be rated EPEAT silver or gold.

AIM SCS Hardware Upgrades: This alternative shall include the supply of new computer hardware to replace the existing AIM SCS system hardware. The new hardware infrastructure shall use the latest commercial-off-the-shelf (COTS) modular hardware wherever possible to facilitate system maintenance, scalability, and future enhancements. This includes standard TCP/IP protocols, Windows operating systems, and Intel based servers and workstations. The software and hardware configurations shall enable high availability and support a multi-user/multi-function environment for data throughput, management, storage, and retrieval. The system design, including: servers, workstations, LAN infrastructure, and field components shall be designed to ensure that no single point of failure degrades system functions or creates a loss of real-time and/or historical data. The proposed hardware configurations shall meet the performance and reliability expectations for continued security operations and sustainability.

AIM SCS Host Servers: The new AIM SCS host servers shall be loaded with Windows Server 2008 R2 at a minimum and shall include the latest AIM release 2013/2014+ or later if certified by the time the software is loaded. The current AIM database shall be re-loaded and the servers shall be configured, integrated, and factory tested to ensure all applications and user functions operate as documented in the vendor's test plans and procedures. Operational features for both users and administrators shall be retained. The host servers shall perform all processing of software functions, interfaces to third party systems/edge devices, and field I/O panels, alarm processing, access control, IP/CCTV surveillance, and a security suite of applications.

The host server hardware at each site will meet the following requirements at a minimum:

- (2) Identical Dell R720's or later models running a minimum of Windows Server 2008 R2 or most current version.
- Hosting AIM 2014.R2 or later version as the primary application.
- AIM SCS relational databases are stored in a RAID5 10TB disk array.
- Both servers shall be configured to operate independent of each other. (Primary & Standby).
- A network link mirrors information for failover preparations with additional high speed NIC cards for Data/Video processing and connectivity.
- Configured to assist the entire system specified to at least 99.999% of system availability.
- Redundant power supplies for each server for increased reliability.
- Compatible with ARINC's current suite of Cyber Security products and policies.

Active Directory Servers: Active Directory (AD) servers shall be added to the system to provide the framework for storing information about the network of computers (servers and workstations) that form the AIM System domain. The AD servers shall be loaded with Windows Server 2008 R2 at a minimum and shall be staged, and configured to maintain the necessary policy and environmental variable structures.

The AD servers shall incorporate the necessary tools to configure user rights and privileges in the AIM System at the operating system level and to facilitate network identification of the various computers in the System network domain.

The user management tools provided by Windows shall provide standard user authentication (username, password) facilities for preventing unauthorized access to the system computers.

The AD server hardware at the site will meet the following requirements at a minimum:

- (2) Identical Dell R720's or later models running Windows Server 2008 R2 or most current version.
- Hosting Active Directory v1.1 or later version as the primary application.
- AD databases are stored in a RAID5 5TB disk array.
- Both servers shall be configured to operate independent of each other. (Primary & Standby).
- A network link mirrors information for failover preparations with dual GB NIC's.
- Configured to assist the entire system specified to at least 99.999% of system availability.
- Redundant power supplies for each server for increased reliability.
- Compatible with ARINC's current suite of Cyber Security products and policies.

AIM SCS User and Video Workstations: The new workstations shall meet ARINC's graphical, user, and video requirements for viewing system graphics, alarm/event information, and reports. These workstations shall provide a standard Windows-based GUI with easy-to-use security applications. Standard windows shall be used to access security information prepared by the host server(s). System workstations shall communicate with the host servers to store and retrieve information. The new workstations shall replace the existing CAS, Computer Room, and AAP alarm and video workstations with new systems connected to the AIM system data and video LANs. The Alarm workstations shall be designed to execute and present user requested information and video in a timely manner for applications such as auto video call-up, PTZ control, user requests, reports, data input, PTZ tours, and video sequencing/display.

The workstations shall be configured with components to view, and modify database configuration information, which shall be fully capable of meeting or exceeding functional and operational requirements defined in relevant ARINC documentation volumes. They will also support future security requirements for video call-up as required.

The user workstation hardware (one in the CAS and one training workstation in the computer room) shall meet the following requirements at a minimum:

- Dell T5000's, 4GB RAM, 1TB HDD, Dual VGA Graphics Card, Dual GB NIC.
- Windows 7 Ultimate or approved equal.
- AIM Alarm GUI connected to the data and video LAN.
- Two (2) 24" LCD displays in the CAS, 1 19" LCD display in the computer room.

The video workstation hardware (two in the CAS) shall meet the following requirements at a minimum:

- Dell T5000's, 8GB RAM, 1TB HDD, Dual HD Graphics Card, Dual GB NIC.
- Windows 7 Ultimate approved equal.
- AIM Video GUI connected to the video LAN.
- Two (2) 24" LCD displays per workstation.

Local Area Network Switches: The data LAN communications backbone shall be configured in a redundant configuration meeting the ARINC AIM specification requirements for redundancy and system availability.

The LAN network devices shall support 10/100/1000+ gigabit TCP/IP network communications between all network nodes (e.g., system servers, workstations, IP based field devices, clipping servers and video workstations), and printers, etc.). A pair of Ethernet Local Area Networks CISCO Catalyst 3750 (Vx) models (Data LANs) shall provide a dual redundant communications data backbone for the entire AIM SCS system. Video network devices shall be configured for high availability operations to the maximum extent as possible.

The data network LAN shall meet the following requirements:

- (2) Cisco Catalyst 3750Vx - 24 Gb port, w/4 SFP Slots (A/B rails) approved equal.
- (2) Cisco Catalyst 3750Vx - 48 Gb port, w/4 SFP Slots w/ Network Mod, 4 GbE ports, and 24 units of GLC-FE-100FX approved equal.

The video network LAN shall meet the following requirements:

- (2) Cisco Catalyst 3750Vx - 24 Gb port, w/4 SFP Slots (A/B rails) approved equal.
- (2) Cisco Catalyst 3750Vx - 48 Gb port, w/4 SFP Slots w/ Network Mod, 4 GbE ports, and 24 units of GLC-FE-100FX approved equal.

Video Management System: An updated video management system shall be provided that will be integrated with the AIM SCS system and shall provide automated and manual camera video streaming as configured for the video workstations in the CAS alarm stations. The upgraded video management system will retain all video recording capabilities currently operational in the AIM SCS systems at the site, and will be fully compatible with the existing cameras and encoder/decoder devices. All servers, workstations, and video recorders provided as part of this system shall utilize currently-supported operating systems (Server 2008, Windows 7 as a minimum).

AIM SCS Software Upgrade: The vendor shall supply new updated operating system and application software to replace the existing AIM SCS system software. All operating systems provided will be the latest versions supported by both the operating system provider and the AIM SCS system software. All functions currently present in the AIM SCS system shall be retained in the new application software versions. Additionally, all vendor-developed improvements and increased functionality that have been added to the application software since the initial delivery of AIM SCS Version 2008.1 to the Big Hill SPR site shall be included in the version of the application software installed.

All applicable software licenses shall be provided, installed, and configured on the appropriate servers/workstations as required for the functionality included with the upgraded system. This includes all operating systems, vendor-developed application software, and third- party software applications.

Assumptions & Constraints

Assumptions:

- The ADAS will be temporarily out of service during installation of upgrades.

Constraints:

- Technology/equipment performance requirements advances prior to installation.

Benefits & Effectiveness

Replacing/upgrading the ADAS system servers and workstations extends equipment life cycle and allows for increased security. The items below summarize the benefits/effectiveness and mission need items addressed of replacing the mentioned systems on the Big Hill site.

- Installing upgrades to the site ADAS system increases security posture and complies with physical security directives. (DOE 473.3 A.)
- Replaces a system that was installed over 5 years ago, increasing security software and components susceptible to increasingly advanced cyber-attacks.

Risk & Mitigation Factors

Some potential risks associated with upgrading/replacing the existing ADAS servers and workstations include, but are not limited to, additional security measures during construction, training employees on a new system, potential safety issues while updating/installing equipment and technology advances prior to installation. The table below summarizes mentioned risks with a correlating mitigation strategy. The table describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Upgrade/Replace Existing ADAS Servers and Workstations

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
The ADAS will be temporarily out of service during construction.	Heightened security measures during installation, planning with site and contractor to compensate for gaps in coverage.	High - High	High Risk Hazard
Upgraded system and technology require employee instruction.	Ensure the contractor is required to include training packages (software and hands-on) with the installation.	High - High	High Risk Hazard
Potential for safety issues during installation.	Ensure a robust Job Safety Analysis is done by the site and contractor during installation.	Low - Low	Low Risk Hazard
Reduced security posture during construction.	Close coordination between NOLA, site security and contractor work scheduling and sequence.	Medium - High	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

Recommended Go Project

A. Upgrade/Replace Existing ADAS Servers and Workstations

Replace/upgrade the applicable servers and workstations to the latest generation of applicable software with ARINC AIM compatible software server and workstation hardware. Upgrade the current ARINC and AIM software and Cisco video server software. Replace the NICE audio logger with an applicable Windows software compliant version. Current version levels of the ARINC AIM System, components, and Microsoft Operating Systems shall be upgraded concurrently to ensure maintainability and support from current system integrators and warranties. Incorporate system enhancement features determined appropriate for ARINC AIM software upgrades.

Cost

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$1,199,790**	**$2,353,923**

BH-MM-756, BH-MM-756A

Replace Section of 36” COP at Hillebrandt Bayou (Install and Government Furnished Equipment)

VCI Project Engineer: Bill Fogle

Recommended Alternative:

This project has been issued as Approved for Construction (AFC)

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The Big Hill 36-inch crude oil pipeline was installed in 1987 and is 24.7 miles long with 0.500-in wall thickness. The original crossing at Hillebrandt was constructed of 0.625-in wall materials. Several corrosion anomalies were identified during the 2009 and 2014 surveys. The 2014 survey identified 202 corrosion anomalies along the entire pipeline, with greater than 40% wall loss. Of the 202 locations, 29 (14 percent, including 2 anomalies with over 50 percent wall loss) were located within a 135-foot segment under Hillebrandt Bayou. The location is abutted by marsh area mostly on the south side of the bayou and pastureland on the north side. The pipeline segment is located north of FM 365, which runs east to west. This area is at a point just beyond the southern bank of the waterway.

Functional Requirements

- The design of the pipeline must be able to meet or exceed the 25-year life ascribed to the Life Extension 2 projects.
- The construction installation must ensure no more than 13-day outage of the pipeline per SPR guidelines

II. PROCESS

Alternatives Analysis Plan

The Analysis of Alternatives (AoA) Process Plan is not applicable to projects with detailed design packages issued to DOE as Approved for Construction (AFC).

This document outlines completed design Scope of Work for BH-MM-756, BH-MM-756A

III. SELECTION CRITERIA

Formal selection criteria are not applicable to projects with detailed design packages issued as AFC.

IV. ALTERNATIVES IDENTIFICATION

Alternative Identification is not applicable to projects with detailed design packages issued as AFC.

V. ALTERNATIVES ANALYSIS

Alternative Analysis is not applicable to projects with detailed design packages issued as AFC.

The AFC detailed design identified and outlined the following scope of work:

- Install two (2) 22.5-degree piping offsets to connect the existing pipeline into the new segment. These offsets will each be constructed of two (2) 22.5-degree 5-R bends with 3-D tangents length on each end. These offsets may also include engineered trust blocks to address the forces imparted while flowing. This will permit the new pipeline segment to be placed in a lateral position approximately 10-20-feet away. Due to the size of the bends, the offsets will be assembled at or near the final installation position, with full NDT and coatings as required.
- Field-applied coatings are limited to weld joints and repairs. Coating system to be compatible with factory applied coating.
- Remove two to four (2-4) 100-foot pipeline sections to allow for the installation of the offsets and mobility of the required equipment. The final length of the pipeline segment to be installed is estimated at approximately 1,800 – 2,100 LF.

- Abandon in place 1250 – 1600 LF of 36-in line pipe across and below Hillebrandt Bayou. Line to be capped in place. Final length to be determined in field.
- The abandoned sections are to be cleaned, inspected, capped, and inserted in accordance with ASME B31.4, section 457, and TXRRC requirements.
- Removed pipe material to be cleaned and checked for NORM before removal from worksite for disposal.
- The spoil slurry from the drilling operations shall be collected with frac tanks and/or vacuum trucks for disposal at predetermined location(s) adjoining the pipeline work area for natural absorption into the ecosystem. The original bayou crossing segment, approximately 1250-foot long will be capped and left in place. The estimated volume for the bore is 750-800 cubic yards, based upon volume of 12.56 cu. Ft / LF of 48" bore. The total excavated material is estimated at 2200 cu yds. The non-drill material will be replaced as backfill over the pipeline, and drill site locations to restore the area.
- Install new pipeline crossing signage on both sides of Hillebrandt Bayou above the new crossing location. The existing signage will be left in position since the original pipeline segment will be left in position. It is recommended that the existing signage be modified to reflect that the pipeline is out of service.
- Civil / Site preparation activities, to include roadside site access points for contractors, drainage requirements, roads and defined matted work areas to support project activities before during and after execution. Traffic signage and control package as required by TxDOT.
- Current SPR Spill Prevention Control and Contingency (SPCC) Plan, will be incorporated into project construction-specific plan as deemed necessary.
- Install 1650 LF of 36-inch x 0.75" wt. API-5LX-60-line pipe in a parallel route to the original with a minimum offset**.**
- Offset spool components in accordance with ASME B16.49.
- Employ Horizontal Directional Drilling (HDD) to minimize ecological impacts to sensitive bayou area.
- Submittal and approval of USACE of drilling plan.
- Drilling location and profile drawings
- Drilling Fracture calculations
- Fracture Contingency recovery plan
- Submittal and Approval of TX DOT required traffic control plan, including:
  - Signage and traffic control for two access points
  - Temporary roadway and fencing construction and removal
- Install water crossing signage as required.

VI. ALTERNATIVE SELECTION

Alternative Selection is not applicable to projects with detailed design packages issued as AFC.

BH-MM-756, BH-MM-756A Scope of Work is outlined in Section V.: Alternatives of Analysis of this document.

AFC Cost

	Total Estimated Cost (TEC)	Life Cycle Cost (LCC)
BH-MM-756, 756A	**$9,541,558**	**$10,352,243**

BH-MM-776; BH-MM-776A

Replace Actuators on Meter Skid Valves (Install and Government Furnished Equipment)

VCI Project Engineer: Bill Fogle

Recommended Go Project:

Replace Meter Skid Actuators at Big Hill and Sun Logistics Nederland Terminal

Analysis of Alternatives
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I. PROJECT CONCEPT

Mission Need

Big Hill's crude oil Allocation Custody Transfer (ACT) meter skid is configured as a 4-train unit. The original station utilized electric motor actuators manufactured by EIM. Reliability issues, operability issues, and part availability dictate the need to replace or upgrade, particularly the EIM units to more current technology. These valve actuators allow the ACT Unit facility to record the volumes of oil transfer for drawdown.

SPR crude oil from the BH and WH sites also flows through the Sun Logistics Nederland Terminal for sale/transfer to local refiners. This location is made up of three (3) parallel meter trains. Each of these trains contains six (6) motor-operated valves. Beyond the meter trains, there are another five (5) switching valves. All of the actuators located at this location are EIM branded.

The EIM actuators on the MOVs were replaced with Rotork Mark III units several years ago. The associated Flow Control Valves, (FV) retain their original EIM actuators. The original EIM actuators have exceeded their intended design service life and have poor reliability, therefore they should be replaced. The replacement Rotork actuators are nearing their design life span, and should be replaced with the current Rotork Generation III units produced by Rotork to standardize the equipment across the metering and site pipeline systems.

This project will work in conjunction with similar efforts at the Bryan Mound and West Hackberry SPR sites, along with the outlying Lake Charles Meter Station location.

Functional Requirements

- Actuators shall be US registered, i.e., UL, FM, or CSA-US for Class 1, Division 2; hazardous area locations.
- Actuator torque requirements are based on base valve vendor calculations for Breaking, Running, and Seating force requirements at 1.5X MAWP design pressure. Calculations shall also take into account the valve body orientation, particularly as applied to gate valves.
- The valve actuator selection should provide a 25-year service life with minimum maintenance.
- The valve actuator selection should provide standardization across the SPR sites, and associated metering locations.
- The design should accommodate in-place local and remote inspection/diagnostic testing

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for Go/No Go Projects has been standardized for all Go/No Go AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Bill Fogle	VCI, Project Engineer
Chris Vedros	FFPO, Manager Pipeline and Equipment Integrity

Team Members

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Tony DeVille	FFPO, Manager Site Operations
Mark Thorn	FFPO, Operations Superintendent

III. SELECTION CRITERIA

Formal selection criteria will not be applicable in a Go/No Go Project.

IV. ALTERNATIVES IDENTIFICATION

Alternatives Identification is not applicable in a Go/No-Go Project.

V. ALTERNATIVES ANALYSIS

The existing actuators on the seven meter runs on the meter skid headers would require continued repair and replacement of the actuators as they fail. This would require an acceptance of a lower level of reliability and subject the SPR to an unanticipated failure during an oil movement. The failure of any one actuator can take an entire meter train out of service and result in the inability to meet the Level I drawdown requirement.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Replace Meter Skid Actuators at Big Hill and Sun Logistics Nederland Terminal

Replace the existing actuators on the meter skid isolation valves. The new replacement valve actuators will provide more reliability, reduce operations and maintenance down time, and provide accurate metered oil deliveries.

The intent of this alternative is twofold: first replace the outdated EIM actuators with curremt Rotork IQ / IQT actuators; secondly upgrade the older Rotork IQ series actuators with similar, current technology actuators. (See Table 1 for Big Hill site actuator list and Table 2 for Sun Logistics Nederland Terminal actuator list.)

This effort will serve to standardize the actuator selection and sizing across the SPR which should reduce long term parts system-wide inventory requirements. The replacement of the valve actuators will also ensure BM's ability to meet its Level I drawdown which the SPR is committed to maintaining.

DOE TAG #	VALVE					ACTUATOR				PROJECT
	BRAND	MODEL	SIZE	CLASS	ORIENTATION	BRAND	MODEL	S/N	STATUS	RECOMMENDATION
BIG HILL METER STATION										
8M001 MOV 01	DANIEL	M303 SLAB GATE	16"	300	VERTICAL	EIM		E2764-01-01	OLD	REPLACE
8M001 HV 02	DANIEL	M303 SLAB GATE	12"	300	VERTICAL					
8M001 MOV 04	DAN-EX	FIG 273 PLUG	16	300	HORIZONTAL	EIM		E2764-01-05	OLD	REPLACE
8M002 MOV 01	DANIEL	M303 SLAB GATE	16"	300	VERTICAL	EIM		E2764-01-02	OLD	REPLACE
8M002 HV 02	BEGEMANN	XX36, 8000 GATE VALVE	12"	300	VERTICAL					
8M002 MOV 04	DAN-EX	FIG 273 PLUG	16	300	HORIZONTAL	EIM		E2764-01-06	OLD	REPLACE
8M003 MOV 01	DANIEL	M303 SLAB GATE	16	300	VERTICAL	EIM		E2764-01-03	OLD	REPLACE
8M003 HV 02	GENERAL	TWINSEAL CB-416	16	600	HORIZONTAL					UPGRADE
8M003 MOV 04	DAN-EX	FIG 273 PLUG	16	300	VERTICAL	EIM		E2764-01-07	OLD	REPLACE
8M004 MOV 01	DANIEL	M303 SLAB GATE	16	300	VERTICAL	EIM		E2764-01-04	OLD	REPLACE
8M004 HV 02	M&J	M303 SLAB GATE	12	600	VERTICAL					UPGRADE
8M004 MOV 04	DAN-EX	FIG 273 PLUG	16	300	HORIZONTAL	EIM	2405-0	E2764-01-08	OLD	REPLACE
8M000 MOV 41	DANIEL	M303 SLAB GATE	16	300	VERTICAL	EIM			OLD	REPLACE
BIG HILL SWITCHING AND LAUNCHER VALVES										
PROVER SW VLV.	DANIEL	MODEL 1945 4-WAY VALVE	16	300	VERTICAL	EIM				REPLACE
8M004FV05	PBV	6760-01-22ZZ-ZF-NA-20	12	600	VERTICAL	EIM				REPLACE
8H000MOV17	DANIEL	20x16 E-2152-01-02	20	300	VERTICAL	ROTORK	IQ25FA-14Z	HD254301/01		UPGRADE
8H000MOV18	DANIEL	M303 SLAB GATE	30	300	VERTICAL	ROTORK	IQ40-FA25A	B31485030101		UPGRADE
8H000MOV19	DANIEL	M303 SLAB GATE	30	300	VERTICAL	ROTORK	IQ40-FA25A	B2837020102		UPGRADE
8H000MOV20	DANIEL	20x16 E-2152-01-02, GLOBE	20	300	VERTICAL	ROTORK	IQ25FA-14Z			UPGRADE
8H000MOV25	DSI	12B-23-LU-N	12	300	VERTICAL	EIM				REPLACE
4000HV002	DANIEL	M303 SLAB GATE	12	300	VERTICAL	EIM				REPLACE
8L110MOV 1	M&J	M303 SLAB GATE	36	300	VERTICAL	ROTORK				UPGRADE
8L110MOV 2	M&J	M303 SLAB GATE	36	300	VERTICAL	ROTORK				UPGRADE
8L110MOV 3	M&J	M303 SLAB GATE		300	VERTICAL					
8L110MOV 4	M&J	M303 SLAB GATE		300	VERTICAL					

Table 1: Big Hill Meter Station Valve Actuators

DOE TAG #	VALVE					ACTUATOR				PROJECT
	BRAND	MODEL	SIZE	CLASS	ORIENTATION	BRAND	MODEL	S/N	STATUS	RECOMMENDATION
SUN LOGISTICS NEDERLAND TERMINAL										
6M001MOV01	Crane	WEDGE GATE	16	300	VERTICAL	EIM	9C4603FC-G		OLD	REPLACE
6M001MOV02	General	PLUG, FIG 821	16	300	VERTICAL	EIM	9C4603FC-G	0688843A02	OLD	REPLACE
6M001MOV03	Dan-Ex	PLUG, FIG 273	16	300	VERTICAL	EIM	9C4603FC-G		OLD	REPLACE
6M001M0V06	General	PLUG, FIG 821	16	300	HORIZONTAL	EIM	9C4603FC-G		OLD	REPLACE
6M001FV05	Fisher	VEE-BALL, V250	12	600	VERTICAL	EIM	R7N6-3	5546201	OLD	REPLACE
6M002MOV01	Crane	WEDGE GATE	16	300	VERTICAL	EIM	9H2/43FO-K	6095416	OLD	REPLACE
6M002MOV02	General	PLUG, FIG 821G	16	300	VERTICAL	EIM		068849A04	OLD	REPLACE
6M002MOV03	General	PLUG, FIG 821G	16	300	VERTICAL	EIM		068591A02	OLD	REPLACE
6M002FV05	Fisher	VEE-BALL, V250	12	600	HORIZONTAL	EIM	JHC Reman.		OLD	REPLACE
6M003MOV01	DSI	WEDGE GATE	16	300	VERTICAL	EIM	4KNN-3	6497210	OLD	REPLACE
6M003MOV02	General	PLUG, FIG 821G	16	300	VERTICAL	EIM		068591A01	OLD	REPLACE
6M003MOV03	General	PLUG, FIG 821G	16	300	VERTICAL	EIM		068591A03	OLD	REPLACE
6M003FV05	Fisher	VEE-BALL, V250	12	300	VERTICAL	EIM			OLD	REPLACE
SUN LOGISTICS SWITCHING VALVES										
6H00MOV08	M-J	M303 SLAB GATE	30	300	VERTICAL	EIM			OLD	REPLACE
6H00MOV09	M-J	M303 SLAB GATE	24	300	VERTICAL	EIM			OLD	REPLACE
6H00MOV10	M-J	M303 SLAB GATE	24	300	VERTICAL	EIM			OLD	REPLACE
6H00MOV11	M-J	M303 SLAB GATE	24	300	VERTICAL	EIM			OLD	REPLACE
6H00MOV12	M-J	M303 SLAB GATE	24	300	VERTICAL	EIM			OLD	REPLACE
6H00MOV13	M-J	M303 SLAB GATE	16	300	VERTICAL	EIM			OLD	REPLACE

Table 2: Sun Logistics Nederland Terminal Valve Actuators

VI. ALTERNATIVE SELECTION

Recommended Go Project

A. Replace Meter Skid Actuators at Big Hill and Sun Logistics Nederland Terminal

Replace the existing actuators on the meter skid isolation valves. The new replacement valve actuators will provide more reliability, reduce operations and maintenance down time, and provide accurate metered oil deliveries.

Cost

	Total Estimated Cost (TEC)	Life Cycle Cost (LCC)
Alternative A	**$3,375,124**	**$3,439,685**

BH-MM-782

Replace Slop Oil Tank and Pumps (BHT-6, BHP-51 & 52)

VCI Project Engineer: Lorna Madison

Recommended Alternative:

Replace Pumps in Kind and Tank with Upgrade to Stainless Steel

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I. PROJECT CONCEPT

Mission Need

The Big Hill (BH) site in Texas will explore replacing and relocating the carbon steel Slop Oil Tank BHT-6 and associated Slop Oil Pumps BHP-51 and BHP-52 alongside Tank 7.

Functional Requirements

The following are the functional requirements for the replacement of the Slop Oil Tank and Pumps at Big Hill:

- The affected oil recovery system components life should meet or exceed the 25 year life of Life Extension 2 (LE 2).
- Pump installation reliability must be greater than or equal to 95%.
- The mechanical integrity of the affected oil recovery system at the Big Hill site must be maintained to ensure that the required oil water separations can be performed to support and ensure continuity of site wide operations in an efficient and safe manner.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

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III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as necessary to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate alternatives and select a recommendation.

Safety during Construction

The selected alternative when implemented will be able to be constructed and operated safely and have the ability to address safety and security concerns during implementation. A robust contractor work plan shall be vetted by the Government for all safety concerns that might be of note during construction.

Weight: Most Important

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment. The affected oil recovery system components life should meet or exceed the 25-year life of LE 2.

Weight: Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment, resulting in commonality of similar systems for future maintenance and sparing consideration. Pump installation reliability must be greater than or equal to 95%.

Weight: Important

Sustainability

The selected alternative when implemented will be able to achieve the Department of Energy (DOE) sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

The status quo is to operate/maintain the existing Slop Oil Tank BHT-6 and Slop Oil Pumps BHP-51 and BHP-52. In the existing oil recovery system for Big Hill, oil/brine mixtures are collected at Slop Oil Tank BHT-6 and transferred by Slop Oil Pumps BHP-51 and BHP-52 back to the Crude Oil Injection Pumps for injection back into the caverns. Continuing to operate these pieces of equipment, which are in a badly corroded condition, may result in a loss of mechanical integrity and failure. This could result in an environmental upset for the site, especially since BHT-6 is mounted over the brine pond. In addition, the slop oil will not be disposed in an efficient manner and may cause a safety condition due to potential exposure. Thus, the site may not be able to meet the required environmental and safety standards.

Viability: No Further Analysis

B. Replace Pumps and Tank in Kind

This alternative consists of replacing the existing Slop Oil Pumps BHP-51 and BHP-52 and the Slop Oil Tank BHT-6 in kind in a new location adjacent to Tank 7. The new pumps will satisfy the required critical design parameters (e.g. flow and delivery pressure) with material selection for operability, efficiency, and longevity factors to meet the required pump and piping standards and inspection requirements. The corroded Slop Oil Tank will be replaced in kind with a new carbon steel (CS) tank. Tank replacement is more expeditious than tank repair. Specification of carbon steel metallurgy, which has a more generous corrosion allowance, leads to less stringent welding and inspection requirements compared to an upgrade to higher metallurgy. The new tank and new pumps will be relocated next to Tank 7 to address slop oil

handling away from the brine pond. Using this option, the site will be able to meet the required environmental and safety standards.

Viability: Continue Analysis

C. Replace Pumps in Kind and Tank with Upgrade to Stainless Steel

This alternative consists of replacing the Slop Oil Pumps BHP-51 and BHP-52 in kind and replacing the Slop Oil Tank BHT-6 with a new stainless steel (SS) tank. The new pumps will satisfy the required critical design parameters, such as flow and delivery pressure, with material selection for operability, efficiency, and longevity factors to meet required pump and piping standards and inspection requirements. The corroded Slop Oil Tank will be replaced with a new SS tank. Tank replacement is more expeditious than tank repair. Upgrade of the new tank from CS metallurgy to SS will provide the tank with greater corrosion resistance for longer service life. The new tank and new pumps will be relocated next to Tank 7 to address slop oil handling away from the brine pond. Installation of the SS tank will require more detailed flange design to cope with the joining of dissimilar metals and will require more stringent welding and inspection requirements. Using this option, the site will be able to meet the required environmental and safety standards.

Viability: Continue Analysis

D. Replace Pumps in Kind and Tank with Upgrade to Fiberglass

This alternative consists of replacing the Slop Oil Pumps BHP-51 and BHP-52 in kind and replacing the Slop Oil Tank BHT-6 with a new fiberglass (FRP) tank. The new pumps will satisfy the required critical design parameters, such as flow and delivery pressure, with material selection for operability, efficiency, and longevity factors to meet required pump and piping standards and inspection requirements. The corroded Slop Oil Tank will be replaced with a new FRP tank to withstand the corrosion experienced by the existing tank. Tank replacement is more expeditious than tank repair. However, FRP is less impact resistant and more prone to damage. With the tank installed up and over the brine pond, the greater fragility of an FRP tank creates new potential environmental risk to the site, which is deemed unacceptable. Hence, this option is eliminated from further consideration.

Viability: No Further Analysis

V. ALTERNATIVES ANALYSIS

Based on the initial analysis of the alternatives, alternatives A and D are eliminated from further consideration as unacceptable or infeasible for replacing the Slop Oil Tanks and Pumps. The remaining alternatives, B and C, are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

Common Assumptions & Constraints

Assumptions:

- Relocation of BHT-6 away from the brine pond is advantageous to operation of the slop oil system with minimal environmental impact.
- The affected oil recovery system components life will meet or exceed the 25 year life of LE 2.
- The new tank will be resized for adequate service.
- New pump switchgear will be provided on the assumption that physical relocation of the pumps relocates the switchgear as well.
- Pump installation reliability will be greater than or equal to 95%.
- The new tank will be provided with berms impinging upon those of Tank 7.

- The new pumps will be provided with concrete containment under pumps.
- A new stormwater sump will be provided with a sump pump to manage runoff from the concrete containment.
- Slop oil pump status and on/off function will be routed into the control room DCS to provide remote operation in addition to local operation.
- The existing Slop Oil Tank BHT-6 and Slop Oil Pumps BHP-51 and BHP-52 will be abandoned in place by the brine pond.
- Oil water separations will be adequate to support and ensure continuity of site wide operations in an efficient and safe manner.
- New level instrumentation will be provided for the new tank.
- The existing pump motor will not be replaced unless required.
- The tank and pump base structures will not be replaced unless required.

Constraints:

- The fabrication and procurement of the tank and pumps may be long lead items.
- Changes in the composition of the oil/brine mixture can significantly affect the corrosion of the tank and wear on the pumps.
- May require revision to the DCS.
- The design capacity of the new BHT-6 Slop Oil Tank must not exceed 19,800 gallons to remain a fixed roof tank. If the tank design capacity exceeds 19,800 gallons, then a floating roof tank with seals will be required by TCEQ. A new air Permit by Rule (PBR) must be obtained from the Texas Commission on Environmental Quality (TCEQ) prior to start of construction of the new tank. Allow 2 months in the project schedule for Fluor Federal Petroleum Operations (FFPO) Environmental to prepare the permit application and obtain the air permit from TCEQ.

A. Replace Pumps and Tank in Kind

This alternative consists of replacing the existing Slop Oil Pumps BHP-51 and BHP-52 and the Slop Oil Tank BHT-6 in kind along with associated valves and instrumentation at a new location adjacent to Tank 7.

Benefits & Effectiveness

The replacement of the existing Slop Oil Pumps and the Slop Oil Tank in kind allows for multiple benefits and addresses current mission needs. The items below summarize the benefits and effectiveness of replacing the Slop Oil Pumps and Tanks on-site.

- The replacement will meet required critical design parameters, such as flow and delivery pressure, and material selection for operability, efficiency, and longevity factors to meet required pump and piping standards and inspection requirements.
- Replacing the existing corroded Slop Oil Tank, BHT-6, with an in kind replacement (CS tank) will help meet the required tank standards and inspection requirements.
- Tank fabrication and procurement can be efficiently managed to reduce time and effort for ease of tank change over.
- Replacement in kind for the CS tank provides for basis material selection, fabrication, and less stringent welding and inspection requirements.
- The site will be able to meet the required environmental and safety standards.

Risk & Mitigation Factors

Replacing the existing Slop Oil Pumps and the Slop Oil Tank in kind will come with associated risks such as safety during installation, corrosion, and location of the tank. The table below summarizes the risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing Pumps and Tank in Kind

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Safety while removing and installing the new Slop Oil Pumps and Tank.	Ensure a job hazard analysis is prepared by contractors and for anyone on-site in the area of replacement.	Medium - Medium	Medium Risk Hazard
Corrosion of tank.	Ensure a plan is in place for studying how long the tank will last before corrosion, and plan to install a new tank before the installed tank becomes inoperable.	High - High	High Risk Hazard
New pumps availability/delivery delayed.	Procure pumps and motors in advance to develop schedule to avoid delays with equipment delivery.	Low - Low	Low Risk Hazard
New pumps are inadequate for required flow and pressure.	Supply the pump vendors with adequate information for the required minimum and maximum flow rates and pressures. Characterize the brine/oil mixture to provide the vendors with the correct chemical/physical properties.	Medium - High	Medium Risk Hazard
New pumps metallurgy is inadequate for slop.	Ensure the chosen pump metallurgy is compatible with the slop.	Medium - Medium	Medium Risk Hazard
Pump base not structurally sound.	Verify with a structural engineer that the new pumps will be supported on the existing pump base structure for the duration of LE 2. New pump base structures may be required for the new pumps.	Medium - High	Medium Risk Hazard

Risk and Mitigation Strategies for Replacing Pumps and Tank in Kind (continued)			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Existing pump motors are inadequate.	Verify with the pump vendors that the pump motors will provide adequate horsepower to the new pumps.	Low - Medium	Low Risk Hazard
Inlet/Outlet pipe misaligned.	Verify new pumps' inlet and outlet will align with existing pipe. If not, design to modify inlet and outlet pipe to fit new pumps.	Medium - Medium	Medium Risk Hazard
Tank design inadequate for required volume and water-oil separation.	Provide the tank vendor adequate chemical/physical properties and volumes of the oil/brine mixture for the design of the tank.	Medium - High	Medium Risk Hazard
Deficient welds present in new tank.	Ensure 100% x-ray will be completed on the welds and have inspector approval prior to the installation and use of the tank.	Medium - High	Medium Risk Hazard
Tank support not structurally sound.	Verify with a structural engineer that the new pumps will be supported on the existing pump base structure for the duration of LE 2. New pump base structures may be required for the new pumps.	Medium - Medium	Medium Risk Hazard
Tank instrumentation is inadequate.	Provide the instrument vendor adequate chemical/physical properties of the oil/brine mixture and new tank dimensions for the design of the level instrumentation.	Medium - Medium	Medium Risk Hazard

B. Replace Pumps in Kind and Tank with Upgrade to Stainless Steel

This alternative consists of replacing the Slop Oil Pumps BHP-51 and BHP-52 in kind and replacing the Slop Oil Tank BHT-6 with a new stainless steel (SS) tank along with associated valves and instrumentation at a new location adjacent to Tank 7.

Benefits & Effectiveness

The replacement of the Slop Oil Pumps and the upgrade of the Slop Oil Tank to SS allows for multiple benefits and addresses current mission needs. The items below summarize the benefits and effectiveness of replacing the Slop Oil Pumps and Tank on-site.

- The replacement will meet required critical design parameters such as flow and delivery pressure, and material selection for operability, efficiency, and longevity factors to meet required pump and piping standards and inspection requirements.
- Replacing the existing corroded Slop Oil Tank (CS), BHT-6, with a new SS tank, will help meet required tank standards and inspection requirements.
- Tank fabrication and procurement may be efficiently managed to reduce time and effort for ease of tank change over.
- Replacing the existing CS tank with a new SS tank will provide for basis material selection, lower corrosion rates, and maintenance requirements.
- A correctly chosen grade of SS will adequately address corrosion concerns in the long run.
- The site will be able to meet the required environmental and safety standards.

Risk & Mitigation Factors

Replacing the Slop Oil Pumps and upgrading the Slop Oil Tank to SS will come with associated risks such as safety during installation and the location of the tank. The table below summarizes the risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing Pumps in Kind and Tank with Upgrade to Stainless Steel

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Safety while removing and installing the new Slop Oil Tank and Pumps.	Ensure a job hazard analysis is prepared by contractors and for anyone on-site in the area of replacement.	Medium - Medium	Medium Risk Hazard
Tank is located above the brine pond and could leak into the pond.	Ensure a plan is in place for studying how long the tank will last before corrosion, and plan to install a new tank before the installed tank becomes inoperable.	Medium - High	Medium Risk Hazard
Corrosion of tank.	Ensure a plan is in place for studying how long the tank will last before corrosion, and plan to install a new tank before the installed tank becomes inoperable.	High - High	High Risk Hazard
New pumps are inadequate for required flow and pressure.	Supply the pump vendors with adequate information for the required minimum and maximum flow rates and pressures. Characterize the brine/oil mixture to provide the vendors with the correct chemical/physical properties.	Medium - High	Medium Risk Hazard
New pumps metallurgy is inadequate for brine/oil.	Ensure the chosen pump metallurgy is compatible with the brine/oil mixture.	Medium - Medium	Medium Risk Hazard

Risk and Mitigation Strategies for Replacing Pumps in Kind and Tank with Upgrade to Stainless Steel (continued)			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Pump base not structurally sound.	Verify with a structural engineer that the new pumps will be supported on the existing pump base structure for the duration of LE 2. New pump base structures may be required for the new pumps.	Medium - High	Medium Risk Hazard
Existing pump motors are inadequate.	Verify with the pump vendors that the pump motors will provide adequate horsepower to the new pumps.	Low - Medium	Low Risk Hazard
Tank design inadequate for required volume.	Provide the tank vendor adequate chemical/physical properties and volumes of the oil/brine mixture for the design of the tank.	Medium - Medium	Medium Risk Hazard
Deficient welds present in new tank.	Ensure 100% x-ray will be completed on the welds and have inspector approval prior to the installation and use of the tank.	Medium - High	Medium Risk Hazard
Tank support not structurally sound.	Verify with a structural engineer that the new pumps will be supported on the existing pump base structure for the duration of LE 2. New pump base structures may be required for the new pumps.	Medium - Medium	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Replace Pumps and Tank in Kind

This alternative consists of replacing the existing Slop Oil Pumps BHP-51 and BHP-52 and the Slop Oil Tank BHT-6 in kind along with associated valves and instrumentation.

B. Replace Pumps in Kind and Tank with Upgrade to Stainless Steel

This alternative consists of replacing the Slop Oil Pumps BHP-51 and BHP-52 in kind and replacing the Slop Oil Tank BHT-6 with a new SS tank along with associated valves and instrumentation.

Comparison of Alternatives

Core Team Member Ratings

	Safety During Construction	**Ease of Operations**	**Ease of Maintenance**	**Sustainability**
	Most Important	*Important*	*Important*	*Less Important*
Alternative A	*Excellent*	*Excellent*	*Adequate*	*Good*
	Excellent	*Excellent*	*Adequate*	*Good*
	Good	*Excellent*	*Good*	*Excellent*
Alternative B	*Excellent*	*Excellent*	*Good*	*Excellent*
	Excellent	*Excellent*	*Good*	*Excellent*
	Good	*Excellent*	*Excellent*	*Excellent*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$1,950,241**	**$2,251,586**
Alternative B	**$2,055,712**	**$2,273,969**

Recommended Alternative

B. Replace Pumps in Kind and Tank with Upgrade to Stainless Steel

Based on the technical evaluation of the Core Team Members, Alternative B was rated equal or superior on all evaluation criteria. Alternative A has a slightly lower investment cost and life cycle cost. Therefore, Alternative B is the recommended preferred alternative, with the technical benefits outweighing the minimally higher investment cost and life cycle cost.

BH-MM-806

Replace S&C Mark V Circuit Switches

VCI Project Engineer: Lorna Madison

Recommended Alternative:

Replace the Existing S&C Mark V Circuit Switchers with Technology Upgrades

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The existing Schweitzer & Conrad (S&C) Electric Company manufactured Mark V Circuit Switchers, which are located at the main substation and interconnect the two incoming Entergy transmission lines, need replacing at the Big Hill (BH) site in Texas. Increased reliability and reduced maintenance of the Circuit Switchers will support and ensure the continuity of the site-wide operations in an efficient and continuous manner.

Functional Requirements

The following are the functional requirements for the replacement of the existing S&C Mark V Circuit Switchers:

- The S&C Mark V Circuit Switchers at Big Hill should be modified to ensure that inspection and repair can be minimized or eliminated over the estimated 25 years.
- Any modification involving the affected S&C Mark V Circuit Switchers at Big Hill should consider providing an alternative means of power back up for no less than 1 week during the change process.
- Material selections will provide a 25-year life with minimum maintenance.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Lorna Madison	VCI, Project Engineer
Mark Gross	FFPO, Manager Design Engineering

Team Members

Joy Berndsen	DOE, Project Engineer - Electrical
Anthony Bonadona	VCI, Project Engineer
William Leet	VCI, Process Engineer
Rachel Gray	VCI, Process Engineer
Scott Salter, II	FFPO, Electrical Engineer
Lisa Eldredge	FFPO, Principal Operations System Engineer
Buddy Delaune	FFPO, Principal Mechanical Engineer
Paul Riegert	FFPO, Manager Site Construction

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as necessary to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate alternatives and select a recommendation.

Constructability during Ongoing Oil Deliveries

The selected alternative is able to be implemented with little or no impact to ongoing oil delivery operations. Any modification involving the affected S&C Mark V Circuit Switchers at Big Hill should consider providing an alternative means of power back up for no less than 1 week during the change process.

Weight: Most Important

Safety during Construction

The selected alternative when implemented will be able to be constructed and operated safely and have the ability to address safety and security concerns during implementation. A robust contractor work plan shall be vetted by the Government for all safety concerns that might be of note during construction.

Weight: Most Important

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment.

Weight: Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration. The S&C Mark V Circuit Switchers at Big Hill should be modified to ensure that inspection and repair can be minimized or eliminated over the estimated 25 years.

Weight: Important

Sustainability

The selected alternative when implemented will be able to achieve the Department of Energy (DOE) sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

The status quo consists of maintaining the existing S&C Mark V Circuit Switchers. The existing S&C Mark V Circuit Switchers facilitate switching and isolation of the Main Substation from the Electrical Utility System at the Big Hill site. This is done by interconnecting the two incoming Entergy transmission lines. The Circuit Switchers are at the end of their economic life and need to be replaced due to age, deterioration, and scarcity of replacement parts. Continuing to maintain the existing S&C Mark V Circuit Switchers will lead to more frequent and prolonged outages to repair this outdated equipment.

If the existing S&C Mark V Circuit Switchers are not replaced, there will be an increased risk of adversely affecting the Utility Feed to the Strategic Petroleum Reserve (SPR) and other utility customers. This option does not support and ensure continuity of the site wide operations in an efficient and continuous manner.

Viability: No Further Analysis

B. Replace the Existing S&C Mark V Circuit Switchers in Kind

The site will replace the existing S&C Mark V Circuit Switchers in kind with new 138 KV circuit switchers, which will reduce the frequent and prolonged outages triggered by continued aging and deterioration of the equipment.

This option typically makes for an easy replacement given that this is replacement in kind work. There is no need for related site foundation, bus-work, etc. on-site. However, true replacement in kind is not available given the advancements made in circuit switcher design since the installation of the original circuit switchers.

Viability: No Further Analysis

C. Replace the Existing S&C Mark V Circuit Switchers in Kind with Technology Upgrades

The site will replace the existing S&C Mark V Circuit Switchers in kind with technology upgrades. This action will reduce the frequent and prolonged outages necessitated by continued aging, deterioration, and repair of the existing circuit switchers. Additional modifications would be made to include desirable performance enhancing features like solar powered switch operators and composite-silicone rubber insulators. The silicone insulators are nearly half the weight of porcelain insulators and are hydrophobic such that they provide improved performance in severe environments with high humidity and air born salts and pollutants (e.g. coastal areas and areas with heavy industrial pollution).

This option would support and ensure continuity of site wide operations in an efficient and continuous manner, while addressing the future availability of replacement parts.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on the initial analysis of the alternatives, alternatives A and B are eliminated from further consideration. The remaining alternative C is examined below as alternative A.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

A. Replace the Existing S&C Mark V Circuit Switchers with Technology Upgrades

The site will replace the existing S&C Mark V Circuit Switchers in kind with technology upgrades.

Assumptions & Constraints

- The S&C Mark V Circuit Switchers at Big Hill will be modified to ensure that inspection and repair can be minimized or eliminated over the estimated 25 years. Material selections will provide a 25-year life with minimum maintenance.
- Any modification involving the affected S&C Mark V Circuit Switchers at Big Hill will consider providing an alternative means of power back up for no less than 1 week during the change process.
- S&C Mark V Circuit Switchers in kind with technology upgrades will ensure continuity of site wide operation.

Benefits & Effectiveness

The replacement of the existing S&C Mark V Circuit Switchers with technology upgrades allows for multiple benefits and addresses current mission needs. The items below summarize the benefits and effectiveness of replacing the S&C Mark V Circuit Switchers with technology upgrades on-site.

- Replacing the existing S&C Mark V Circuit Switchers with current technology will reduce the frequent and prolonged outages necessitated by age, deterioration, and repairs of the existing circuit switchers.
- The solar powered switch operators and composite-silicon rubber insulators will enhance performance.
- The composite-silicone rubber insulators are nearly half the weight of porcelain insulators and are also hydrophobic for excellent performance in severe environments.
- Replacing the Circuit Switchers with current technology allows for the future availability of replacement parts.

Risk & Mitigation Factors

There are associated risks with eplacing the existing S&C Mark V Circuit Switchers with technology upgrades. The table below summarizes the risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Replacing the Existing S&C Mark V Circuit Switchers with Technology Upgrades

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Safety while removing and installing the new circuit switchers with technology upgrades.	Ensure a job hazard analysis is prepared by contractors and for anyone on-site in the area of replacement.	Medium - Medium	Medium Risk Hazard
The circuit switchers are located at the main substation that interconnects the two incoming Entergy transmission lines.	Coordinate with Entergy.	High - High	High Risk Hazard
Improper sizing of switches.	Provide adequate information to switch vendor to design proper sizing of switch.	Medium - High	Medium Risk Hazard
Improper installation of switches.	Vendor representative should be available for installation of switches.	Medium - High	Medium Risk Hazard
Improper installation of solar power panels.	Vendor representative should be available for installation of solar panels.	Medium - Medium	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Replace the Existing S&C Mark V Circuit Switchers with Technology Upgrades

The site will replace the existing S&C Mark V Circuit Switchers in kind with technology upgrades.

Comparison of Alternatives

Core Team Member Ratings

	Safety During Construction	**Constructability During Ongoing Oil Deliveries**	**Ease of Operations**	**Ease of Maintenance**	**Sustainability**
	Most Important	*Most Important*	*Important*	*Important*	*Less Important*
Alternative A	*Excellent*	*Excellent*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Excellent*	*Excellent*	*Excellent*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$773,249**	**$795,886**

Recommended Alternative

A. Replace the Existing S&C Mark V Circuit Switchers with Technology Upgrades

Based on the screening process led by the Core Team Members that reviewed three possible alternatives, Alternative A was the only viable alternative selected to be studied that would meet the mission need and functional requirements. Therefore, Alternative A is the recommended preferred alternative.

BH-SP-1307

Shell-Zydeco Custody Meter Station

VCI Project Engineer: Bill Fogle

Recommended Alternative:

Local Control of ACT Flow Meter Skid at Shell-Zydeco (Habitable) with Standard Security Fence without Full SPR Security Measures

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The Big Hill (BH) site delivers crude oil via a single 36-inch pipeline leaving the site to one of three destinations: The Shell-Zydeco Pipeline System (Zydeco), the Phillips 66 Beaumont Terminal Marine Terminal, and the Sunoco Logistics Nederland Terminal. The current BH site configuration does not have the capability to control flow rates to multiple destinations. In addition, there is no means of flow measurement at the Shell or Phillips 66 Beaumont Terminal junctures. Therefore, crude oil deliveries from BH may be made to only one destination at a time.

BH distribution system will be modified for simultaneous controlled delivery with BH-SP-1407 to all three destinations. There are custody agreements in place for Phillips 66 and Sun Terminal. Additionally, BH-SP-1407 Project will add ultrasonic meters at Phillips 66 and Sun Terminal. There is not a custody transfer meter or agreement at Shell-Zydeco; therefore, the delivered crude oil can only be measured with BH site custody metering skid.

A custody transfer metering skid at Shell-Zydeco is needed to allow for simultaneous delivery to all three destinations. Big Hill will have the ability to achieve Level I drawdown rate which the SPR is committed to maintaining.

Functional Requirements

- Big Hill is required to deliver 250 thousand barrels per day (MBD) to Shell-Zydeco Pipeline.
- The design of the metering station must be able to meet or exceed the 25-year life ascribed to the Life Extension 2 projects.
- The new custody metering station must be able to measure flow rates between 33 MBD and 250 MBD (maximum pipeline capacity).
- The reading accuracy should be ±0.25 percent over the normal flow range with a repeatability of 0.02% in accordance with Level III, design criteria, paragraph 9.2.4-Metering, and API Manual of Petroleum Measurement Standards (MPMS)
- The metering skid must meet the strict definition of an Allocation Custody Transfer (ACT) skid.
- A prover will be required to verify the accuracy of the meter which is essential in ensuring sustainable measurement and appropriate compliance to accuracy and repeatability requirements over time.
- Onsite sample storage shall be provided for 60-day, in accordance with section 9.2.3 requirements
- The metering station area must be secured from intrusions.
- The accessibility to Shell-Zydeco site must be improved.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Bill Fogle	VCI, Project Engineer
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Charles DeLuca	FFPO, Principal Operational Systems Engineer
Austin Thompson	FFPO, Manager Crude Oil Program and Logistics
John Guidry	FFPO, Site Director
Tony DeVille	FFPO, Manager Site Operations
Mark Thorn	FFPO, Operations Superintendent

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations. BH must be able to provide crude deliveries to Shell-Zydeco during the construction of the custody metering station.

Weight: Most Important

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment. The operation of the custody metering station has to be understandable and functional for BH operators.

Weight: Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration. The maintenance of the custody metering station will be maintained by Shell-Zydeco after its installation.

Weight: Important

Safety during Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation.

Weight: Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

The current BH site configuration does not have the ability to control flow rates to multiple destinations. BH-SP-1407 Project will allow simultaneous deliveries to all three destinations. There are custody agreements in place for Phillips 66 and Sun Terminal. Additionally, BH-SP-1407 Project will add ultrasonic meters at Phillips 66 and Sun Terminal. There is not a custody transfer meter or agreement at Shell-Zydeco; therefore, the delivered crude oil can only be measured with BH site custody metering skid.

A custody transfer metering skid at Shell-Zydeco is needed to allow for simultaneous delivery to all three destinations. Big Hill will have the ability to maintain its Level I drawdown rate which the SPR is committed to maintaining.

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

Due to the current delivery infrastructure design, sequential deliveries are made alternately between the Shell-Zydeco Pipeline at 250 thousand barrels per day (MBD), the Phillips 66 Terminal at 225 MBD, and the Sun Terminal at up to 1.1 million barrels per day (MMBD), thus the average rate is lower than the required 1.1 MMBD site drawdown rate criteria.

Big Hill continues with batch sales of crude oil to single end point users. Due to the current delivery infrastructure design, sequential deliveries are made alternately between the Shell-Zydeco Pipeline at 250 thousand barrels per day (MBD), the Phillips 66 Terminal at 225 MBD, and the Sun Terminal at up to 1.1 MMBD, thus the average rate is lower than the required 1.1 MMBD site drawdown rate criteria.

The crude oil drawdowns will be limited to 250 MBD when going to Shell-Zydeco and 225 MBD when going to Phillips 66 Terminal. The drawdown for Sun Terminal may not meet the required rate of 1.1 MMBD when delivering to the other destinations. The crude oil sales rate to Shell-Zydeco will be measured with BH's Allocation Custody Transfer (ACT) flow meter skid. The ACT for Phillips 66 crude rate will be based on contractual agreements. The ACT for Sun crude rate will be measured per manual tank strapping done by site operations.

BH will not be able to proceed with simultaneous deliveries to Shell/Zydeco Station, Phillips 66 Terminal, and Sun Terminal. BH will not have the ability to maintain its Level I drawdown rate which the SPR is committed to maintaining. This alternative does not meet mission need or functional requirements set by the project. Therefore, this alternative is not feasible.

Viability: <u>No Further Analysis</u>

B. Install Ultrasonic Flow Meter at Shell-Zydeco with Flow Controlled and Monitored at BH Control Room.

Install Krone Altosonic III™ ultrasonic flow meters at Shell-Zydeco with Rosemount pressure / temperature indicator transmitters. The measurements will be linked through local A-B Slick 500/5000 PLC back through telecommunications to Big Hill's SPR Distributed Control System (DCS). This alternative is the minimal installation option. This option assumes installation of BH-SP-1407 flow control scope.

The system will enhance the measurement capabilities at Shell-Zydeco. BH will be able to proceed with simultaneous deliveries to Shell-Zydeco Station, Phillips 66 Terminal, and Sun Terminal. However, a single meter does not meet the strict definition of an ACT skid for Shell-Zydeco Station. In addition, there is no connection for a prover to verify flow accuracy, improvement to accessibility, or enhanced security measures. This alternative meets the mission need; however, it does not meet all of the functional requirements of the project. Therefore, this alternative is not feasible.

Viability: <u>No Further Analysis</u>

C. Local Control of ACT Flow Meter Skid at Shell-Zydeco (Not-Habitable) with Standard Security Fence without Full SPR Security Measures.

A new 20-foot by 4000-foot road will be built from Hebert Road to the existing Shell-Zydeco site. The road will be paved with crushed stone. A drainage structure will be needed to cross a 54-inch culvert. In addition, water shed management must be addressed. The meter site area will be stripped of vegetation and built up 24 inches with select fill. Foundations will be provided for the Control Building, Prover Skid, Meter Skid, Sampler Skid, and Sampler Tank. Area lighting will be provided with 39-foot tall light poles that are installed on concrete drilled piers. The area will be paved with crushed stone. A security fence with double gates will be installed around the site perimeter.

Shell-Zydeco will have a skid mounted ACT unit equipped with 2 to 3 parallel helical turbine meter trains. The inlet and outlet headers will be sized to match Shell-Zydeco pipeline tie-ins. A vertical flow prover with separate master meter connections will be included. All valves and instrumentation will meet the requirements set by Shell. This option assumes installation of BH-SP-1407 flow control scope.

In addition, the installation will include a modular habitable building as the Control Building that is similar to the Lake Charles site. The site and habitable building will require a sanitary sump, oil/water sump, security measures, area lighting, Close Circuit (CC) security monitoring, full OSHA health and safety elements, and 24hr VDC back-up power supply for instrumentation to maintain operation in event of local outage. Shell-Zydeco location will require at a minimum electric power and access to city water supply for sanitary purposes. The final selected position will be dependent upon these factors. A minimum of 6 to 9 additional BH Operators are required during drawdowns (3 shifts at the new location).

BH will be able to proceed with simultaneous deliveries to Shell-Zydeco Station, Phillips 66 Terminal, and Sun Terminal. BH will have the ability to achieve the Level I drawdown rate which the SPR is committed to maintaining. This alternative meets the mission need and all of the functional requirements of the project. Therefore, this alternative is feasible.

Viability: Continue Analysis

D. Local Control of ACT Flow Meter Skid at Shell-Zydeco (Habitable) with Security Fence that Meets Full SPR Security Measures

A new 20-foot by 4000-foot road will be built from Hebert Road to the existing Shell-Zydeco site. The road will be paved with crushed stone. A drainage structure will be needed to cross a 54-inch culvert. In addition, water shed management must be addressed. The meter station area will be stripped of vegetation and built up 24 inches with select fill. Foundations will be provided for the Control Building, Prover Skid, Meter Skid, Sampler Skid, and Sampler Tank. Area lighting will be provided with 39-foot tall light poles that are installed on concrete drilled piers. The area will be paved with crushed stone. A security fence with double gates will be installed around the site perimeter. In addition, an Intelli-Flex Fence Sensor Zone 4 will be installed around the perimeter. A card reader and foundation will be required at the gate.

Shell-Zydeco will have a skid mounted ACT unit equipped with 2 to 3 parallel helical turbine meter trains. The inlet and outlet headers will be sized to match Shell-Zydeco pipeline tie-ins. A vertical flow prover with separate master meter connections will be included. All valves and instrumentation will meet the requirements set by Shell. This option assumes installation of BH-SP-1407 flow control scope.

In addition, the installation will include a modular habitable building as the Control Building that is similar to the Lake Charles site. The site and habitable building will require a sanitary sump, oil/water sump, MARSAC type security measures, area lighting, CC security monitoring, full OSHA health and safety elements, and 24hr VDC back-up power supply for instrumentation to maintain operation in event of local outage. Shell-Zydeco location will require at a minimum electric power and access to city water supply for sanitary purposes. The final selected position will be dependent upon these factors. A minimum of 6 to 9 additional BH Operators are required during drawdowns (3 shifts at the new location).

BH will be able to proceed with simultaneous deliveries to Shell/Zydeco Station, Phillips 66 Terminal, and Sun Terminal. BH will have the ability to achieve the Level I drawdown rate which the SPR is committed to maintaining. This alternative meets the mission need and all of the functional requirements of the project. Therefore, this alternative is feasible.

Viability: Continue Analysis

E. Remote Control of ACT Flow Meter Skid at Shell-Zydeco

Shell-Zydeco will have a skid mounted ACT unit equipped with 2 to 3 parallel helical turbine meter trains. The inlet and outlet headers will be sized to match Shell-Zydeco pipeline tie-ins. A vertical flow prover with separate master meter connections will be included. All valves and instrumentation will meet the requirements set by Shell. This option assumes installation of BH-SP-1407 flow control scope.

The site will have local monitoring and control panel only. The primary control will be done at BH SPR site. The site will be secured with a perimeter fence and padlock. The Shell-Zydeco delivery point is located in a remote area that is not easily accessible with current roadways. Additional contract negotiation with Shell Pipeline is required if proceeding without a habitable site. It is not desired to renegotiate the terms with Shell Pipeline.

BH will be able to proceed with simultaneous deliveries to Shell-Zydeco Station, Phillips 66 Terminal, and Sun Terminal. BH will have the ability to achieve the Level I drawdown rate which the SPR is committed to maintaining. This alternative meets the mission need; however, it does not meet all of the functional requirements of the project. There is no improvement to accessibility or enhanced security measures. In addition, it requires contract renegotiation with Shell Pipeline. Therefore, this alternative is not feasible.

Viability: No Further Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A, B, and E are eliminated from further consideration. The remaining alternatives, C and D are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

Assumptions & Constraints

- The alternatives assume the installation of BH-SP-1407 flow control scope.
- The design of the metering station will meet or exceed the 25-year life ascribed to the Life Extension 2 projects.
- The new custody metering station will measure flow rates between 33 MBD and 250 MBD (maximum pipeline capacity). The reading accuracy will be ±0.25 over the normal flow range with a repeatability of 0.02%.
- The metering skid will meet the strict definition of an Allocation Custody Transfer (ACT) skid.
- A prover will be required to verify the accuracy of the meter.
- The accessibility to Shell-Zydeco site will be improved by the construction of a new 20’ by 4000’ road from Hebert Rd.

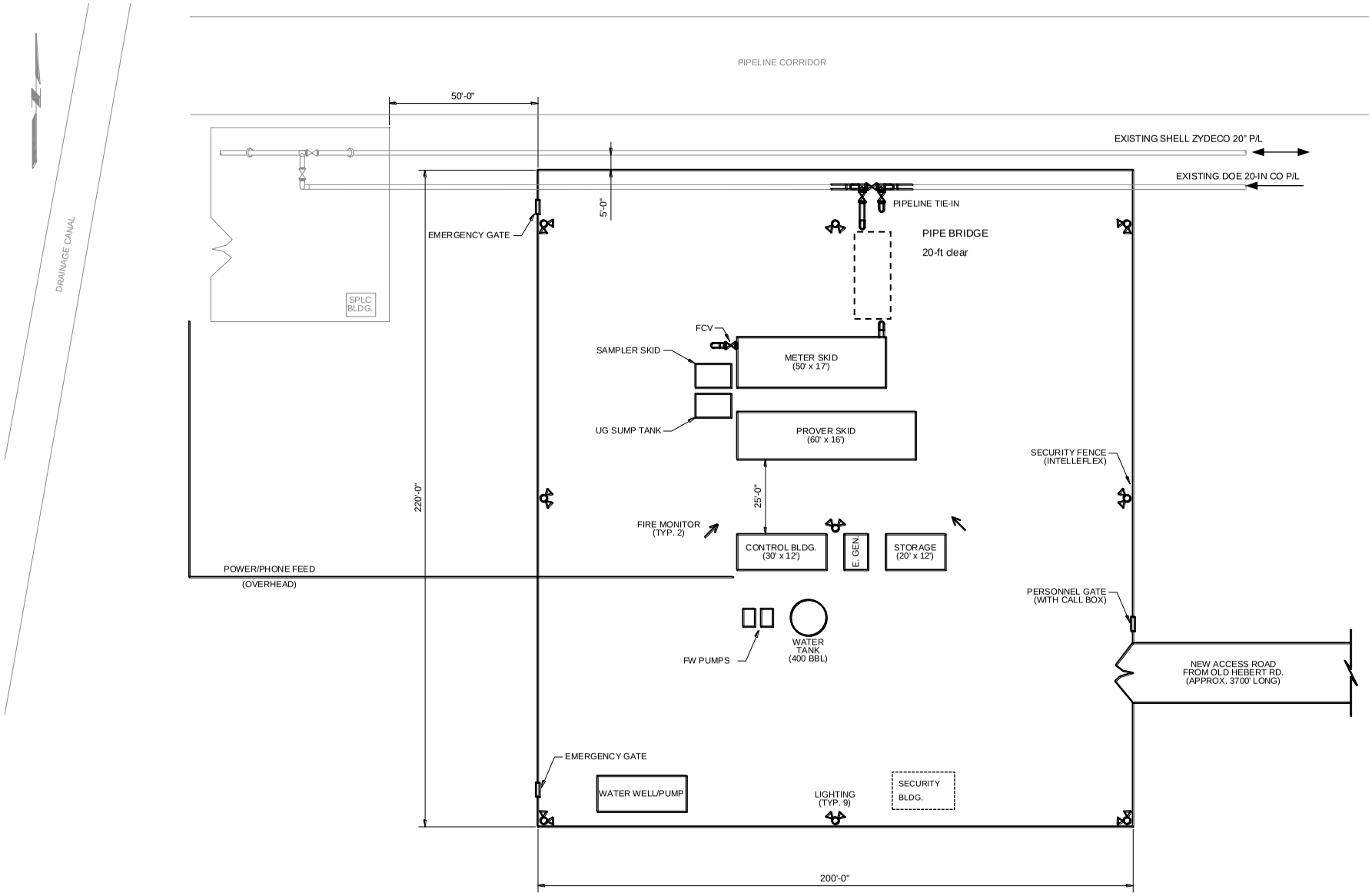

Figure 1 – Shell-Zydeco Meter Station

A. Local Control of ACT Flow Meter Skid at Shell-Zydeco (Not-Habitable) with Standard Security Fence without Full SPR Security Measures.

This alternative will add an Allocation Custody Transfer (ACT) flow meter skid at Shell-Zydeco that will be locally controlled in a building not fully built out but operational with remote monitoring and control from Big Hill's control room. The site will not have full SPR security measures.

Benefits & Effectiveness

Big Hill will be able to simultaneously deliver crude oil to Shell-Zydeco Station, Phillips 66 Terminal, and Sun Terminal with this alternative and the installation of BH-SP-1407 flow control scope. BH will meet the required delivery of 1.0 MMBD of sweet crude oil or 1.1 MMBD of sour crude oil.

This alternative will allow custody transfer metering of crude oil at the Shell-Zydeco Station with the ACT metering skid. The helical turbine meters and prover will accurately measure the crude oil rate delivered to Shell-Zydeco Station. The master meter connection will allow additional verification of the accuracy of the flow. The habitable building will provide adequate shelter and sanitary facility to operators during crude oil drawdowns. Big Hill's control room will be able to monitor the activities at the metering station through telecommunication. The standard security fence without full SPR security measures will provide adequate security to deter intrusions.

Big Hill will be able to maintain the Level 1 drawdown rate, committed by the Strategic Petroleum Reserve (SPR), as it simultaneously delivers crude oil to Shell-Zydeco Station, Phillips 66 Terminal, and Sun Terminal.

Risk & Mitigation Factors

There are associated risks with the installation of flow meters and instrumentation and construction of a habitable building. The table below summarizes the risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Local Control of ACT Flow Meter Skid at Shell-Zydeco (Habitable) with Standard Security Fence without Full SPR Security Measures

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Under-estimated cost	Make sure all possible costs have been analyzed in the life cycle cost analysis.	Low - Low	Low Risk Hazard
Pipeline outage for installation	To avoid a pipeline outage for the installation, hot tap and stopple can be used to access the pipeline while the crude oil rate is maintained through the bypass. The flow meter station can be pre-fabricated and flanges installed on existing pipeline.	Low – High	Low Risk Hazard
Stopple/Hot-Tap equipment un-available	GFP Procurement, contractor schedule work in advance to avoid delays with component/equipment availability.	Medium– High	Medium Risk Hazard
BH-SP-1407 flow control project cancelled	Ensure approval and project progression of BH-SP-1407 before planning the construction on BH-SP-1307	Low – High	Low Risk Hazard
Tie-in/Isolation Valve availability	GFP procurement strategy to order identified long-lead valves	Medium– High	Medium Risk Hazard
Helical turbine flow meter availability	GFP procurement of complete ACT meter skid and prover system	Medium – High	Medium Risk Hazard
PLC malfunctions	Robust PLC housing sustainable in all environmental conditions. Fail safe condition logic written into PLC program, Back-up UPS System, and. Alert functions to BH site of PLC failure.	Medium – High	Medium Risk Hazard

Risk and Mitigation Strategies for Local Control of ACT Flow Meter Skid at Shell-Zydeco (Habitable) with Standard Security Fence without Full SPR Security Measures (continued)			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Telecommunication failure	Alert to BH site for loss of telecommunication. PLC will still control flows and pressure, back-up UPS system.	Medium – Low	Low Risk Hazard
Stationary prover malfunctions	Alert to BH site for loss of prover communication. Set-up monthly site checks to verify flow meter and prover functionality.	Medium – High	Medium Risk Hazard
Utilities availability for habitable building	Local dedicated water well, shared water storage tank, and pressure set. Verify with local electrical utility for adequate supply to support the installed facility, including MCC/Operations Office/ Lab building, and fire pumps	Medium – High	Medium Risk Hazard
Modular building availability and suitability	GFP procurement of modular building. Select building that will meet the needs for habitability and functionality.	Low – Medium	Low Risk Hazard
Foundation support for modular building not adequate	Ensure the concrete pad will support the weight of the building and additional weight from operators and office/lab equipment.	Low – Medium	Low Risk Hazard

B. Local Control of ACT Flow Meter Skid at Shell-Zydeco (Habitable) with Security Fence with Full SPR Security Measures.

This alternative will add an Allocation Custody Transfer (ACT) flow meter skid at Shell-Zydeco that will be locally controlled in a habitable building with remote monitoring and control from Big Hill's control room. The site will have full SPR security measures.

Benefits & Effectiveness

Big Hill (BH) will be able to simultaneously deliver crude oil to the 20-inch Shell Zydeco Pipeline, Phillips 66 Terminal, and Sun Terminal with this alternative and the installation of BH-SP-1407 flow control scope. BH will meet the required delivery of 1.0 MMBD of sweet crude oil or 1.1 MMBD of sour crude oil.

This alternative will allow custody transfer metering of crude oil at the Shell-Zydeco Station with the ACT metering skid. The helical turbine meters and prover will accurately measure the crude oil rate delivered to Shell-Zydeco Station. The master meter connection will allow additional verification of the accuracy of the flow. The habitable building will provide adequate shelter and sanitary facility to operators during crude oil drawdowns. Big Hill's control room will be able to monitor the activities at the metering station through telecommunication. The security system will comply with all SPR security measures and provide adequate security to deter intrusions.

Big Hill will be able to maintain the Level 1 drawdown rate, committed by the Strategic Petroleum Reserve (SPR) as it simultaneously delivers crude oil to Shell-Zydeco Station, Phillips 66 Terminal, and Sun Terminal.

Risk & Mitigation Factors

There are associated risks with the installation of flow meters and instrumentation and construction of a habitable building. The table below summarizes the risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Local Control of ACT Flow Meter Skid at Shell-Zydeco (Habitable) with Security Fence with Full SPR Security Measures

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Under-estimated cost	Make sure all possible costs have been analyzed in the life cycle cost analysis.	Low – Low	Low Risk Hazard
Pipeline outage for installation	To avoid a pipeline outage for the installation, hot tap and stopple can be used to access the pipeline while the crude oil rate is maintained through the bypass. The flow meter station can be pre-fabricated and flanges installed on existing pipeline.	Low – High	Low Risk Hazard
Stopple/Hot-Tap equipment un-available	GFP Procurement, contractor schedule work in advance to avoid delays with component/equipment availability.	Medium– High	Medium Risk Hazard
BH-SP-1407 flow control project cancelled	Ensure approval and project progression of BH-SP-1407 before planning the construction on BH-SP-1307	Low – High	Low Risk Hazard
Tie-in/Isolation Valve availability	GFP procurement strategy to order identified long-lead valves	Medium– High	Medium Risk Hazard
Helical turbine flow meter availability	GFP procurement of complete ACT meter skid and prover system	Medium – High	Low Risk Hazard
PLC malfunctions	Robust PLC housing sustainable in all environmental conditions. Fail safe condition logic written into PLC program, Back-up UPS System, and. Alert functions to BH site of PLC failure.	Medium – High	Medium Risk Hazard
Telecommunication failure	Alert signal at BH site for loss of telecommunication. PLC will still control flows and pressure, back-up UPS system.	Medium – Low	Low Risk Hazard

Risk and Mitigation Strategies for Local Control of ACT Flow Meter Skid at Shell-Zydeco (Habitable) with Security Fence with Full SPR Security Measures (continued)			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Stationary prover malfunctions	Back-up Alert signal to BH site for loss of prover communication. Manned/monitored oil sale operations. Maintenance and testing Set-up monthly site checks to verify flow meter and prover functionality.	Medium – High	Low Risk Hazard
Utilities availability for habitable building	Local dedicated water well, shared water storage tank, and pressure set. Verify with local electrical utility for adequate supply to support the installed facility, including MCC/Operations Office/ Lab building, and fire pumps	Medium – High	Medium Risk Hazard
Modular building availability and suitability	GFP procurement of modular building. Select building that will meet the needs for habitability and functionality.	Low – Medium	Low Risk Hazard
Foundation support for modular building not adequate	Ensure the concrete pad will support the weight of the building and additional weight from operators and office/lab equipment.	Low – Medium	Low Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Local Control of ACT Flow Meter Skid at Shell-Zydeco (Habitable) with Standard Security Fence without Full SPR Security Measures

This alternative will add an Allocation Custody Transfer (ACT) flow meter skid at Shell-Zydeco that will be locally controlled in a habitable building, with remote monitoring and control from Big Hill's control room. The site will not have full SPR security measures.

B. Local Control of ACT Flow Meter Skid at Shell-Zydeco (Habitable) with Security Fence with Full SPR Security Measures

This alternative will add an Allocation Custody Transfer (ACT) flow meter skid at Shell-Zydeco that will be locally controlled in a habitable building, with remote monitoring and control from Big Hill's control room. The site will have full SPR security measures.

Comparison of Alternatives

Core Team Member Ratings

	Constructability During Ongoing Oil Deliveries	**Ease of Operations**	**Ease of Maintenance**	**Safety During Construction**	**Sustainability**
	Most Important	*Important*	*Important*	*Important*	*Less Important*
Alternative A	*Excellent*	*Good*	*Good*	*Good*	*Excellent*
	Excellent	*Good*	*Good*	*Good*	*Excellent*
	Good	*Good*	*Good*	*Good*	*Good*
Alternative B	*Excellent*	*Good*	*Good*	*Good*	*Excellent*
	Excellent	*Good*	*Good*	*Good*	*Excellent*
	Good	*Good*	*Good*	*Good*	*Good*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$16,702,720**	**$17,005,378**
Alternative B	**$17,145,923**	**$17,451,969**

Recommended Alternative

A. Local Control of ACT Flow Meter Skid at Shell-Zydeco (Habitable) with Standard Security Fence without Full SPR Security Measures

Based on the technical evaluation of the Core Team Members, Alternative A and B received equal ratings on all evaluation criteria. Alternative A has a slightly lower investment cost and life cycle cost. While Alternative B includes added scope that is not required and does not provide significant added benefits. Therefore, Alternative A is the recommended preferred alternative.

BH-SP-1407

BH Simultaneous Flow Control to Shell-Zydeco Station, Phillips 66 at the Beaumont Terminal at Hwy 347 Station and Sun Terminal

VCI Project Engineer: Bill Fogle

Recommended Alternative:

Install Remote Ultrasonic Flow Meters Control at Shell, Phillips 66, and Sun Delivery Points

Analysis of Alternatives
Life Extension 2

US Department of Energy
Strategic Petroleum Reserve

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I. PROJECT CONCEPT

Mission Need

The Big Hill (BH) site delivers crude oil via a single 36-inch pipeline leaving the site to one of three destinations: the Shell-Zydeco Pipeline System (Zydeco), the Phillips 66 Beaumont Terminal, and the Sunoco Logistics Nederland (Sun) Terminal. The current BH site configuration does not have the capability to control flow rates to multiple destinations. In addition, there is no means of flow measurement at the Shell-Zydeco Pipeline. Therefore, crude oil deliveries from BH may be made to only one destination at a time. The meter skid at BH is used to meter the flow to each delivery point. System modifications will be necessary to permit simultaneous deliveries to the Shell-Zydeco Station, the Phillips 66 Terminal, and the Sun Terminal. Adding flow control to each of the three points will allow BH to simultaneously deliver crude oil to multiple points.

There are established custody transfer agreements with the Phillips 66 Terminal and the Sun Terminal. Shell-Zydeco Station requires a new custody transfer meter in order to proceed with simultaneous deliveries. Big Hill will have the ability to achieve Level I drawdown rate which the Strategic Petroleum Reserve (SPR) is committed to maintaining.

Functional Requirements

- Simultaneous controlled delivery of crude oil to Shell-Zydeco Pipeline, the Phillips 66 Terminal, and the Sun Terminal. The total required delivery rate is one million barrels per day (MMBD) of sweet crude oil or 1.1 MMBD of sour crude oil.
- The individual rates are Shell Pipeline at 250 thousand barrels per day (MBD), the Phillips 66 Terminal at 225 MBD, and the Sun Terminal at up to 1.1 MMBD.
- The design of the control station must be able to meet or exceed the 25-year life ascribed to the Life Extension 2 projects. DOE I&E standards should be used in the design.
- Any measured flow rates must be within a range of plus-or-minus a certain percent of the desired flow rate.
- Address custody transfer requirements at Shell-Zydeco Station.
- The Big Hill pipeline must have the capability to be completely isolated from Phillips 66 Terminal, Sun Terminal, and the Shell-Zydeco Pipeline system.
- The design must incorporate the ability to equalize or verify pressures between the systems for maintenance purposes.

II. PROCESS

Alternatives Analysis Plan

The complete Analysis of Alternatives (AoA) Process Plan for selection of the preferred alternative has been standardized for all AoA's and is detailed in Volume 1 of this Conceptual Design Report.

Alternative Analysis Team Members

Core Team Members

Claudia Carroll	DOE, Systems Engineer
Bill Fogle	VCI, Project Engineer
Chris Vedros	FFPO, Manager Pipeline and Equipment Integrity

Team Members

Christopher Roark	DOE, Crude Oil Marketing Analysist
Reza Zinolabedini	DOE, Lead General Engineer

Levi Gabre	DOE, Lead General Engineer
Laren Tushim	VCI, Mechanical Engineer
David Wilkins	VCI, Lead Process Engineer
Janet Robert	FFPO, Director Facilities Design and Integrity
Charles DeLuca	FFPO, Principal Operational Systems Engineer
Austin Thompson	FFPO, Manager Crude Oil Program and Logistics
John Guidry	FFPO, Site Director
Tony DeVille	FFPO, Manager Site Operations
Mark Thorn	FFPO, Operations Superintendent

III. SELECTION CRITERIA

The AoA Team determined the below listed criteria as relevant to the Analysis of Alternatives. Once alternatives are analyzed by the AoA Team, these criteria are used to evaluate and select a recommended preferred alternative.

Constructability During On-Going Oil Deliveries

The selected alternative is able to be implemented with little or no impact to on-going oil delivery operations. BH must be able to provide crude deliveries to all three locations individually during the construction period.

Weight: Important

Ease of Operations

The selected alternative when implemented will result in a system that is able to be operated without significant additional training and is similar to existing systems and equipment. The operation of the control station has to be understandable and functional for BH operators.

Weight: Important

Ease of Maintenance

The selected alternative is similar in nature to existing equipment resulting in commonality of similar systems for future maintenance and sparing consideration. The control station must have the capability to be isolated for maintenance purposes and maintain crude oil deliveries.

Weight: Important

Safety during Construction

The selected alternative when implemented will be able to be constructed safely and operated safely. Ability to address Safety and Security concerns during implementation.

Weight: Important

Sustainability

The selected alternative when implemented will be able to achieve DOE Sustainability goals for energy consumption as outlined in the Strategic Sustainability Performance Plan.

Weight: Less Important

IV. ALTERNATIVES IDENTIFICATION

Big Hill (BH) is required to deliver one million barrels per day (MMBD) of sweet crude oil or 1.1 MMBD of sour crude oil. Due to the current delivery infrastructure design, sequential deliveries are made alternately between the Shell-Zydeco Pipeline at 300 thousand barrels per day (MBD), the Phillips 66 Terminal at 250 MBD, and the Sun Terminal at up to 1.1 MMBD, thus the average rate will be lower than the required 1.1 MMBD site drawdown rate criteria.

The current BH site configuration does not have the capability to control flow rates to multiple destinations. In addition, there is no means of flow measurement at the Shell or Phillips 66 Terminal junctures. Therefore, crude oil deliveries from BH may be made to only one destination at a time. The meter skid at BH is used to meter the flow to each delivery point.

System modifications will be necessary to permit simultaneous deliveries to the Shell-Zydeco Station, the Phillips 66 Terminal, and Sun Terminal. Adding flow control to each of the three points will allow BH to simultaneously deliver crude oil to multiple points. With simultaneous delivery, the total rate from Big Hill can be maintained at 1.1 MMBD with some portion of the flow delivered to the Shell-Zydeco Pipeline or Phillips 66 Terminal when necessary and the remainder flowing to the Sun Terminal. When deliveries to Shell-Zydeco Pipeline and Phillips 66 Terminal are not required, the entire 1.1 MMBD flow can be directed to Sun Terminal. A range of plus-or-minus a certain percent of the desired flow rate will have to be determined. The custody transfer meter requirements at Shell-Zydeco Station should be addressed. BH will have the ability to maintain its Level I drawdown rate which the Strategic Petroleum Reserve (SPR) is committed to maintaining.

The Big Hill pipeline must incorporate the capability to be completely isolated from Sun Terminal, Phillips 66 Terminal, and the Shell-Zydeco system. Consequently, valves are required to provide positive isolation. In addition, the ability to equalize or verify pressures between the systems may be required for maintenance purposes. Pressure equalization or differential verification requires at least one additional valve to by-pass the control valve.

List of Alternatives

The below listed alternatives are considered for analysis. Initial screenings conducted by the AoA Team determine the viability of each alternative.

A. Status Quo

Big Hill continues with batch sales of crude oil to single end point users. The crude oil drawdowns will be limited to 300 MBD when going to Shell-Zydeco and 250 MBD when going to Phillips 66. However, because of the current delivery infrastructure design, sequential deliveries must be made alternately between the Shell pipeline at 250 thousand barrels per day (MBD) and the Sun Terminal at up to 1.1 MMBD and thus the average rate will be lower than the required 1.1 MMBD site drawdown rate criteria. The crude oil sales rate to Shell-Zydeco, Phillips 66, and Sun will be measured with BH's Allocation Custody Transfer (ACT) flow meter skid. In addition, the ACT for Phillips 66 crude rate will be based on contractual agreements. The ACT for Sun crude rate will be measures per manual tank strapping done by site operations.

BH will not be able to proceed with simultaneous deliveries to Shell-Zydeco Station, Phillips 66 Terminal, and Sun Terminal. BH will not have the ability to maintain its Level I drawdown rate which the SPR is committed to maintaining. This alternative does not meet mission need or functional requirements set by the project. Therefore, this alternative is not feasible.

Viability: <u>No Further Analysis</u>

B. Install Remote Ultrasonic Flow Meter Control at Shell-Zydeco, Phillips 66, and Sun Delivery Points.

Each location will be equipped with Krone AltoSonic III™ Ultrasonic meter, pressure and temperature transmitters, and a flow control valve, sized for full flow, into downstream piping segment. Manual block valves will be installed to provide isolation for the control valve. A bypass valve will allow continuous flow while the control valve is out of service. The mass flow system data stream from the meters shall feedback to a downstream flow control valve via controller/DCS system to manage percent open. The signals will be fed back to the BH site control room.

The Phillips 66 delivery point will require one new ultrasonic flow meter control station. The site is located in a major pipeline and electrical corridor near an accessible roadway. The access road to the site will be improved. The area will be stripped of vegetation and built up 12" with select fill. Foundations will be provided for the meter and flow control valve. Supplemental area lighting will be provided with 39' tall light poles that are installed on concrete drilled piers. The area will be paved with crushed stone. A security

fence with double gate will be installed around the site perimeter. The electrical system will be updated for instrument requirements and protection.

The Sun delivery point will require two new ultrasonic flow meters and control valve station. The area will be stripped of vegetation and built up 12” with select fill. A foundation will be provided for the meter and flow control valve. Pipe Supports will be provided for the meter and above ground piping. The area will be paved with crushed stone. The site has an existing work area in the MCC for operations. No additional development will be needed at Sun.

The Shell-Zydeco Pipeline delivery point will require one new ultrasonic flow meter control station. The access road to the site will be improved. The area will be stripped of vegetation and built up 12” with select fill. Area lighting will be provided with 39' tall light poles that are installed on concrete drilled piers. The area will be paved with crushed stone. A security fence with double gate will be installed around the site perimeter.

This alternative provides better distribution control of the overall Big Hill/Sun pipeline distribution system. It also provides for “validation” of volumes to the three different terminus points. The system will enhance the measurement capabilities at Shell-Zydeco. However, a single meter may not meet strict definition of an Allocation Custody Transfer (ACT) skid for Shell-Zydeco. BH will be able to proceed with simultaneous deliveries to Shell-Zydeco Station, Phillips 66 Terminal, and Sun Terminal. BH will have the ability to maintain its Level I drawdown rate which the SPR is committed to maintaining. This alternative meets the mission need and all of the functional requirements of the project. Therefore, this alternative is feasible.

Viability: Continue Analysis

C. Install Remote Pressure Differential with Valve Positioning Control Valve Station

This option utilizes pressure differential monitoring and valve positioning to control the flow to the three sites. Manual block valves will be installed to provide isolation for the control valve. A bypass valve will allow continuous flow while the control valve is out of service. This option also provides the side benefit of volumetric measurement, but those volumes would be inferred or calculated values based on the data available. As with Alternative B, the DCS/SCADA data streams will be fed back to the BH site. Local satellite panels are recommended for inclusion to provide access to the data stream during inspection/monitoring visits by site personnel.

The Phillips 66 delivery point is located in a major pipeline and electrical corridor near an accessible roadway. The access road to the site will be improved. The area will be stripped of vegetation and built up 12” with select fill. Foundation will be provided for the flow control valve. Supplemental area lighting will be provided with 39' tall light poles that are installed on concrete drilled piers. The area will be paved with crushed stone. A security fence with double gate will be installed around the site perimeter. The electrical system will be updated for instrument requirements and protection.

The Sun delivery point area will be stripped of vegetation and built up 12” with select fill. A foundation will be provided for the flow control valve. Pipe Supports will be provided for the valve and above ground piping. The area will be paved with crushed stone. The site has an existing work area in an MCC for operations. No additional development will be needed at Sun.

The flow to Shell will be handled by exclusion, again a calculated value based upon the total flow, as measured at BH and the outflows at Sun and Phillips. This is somewhat similar to the current operation, with the exception of the inclusion of new flow control valves at Sun and Phillips. The access road to the site will be improved. The area will be stripped of vegetation and built up 12” with select fill. Area lighting will be provided with 39' tall light poles that are installed on concrete drilled piers. The area will be paved with crushed stone. A security fence with double gate will be installed around the site perimeter

BH will be able to proceed with simultaneous deliveries to Shell-Zydeco Station, Phillips 66 Terminal, and Sun Terminal. However, the flow rates are not measured, rather they are volumetrically inferred or calculated values.

This alternative does not meet the current DOE I&E design configuration as it will increase the number of components that will require spares. This alternative meets the mission need; however, it does not meet all of the functional requirements of the project. Therefore, this alternative is not feasible.

Viability: No Further Analysis

D. Install Remote Control Valve Station with Ultrasonic Meters at Sun and Phillips and Pressure Differential at Shell-Zydeco with BH-SP-1307.

This option is similar to alternatives B and C and includes Krone Altosonic III™ ultrasonic meter(s) and flow control valve(s) at the Sun and Phillips 66 site locations. Manual block valves will be installed to provide isolation for the control valve. A bypass valve will allow continuous flow while the control valve is out of service. The mass flow system data stream from the meters shall provide feedback to a downstream flow control valve via controller/DCS system to manage percent open. The signals will be fed back to the BH site control room.

The Phillips 66 delivery point will require one new ultrasonic flow meter control station. The site is located in a major pipeline and electrical corridor near an accessible roadway. The access road to the site will be improved. The area will be stripped of vegetation and built up 12” with select fill. Foundations will be provided for the meter and flow control valve. Supplemental area lighting will be provided with 39' tall light poles that are installed on concrete drilled piers. The area will be paved with crushed stone. A security fence with double gate will be installed around the site perimeter. The electrical system will be updated for instrument requirements and protection.

The Sun delivery point will require two new ultrasonic flow meters and control valve station. The area will be stripped of vegetation and built up 12” with select fill. A foundation will be provided for the meter and flow control valve. Pipe Supports will be provided for the meter and above ground piping. The area will be paved with crushed stone. The site has an existing work area in an MCC for operations. No additional development will be needed at Sun.

The Shell-Zydeco station will have a pressure differential type controller linked to the new flow control valve. The connection into the Shell-Zydeco pipeline will be also configured to incorporate an Allocation Custody Transfer (ACT) metering/prover skid. That unit will be included as a part of BH-SP-1307, which addresses metering and site modifications. The flow controller will be routed through a local PLC/HMI control panel that may be interconnected to the local control building. Also, the DCS/SCADA data streams will be fed back to the BH site.

BH will be able to proceed with simultaneous deliveries to Shell-Zydeco Station, Phillips 66 Terminal, and Sun Terminal. BH will have the ability to maintain its Level I drawdown rate which the SPR is committed to maintaining. This alternative meets the mission need and all of the functional requirements of the project. Therefore, this alternative is feasible.

Viability: Continue Analysis

V. ALTERNATIVES ANALYSIS

Based on initial analysis of the alternatives, alternatives A and C have been eliminated from further consideration. The remaining alternatives, B and D are examined below as alternatives A and B, respectively.

The below analyses provide the research and technical information gathered by the AoA Team. These analyses are not evaluative or comparative.

Assumptions & Constraints

- Simultaneous controlled delivery of crude oil to Shell-Zydeco Pipeline, the Phillips 66 Terminal, and the Sun Terminal. The total required delivery rate is one million barrels per day (MMBD) of sweet crude oil or 1.1 MMBD of sour crude oil.

- The individual rates are Shell Pipeline at 250 thousand barrels per day (MBD), the Phillips 66 Terminal at 250 MBD, and the Sun Terminal at up to 1.1 MMBD.
- The design of the control station must be able to meet or exceed the 25-year life ascribed to the Life Extension 2 projects. DOE I&E standards should be used in the design.
- Any measured flow rates within a range of plus-or-minus a certain percent of the desired flow rate.
- The Big Hill pipeline should be capable to be completely isolated from Phillips 66 Terminal, Sun Terminal, and the Shell Pipeline system.
- The design incorporates the ability to equalize or verify pressures between the systems for maintenance purposes.
- We are capable of addressing all custody transfer requirements at Shell-Zydeco Station.
- The standard security fence will deter intrusions.

A. Install Remote Ultrasonic Flow Meters Control at Shell, Phillips 66, and Sun Delivery Points.

Each location will be equipped with Krone AltoSonic III™ Ultrasonic meter, pressure and temperature transmitters, and a flow control valve, sized for full flow, into downstream piping segment. Manual block valves will be installed to provide isolation for the control valve. A bypass valve will allow continuous flow while the control valve is out of service. The mass flow system data stream from the meters shall feedback to a downstream flow control valve via controller/DCS system to manage percent open. The signals will be fed back to the BH site control room.

The Phillips 66 delivery point will require one new ultrasonic flow meter control station. The site is located in a major pipeline and electrical corridor near an accessible roadway. The access road to the site will be improved. The area will be stripped of vegetation and built up 12” with select fill. Foundations will be provided for the meter and flow control valve. Supplemental area lighting will be provided with 39' tall light poles that are installed on concrete drilled piers. The area will be paved with crushed stone. A security fence with double gate will be installed around the site perimeter. The electrical system will be updated for instrument requirements and protection.

The Sun delivery point will require two new ultrasonic flow meters and control valve station. The area will be stripped of vegetation and built up 12” with select fill. A foundation will be provided for the meter and flow control valve. Pipe Supports will be provided for the meter and above ground piping. The area will be paved with crushed stone. The site has an existing work area in the MCC for operations. No additional development will be needed at Sun.

The Shell-Zydeco Pipeline delivery point will require one new ultrasonic flow meter control station. The access road to the site will be improved. The area will be stripped of vegetation and built up 12” with select fill. Area lighting will be provided with 39' tall light poles that are installed on concrete drilled piers. The area will be paved with crushed stone. A security fence with double gate will be installed around the site perimeter.

This alternative provides better distribution control of the overall Big Hill/Sun pipeline distribution system. It also provides for “validation” of volumes to the three different terminus points. The system will enhance the measurement capabilities at Shell-Zydeco. However, a single meter may not meet strict definition of an Allocation Custody Transfer (ACT) skid for Shell-Zydeco. BH will be able to proceed with simultaneous deliveries to Shell-Zydeco Station, Phillips 66 Terminal, and Sun Terminal. BH will have the ability to maintain its Level I drawdown rate which the SPR is committed to maintaining.

Benefits & Effectiveness

Big Hill will be able to simultaneously deliver crude oil to Shell-Zydeco Station, Phillips 66 Terminal at the Hwy 347 Station, and Sun Terminal with this alternative. BH will meet the required delivery of 1.0 MMBD of sweet crude oil or 1.1 MMBD of sour crude oil.

The new ultrasonic flow meters at Phillips 66 and Sun will provide more accurate measurements than the existing ACT practices. The Phillips 66 measured crude rate will be compared to the contractual agreements. The Sun measured crude rate will be compared to the volume from manual tank strapping done by site operations. The new ultrasonic flow control valve at Shell-Zydeco will allow control of the flows from BH and measure flow rate. Big Hill’s control room will be able to monitor the activities at the metering station through telecommunication. The control valve and bypass station will allow for isolation from the Big Hill pipeline while maintaining flow for future maintenance work.

Big Hill will be able to maintain its Level 1 drawdown rate, committed by the Strategic Petroleum Reserve (SPR) as it simultaneously delivers crude oil to the Shell-Zydeco Station, the Phillips 66 Terminal at the Hwy 347 Station, and Sun Terminal.

Risk & Mitigation Factors

There are associated risks with the installation of flow meters, instrumentation, and valves. The table below summarizes the risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for Install Remote Ultrasonic Flow Meters Control at Shell, Phillips 66, and Sun Delivery Points			
Risks	**Mitigation Strategy**	**Likelihood - Impact**	**Risk Code**
Under-estimated cost	Make sure all possible costs have been analyzed in the life cycle cost analysis.	Low - Low	Low Risk Hazard
Pipeline outage for installation	To avoid a pipeline outage for the installation, hot tap and stopple can be used to access the pipeline while the crude oil rate is maintained through the bypass. The control valve station can be pre-fabricated and flanges installed on existing pipeline.	Low – High	Low Risk Hazard
Hot Tap equipment un-available	Procure contractor and schedule work in advance to avoid delays with hot tap equipment availability.	High – High	High Risk Hazard
Ultrasonic flow meter compatibility with crude oil	Research and verify best flow meter type for crude oil application.	Low - Medium	Low Risk Hazard
Ultrasonic flow meter availability	Check with vendors on size availability and procure as a long lead time for delivery.	Medium – High	Medium Risk Hazard
Control valve availability	Check with vendors on size availability and procure as a long lead item for delivery.	Medium – High	Medium Risk Hazard
PLC malfunctions	Robust PLC housing sustainable in all environmental conditions. Fail safe condition logic written into PLC program. Alert functions to BH site of PLC failure.	Medium – High	Medium Risk Hazard
Telecommunication failure	Alert to BH site for loss of VSAT communication. PLC will still control flows and pressure.	Medium – Low	Medium Risk Hazard
Limited pumping capacity	Review the pump curve. Determine if the pump will be able to deliver the maximum required flow to all three sites simultaneously.	Medium – High	Medium Risk Hazard

B. Install Remote Control Valve Station with Ultrasonic Meters at Sun and Phillips and Pressure Differential at Shell-Zydeco with BH-SP-1307.

This option is similar to alternative A and includes Krone Altosonic III™ ultrasonic meter(s) and flow control valve(s) at the Sun and Phillips 66 site locations. Manual block valves will be installed to provide isolation for the control valve. A bypass valve will allow continuous flow while the control valve is out of service. The mass flow system data stream from the meters shall provide feedback to a downstream flow control valve via controller/DCS system to manage percent open. The signals will be fed back to the BH site control room.

The Phillips 66 delivery point will require one new ultrasonic flow meter control station. The site is located in a major pipeline and electrical corridor near an accessible roadway. The access road to the site will be improved. The area will be stripped of vegetation and built up 12” with select fill. Foundations will be provided for the meter and flow control valve. Supplemental area lighting will be provided with 39' tall light poles that are installed on concrete drilled piers. The area will be paved with crushed stone. A security fence with double gate will be installed around the site perimeter. The electrical system will be updated for instrument requirements and protection.

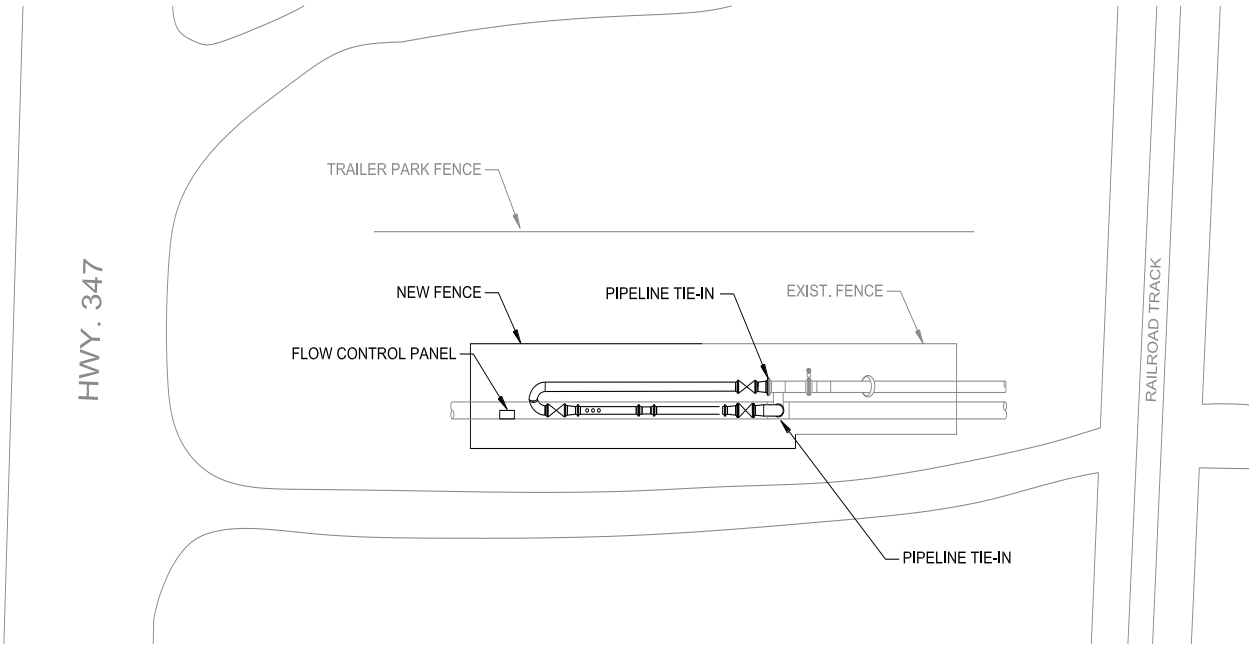

Figure 1 – DOE/Phillips 66 at Beaumont Terminal HWY 347 Station

The Sun delivery point will require two new ultrasonic flow meters and control valve station. The area will be stripped of vegetation and built up 12” with select fill. A foundation will be provided for the meter and flow control valve. Pipe Supports will be provided for the meter and above ground piping. The area will be paved with crushed stone. The site has an existing work area in an MCC for operations. No additional development will be needed at Sun.

The Shell-Zydeco station will have a pressure differential type controller linked to the new flow control valve. The connection into the Shell-Zydeco pipeline will be also configured to incorporate an Allocation Custody Transfer (ACT) metering/prover skid. That unit will be included as a part of BH-SP-1307, which addresses metering and site modifications. The flow controller will be routed through a local PLC/HMI control panel that may be interconnected to the local control building. Also, the DCS/SCADA data streams will be fed back to the BH site.

BH will be able to proceed with simultaneous deliveries to Shell-Zydeco Station, Phillips 66 Terminal, and Sun Terminal. BH will have the ability to maintain its Level I drawdown rate which the SPR is committed to maintaining.

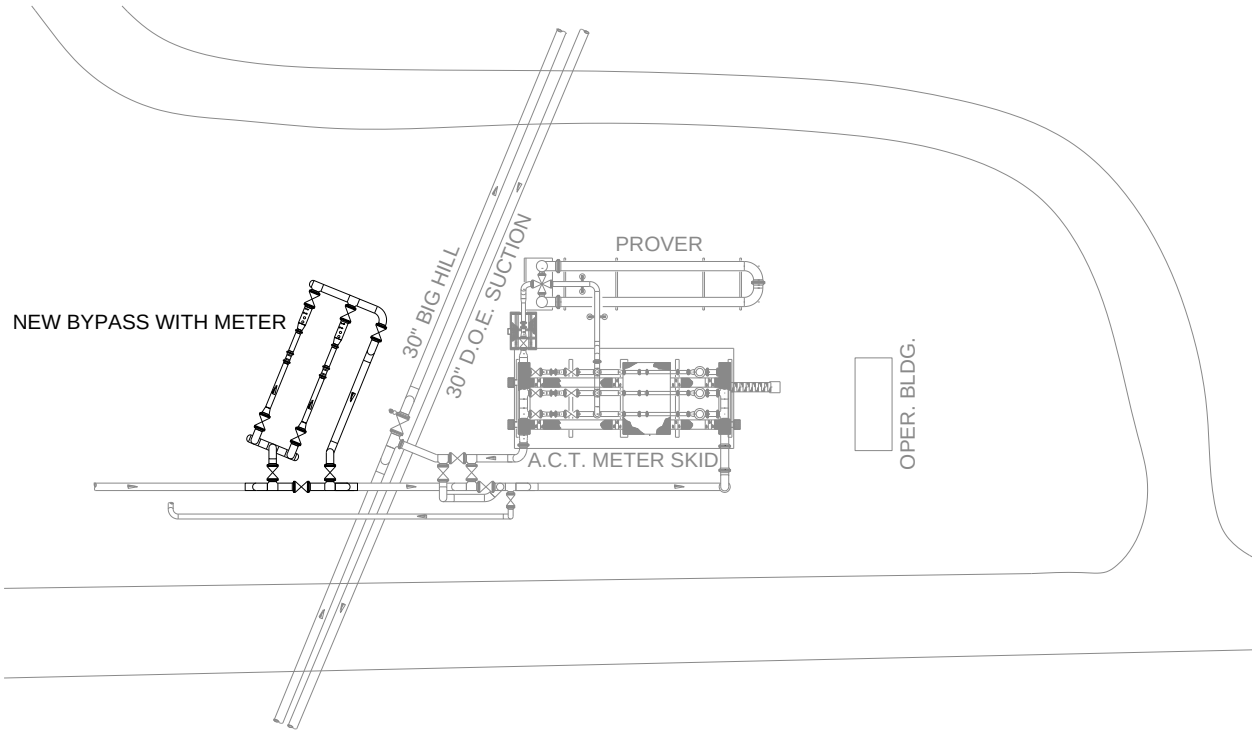

Figure 2 – Sun Logistics Nederland Terminal

Assumptions & Constraints

- Assumes the installation of BH-SP-1307 Shell-Zydeco Custody Meter Skid

Benefits & Effectiveness

Big Hill will be able to simultaneously deliver crude oil to Shell-Zydeco Station, Phillips 66 Terminal at the Hwy 347 Station, and Sun Terminal with this alternative and the installation of BH-SP-1407 flow control scope. BH will meet the required delivery of 1.0 MMBD of sweet crude oil or 1.1 MMBD of sour crude oil.

The new ultrasonic flow meters at Phillips 66 and Sun will provide more accurate measurements than the existing ACT practices. The Phillips 66 measured crude rate will be compared to the contractual agreements. The Sun measured crude rate will be compared to the volume from manual tank strapping done by site operations. The pressure differential control valve at Shell-Zydeco will allow control of the split flows from BH. Big Hill's control room will be able to monitor the activities at the metering station through telecommunication. The control valve and bypass station will allow for isolation from the Big Hill pipeline while maintaining flow for future maintenance work.

Project BH-SP-1407 adds flow control to the Shell-Zydeco Station, Phillips 66 at the HWY 347 Station, and Sun Terminal. There are established custody transfer agreements with the Phillips 66 Terminal at the HWY 347 Station and Sun Terminal. Project BH-SP-1307 adds custody transfer metering at the Shell-Zydeco Station. Projects BH-SP-1307 and BH-SP-1407 can be interdependent

Big Hill will be able to maintain its Level 1 drawdown rate, committed by the Strategic Petroleum Reserve (SPR) as it simultaneously delivers crude oil to Shell-Zydeco Station, Phillips 66 / Hwy 347 Station, and Sun Terminal.

Risk & Mitigation Factors

There are associated risks with the installation of flow meters, instrumentation, and valves. The planning will significantly affect the pipeline operability during the installation. The table below summarizes the risks with the correlating mitigation strategy. The table also describes the likelihood of occurrence at the site along with how great of an impact the event would cause if it were to occur.

Risk and Mitigation Strategies for All Sites with Ultrasonic Meters and Flow Control Valve Station

Risks	Mitigation Strategy	Likelihood - Impact	Risk Code
Under-estimated cost	Make sure all possible costs have been analyzed in the life cycle cost analysis.	Low – Low	Low Risk Hazard
Pipeline outage for installation	To avoid a pipeline outage for the installation, hot tap and stopple can be used to access the pipeline while the crude oil rate is maintained through the bypass. The control valve station can be pre-fabricated and flanges installed on existing pipeline.	Low – High	Low Risk Hazard
Hot Tap equipment un-available	Procure contractor and schedule work in advance to avoid delays with hot tap equipment availability.	High – High	High Risk Hazard
BH-SP-1307 Shell-Zydeco Station Custody Metering cancelled	Ensure approval and project progression of BH-SP-1307 before planning the construction on BH-SP-1407	Low – High	Low Risk Hazard
Ultrasonic flow meter compatibility with crude oil	Research and verify best flow meter type for crude oil application.	Low - Medium	Low Risk Hazard
Ultrasonic flow meter availability	Check with vendors on size availability and procure as a long lead time for delivery.	Medium – High	Medium Risk Hazard
Control valve availability	Check with vendors on size availability and procure as a long lead time for delivery.	Medium – High	Medium Risk Hazard
PLC malfunctions	Robust PLC housing sustainable in all environmental conditions. Fail safe condition logic written into PLC program. Alert functions to BH site of PLC failure.	Medium – High	Medium Risk Hazard
Telecommunication failure	Alert to BH site for loss of VSAT communication. PLC will still control flows and pressure.	Medium – Low	Low Risk Hazard
Limited pumping capacity	Review the pump curve. Determine if the pump will be able to deliver the maximum required flow to all three sites simultaneously.	Medium – High	Medium Risk Hazard

VI. ALTERNATIVE SELECTION

List of Alternatives – Studied Alternatives

A. Install Remote Ultrasonic Flow Meters Control at Shell, Phillips 66, and Sun Delivery Points

This alternative will install ultrasonic meter control valve station at Shell-Zydeco, Sun, and Phillips 66 delivery points. All will be remotely controlled from the BH control room.

B. Install Remote Control Valve Station with Ultrasonic Meters at Sun and Phillips and Pressure Differential at Shell-Zydeco with BH-SP-1307

This alternative will install ultrasonic meter control valve station at Sun and Phillips 66 delivery points. Shell-Zydeco delivery point will have a pressure differential control valve station with an ACT from CDR BH-SP-1307. All will be remotely controlled from the BH control room.

Comparison of Alternatives

Core Team Member Ratings

	Constructability During Ongoing Oil Deliveries	**Ease of Operations**	**Ease of Maintenance**	**Safety During Construction**	**Sustainability**
	Important	*Important*	*Important*	*Important*	*Less Important*
Alternative A	*Good*	*Excellent*	*Good*	*Excellent*	*Excellent*
	Excellent	*Good*	*Good*	*Excellent*	*Excellent*
	Good	*Good*	*Good*	*Good*	*Good*
Alternative B	*Good*	*Excellent*	*Good*	*Excellent*	*Excellent*
	Excellent	*Excellent*	*Good*	*Excellent*	*Excellent*
	Good	*Excellent*	*Good*	*Good*	*Good*

Cost Comparison

	Total Estimated Cost (TEC)	**Life Cycle Cost (LCC)**
Alternative A	**$15,924,977**	**$15,984,682**
Alternative B	**$18,849,691**	**$18,911,177**

Recommended Alternative

A. Install Remote Ultrasonic Flow Meters Control at Shell, Phillips 66, and Sun Delivery Points

Based on the technical evaluation of the Core Team Members, Alternative B was rated slightly higher on one evaluation factor by two members, and the same on all other evaluation factors. Alternative A has a lower investment cost and life cycle cost. The technical factor ratings that favor Alternative B is very slight, and was determined not to outweigh the significantly increased cost of Alternative B. Therefore, Alternative A is the recommended preferred alternative.