Preparation of Method Statements
For
Trans-Saharan Gas
Pipeline Project

Prepared for

Flywheel Resources

Revision A
19 November 2004

by

International Construction Consulting, LLC

Greg Lamberson

Record of Revisions

Rev	Date	Description	Prepared By	Checked By	Client Accept	Approved By
A	19 Nov 04	Internal Review	FGL	FGL		

Table of Contents

1. Report Overview and Scope of Work

This report has been prepared as a result of instructions from Flywheel Resources to perform the following tasks with relation to the Trans-Saharan Gas Pipeline Project:

- Prepare a methodology statement for performing the Engineering and the Construction Infrastructure study portion of the ITB PST-TECH-BID-09-04
- Prepare a methodology statement for performing the Environmental study portion of the ITB PST-TECH-BID-09-04
- Prepare a methodology statement for performing the Project Cost Estimate Analysis portion of the ITB PST-TECH-BID-09-04
- Prepare a level of effort required to perform the pipeline route optimization activities.

The objective was to develop the above write ups based on previous pipeline construction, planning, and design experience in order to achieve overall ITB objectives, which are a quality, constructible, and cost effective pipeline system.

The report has been broken down into four separate sections for clarity. Further, the methodology statements have been prepared based on a review of the scope of work and based on previous experience and best practices.

This report and methodology statements contained herein have been prepared based on previous experience and industry Best Practices. These are the opinions of the author as to what kind of program needs to be implemented and the level of effort required to satisfactorily complete the SOW. It is strongly recommended that the document be reviewed internally against the feasibility study cost estimate to assure the methodology as written here aligns itself to the cost estimate, the envisioned organization, the overall execution philosophy, as well as WEI's internal systems.

Additionally, there are a two "placeholders" that are included that will require something be included in them, in one case it is a time frame, in the other it is additional stakeholders that may be involved in the project. The pages that have the "placeholders" to be addressed are:

- Page 5
- Page 28

2. Engineering

Introduction

This document provides an overall summary of Willbros Engineering, Inc's (WEI) execution plan for the Trans-Saharan Gas Pipeline Project's Conceptual Engineering Services. A more detailed description of project execution and management procedures will be developed upon contract award.

Scope

The Engineering Services scope of work to be performed by WEI will be to develop conceptual and feasibility work which will form the basis for the Trans-Saharan Field Development Plan (FDP) and associated cost optimization work.

WEI will prepare the following items that are directly related to the technical definition of the project components:

- Design Basis Memorandum (DBM), including
- Project Execution Plan
- Project Cost Estimate
- Integrated Project Schedule
- Project Cost Estimate
- Estimate Confidence Package

WEI will also develop supporting documents for the above major deliverable packages, which will include but not be limited to:

- SCADA/Telecoms systems and philosophy,
- Cathodic protection systems, including coating recommendations
- Hydraulics studies
- System optimization
- Environmental Issues Study

Execution Overview

General

The following is the WEI plan for execution for the Trans-Saharan Gas Pipeline Project. It follows the same general outline as the Trans-Saharan's project scope of work document. In our planning, we have assumed performance of the work will be as an integrated team using the combined expertise of WEI, Willbros International, (**add in other stakeholders here**). We have selected our team on the basis of related experience and uniquely focused expertise. This will allow our team to efficiently address the challenges of this project.

Mobilization

A critical activity common with all work segments is receiving and absorption of the preliminary work and plans that serve as the starting point for the Feasibility Study. We anticipate that the Client will deliver these documents to WEI within the first week of the project and will be available to discuss a detailed scope of work and path forward in this same time period. This meeting would be held in Houston with key personnel from all locations in attendance. With this as an introduction, our management team would further distribute the documents to their reports and kick off their detailed review.

WEI will hold regular meetings as the review proceeds to build a common understanding of the specific challenges. These regular meetings will serve as the basis for the development of the detailed technical scope documents for the project. With this detailed understanding of the work, each scope component will be developed and estimated. The Client's active integrated participation is encouraged in order to avoid delays in achieving the Feasibility Study program schedule.

Interface Management

In our integrated team concept, our goal is to make organizational interfaces transparent. Individuals will be encouraged and expected to act as if a single company employed all of them. A cooperative spirit will be instilled through repetitive team building exercises for the key staff and Value Engineering exercises to optimize the designs. The management team will visibly demonstrate commitment to and support for this concept.

Contacts among members of the teams will not be controlled but will be documented in a readily accessible database to the extent of significant decisions made, requests for support, changes in scope allocation, schedule impacts and other information of significance that is discussed.

The teams will function as if they were different departments of a single company. Each will have its own defined scope, goals, budgets, schedule commitments, quality control, responsibilities, etc. The Study Manager will integrate these components into a cohesive organization.

The plan for management of interfaces also focuses on the physical boundaries created by teams in more than one city.

Our plan includes location of the following in WEI's Tulsa offices:

- Trans-Saharan team member(s),
- WEI management team,
- All facilities, including compressor stations, meter station, conceptual design,
- All pipelines, trunk lines, and distribution lines FEED design and

The Market Study, Gas Supply, Policy Issues, Institutional Framework, and Risk Analysis/Regional Benefit Study will be performed in Houston.

Cost estimates and pipeline route selection and optimization will be performed out of the Willbros International office in Houston.

We have analyzed the challenge of these physical interfaces and have developed the following plans to deal with each:

- We believe the various interfaces inside WEI's Tulsa office will be directly managed on a day-to-day basis by the assigned supervisory staff and will not require additional interface managers.

- All segments of the project will have administrative interfaces, shared design specifications and standards, common cost and progress measuring, common needs, etc.

During the initial conceptual engineering effort, key team members from all locations will come to Tulsa for a series of meetings focused on understanding the data and plans delivered by Trans-Sahara, team-building and defining these shared interfaces. The Study Manager and his staff will directly monitor, assess, audit, facilitate, and enforce these interfaces.

- The division of the cost estimates and pipeline route optimization between Tulsa and Houston has been managed successfully on previous projects by Willbros.

Our plan includes locating a Willbros International Constructability Engineer from the staff in Houston to the office in Tulsa to serve as the liason between these offices.

The pipeline interface is subject to relatively specific definition at the start of the project so a Pipeline Interface/Constructability Manager will manage this interface from Houston. This concept will be monitored for effectiveness. A backup plan will provide for placing this individual in Tulsa immediately if needed.

Subcontracting Plan

Our proposal nominates the primary subcontractors required for provision of the Feasibility Study services. WEI has committed to execute these subcontracts on a back-to-back basis having the same terms as our primary contract with Trans-Sahara. Remaining subcontracts will be for limited special services such as consultants, technical specialists, and the like. When identified to be needed, they will be evaluated and awarded with Trans-Sahara's concurrence.

Issues Identification and Management

A master Action Item List will be used throughout the project to assure that issues are identified and resolved in a timely fashion and no overlooked commitments are allowed to become problems. The master Action Item List will track commitments from all teams, including Trans-Sahara, and will be maintained accessible electronically in a form that can be sorted by date, responsible party, ITQ package, DBM, source document, etc. Minutes from each meeting will include a list of the action items agreed to in the meeting. These will be transferred to the master list along with a reference to the minutes.

Each office location will have a local master action item list that will be rolled up into the overall action item list weekly and distributed to all offices. Anyone at a lead level or higher will also be required to document commitments as entries into this action item list when they arise in situations that are not documented by minutes. Items will be transferred off the active list to a historical record after having been shown as complete in one weekly issue of the Action Item List. The Study Manager will have the administrative responsibility to manage the Overall Master Action Item List.

Communication

A detailed communication / coordination plan will be developed for Trans-Sahara's concurrence. The plan will include the following:

- Weekly Project Staff meetings in each office - typically 1 hour in length with minutes shared among offices
- Monthly Status Report Procedure addressing contributions from all offices
- Monthly Status Meetings with Executive Management - typically 2-4 hours in length
- Meeting Minute Procedure
- Action Item List Procedure
- LAN systems configured to meet Trans-Sahara's requirements
- Interoffice Communication Procedure addressing when to use:
  - Postal Service
  - Overnight Package services
  - Facsimile Transmission
  - Long distance and cellular phone services
  - Project Video Conference System
  - Internet email and web page techniques

Cost Control

The cost control effort will culminate in the presentation of both historical and predicted information for use in project management decision making. Key to the cost control effort is to link the Original Budget, client-approved scope changes, committed costs, and actual costs.

Project cost reports will contain information on cost, man-hours and quantities and present the information in a format that clearly shows:

Original Budget

Project cost control procedures will be developed during preparation of the Job Procedures Manual. The following information will be provided in accordance with the WEI Standard Code of Accounts using a Project Work Breakdown Structure (PWBS).

- Approved Change Orders

- Transfers
- Revised Control Budget
- Commitments, inception to date and current month
- Expenditures, inception to date and current month
- Predicted to Complete
- Predicted Total
- Over/Under against Revised Control Budget

Performance Measurement
A Performance Measurement System will be used to calculate performance. The budgeted man-hour effort for each discipline is broken down by standard product related task codes. Physical progress determines the earned man-hours for each product. This is compared with the actual man-hours expended to determine trends in Performance for each discipline. The Man-hour Performance Report is issued on a monthly basis.

Integration
WEI will provide a standardized format and set of instructions for all team members to follow and report against to ensure uniformity. Project Control Procedures and Change Management Procedures will be developed in detail as part of the Job Procedure manual preparation.

Scheduling
The key to effective schedule control is a firm scope of work planned in a logical fashion and scheduled in a realistic manner to meet all required project milestone dates. The milestones and plan for the Trans-Sahara project schedule will be developed with input from both the Trans-Sahara and WEI project team members using the proposal information as a basis.

Immediately after contract award a level I Feasibility Study Schedule will be developed and used to confirm the project major milestones. The proposal schedule will then be expanded to reflect additional detail in both the Engineering & Construction sections resulting in a schedule which contains level II detail.

All schedule updates will be reviewed with the discipline leads to ensure that remaining duration forecasts are accurate and that schedule logic remains valid. This is done in conjunction with reviewing the update of physical progress to ensure that the remaining duration of the deliverables in the schedule match the physical progress reported.

Quality Assurance
WEI will provide overall quality management requirements to be observed by WEI and its subcontract partners. Detailed execution of work being executed by our partners will be performed in accordance with the WEI internal ISO 9001 qualified work methods. WEI and each of its subcontractors will have procedures that will cover the following:

- Project Quality Assurance Planning
- Change Control

- Document and Data Control
- Design Checking and Verification
- Design Reviews
- Technical and Quality Assurance Audits

Project QA/QC requirements and responsibilities will be detailed in the Project TQM Plan which will be included as part of the Job Procedures Manual. The Integrated Team members are responsible for monitoring the technical performance of their assigned project personnel. Where deficiencies are noted, remedial action must be taken by the project and documented.

Value Engineering

Value Engineering is an organized effort directed at analyzing project systems, equipment, facilities, and services to achieve essential functions at the lowest life-cycle or total installed cost (whichever is appropriate) and accomplish this in accordance with required performance, reliability, quality, and safety. This activity includes key members from the Integrated Team as well as off project decision-makers and stakeholders.

WEI has successfully used and applied Value Engineering on various projects as a project execution tool. This has shown to be an effective tool to ensure the adherence to, or improvement of, project budgets and schedules. Value Engineering is used to identify and remove nonessential execution, capital and operating costs while maintaining optimum quality Engineering, Procurement and Construction performance. The Study Manager will establish a Value Engineering Program to identify and analyze areas of significant cost and/or schedule reduction.

Lessons Learned

In order to provide comprehensive feedback from WEI and to draw on the synergies of our partners, WEI will develop a Lessons Learned Program for implementation on the project. The Program will be developed in detail and issued as part of the Job Procedures Manual.

Cost Estimating

The project cost estimate will be categorized as a Class III estimate, with an accuracy of +/-20%.

WEI and its subcontractors will utilize worldwide resources to help ensure the accuracy of this estimate as well as meet the objective of ensuring the lowest life cycle cost for the project.

The final estimate will be summarized and presented in line with the work breakdown structure.

To assist with reviews of the estimates, we will provide various summaries, which roll up the lowest level cost details to view it by discipline or craft, by area, by system, by site location or other breakdown that Trans-Sahara may need.

The estimate results will be benchmarked against WEI database for similar type projects, which includes various gas pipelines, compressor stations, meter stations, etc. and various units constructed in extreme weather, rain forests, and desert conditions similar to the weather and terrain conditions on the Trans-Saharan project.

The estimate itself will consist of a variety of cost data ranging from Vendor quotes received to internal cost data. However all costs will be estimated in detail and will be recognized as such in the estimate.

Equipment

Equipment pricing will be developed by individual tag number using the equipment specifications prepared for this project.

For pricing, WEI will request quotations for non-standard equipment. Other equipment will be priced in-house using WEI's database.

However, depending on the situation, pricing may be budgetary, may only come from single companies or in some cases we may use full competitive bidding as for long lead items. WEI's worldwide procurement capabilities will help to ensure the estimate is based on realistic prices from the most convenient locations. Concurrently, the Logistics department will be working closely with the project to assure that freight and shipping costs are clearly understood.

Materials

Bulk material quantities will be generated and priced against WEI database for like items. Special items unique to the Trans-Saharans Project will be sent out for quotation.

Transportation/Freight

A detailed transportation and freight analysis will be performed and will form the basis for the cost estimate. This analysis will seek to determine the best and lowest cost method of transportation. The study also will identify restraints on timing; paperwork requirements; associated taxes, duties and fees; and other items of cost significant to preparing +/-20% estimates.

Construction Costs

The initial field man-hour estimate will be based upon experience specific to the regions crossed by the pipeline system and our other historical data. This will help to establish a strong baseline of comparison when making a budget analysis. Willbros has recently completed projects in the relevant countries, as well as the current experience of our subcontractors will be used as a resource to help determine the effect on the man-hours including productivity, supervision, crew sizes/composition, etc. for each craft activity. These same offices will help to determine the appropriate wage rates by craft as well as all associated benefits and taxes. Input obtained from their recent experience will be utilized to make the estimate as realistic as possible.

The indirect construction costs at the project and construction sites will be estimated in detail considering camp costs, the construction management staffing plan, transportation, offices, administration and other such costs. Again, Willbros and local contractors will provide relevant recent experience to provide realistic information for inclusion in the estimate.

Additional details of the Project Cost Estimate are contained in Section 5, Project Cost Estimate.

Risk Analysis / Range Estimating

Upon completion of the estimate, WEI will perform a thorough estimate review check to verify the accuracy range of the estimate. Based on experience with a multitude of similar projects, we are confident that we know the appropriate steps to be taken in order to reach the desired +/-15% accuracy.

DBM Development

At the time of contract award, WEI will begin to develop and upgrade a PDM into a draft DBM. During a series of meetings following award, WEI will work with Trans-Sahara to develop its content as required to support completion of the DBM.

During the course of the Study, the WEI team will periodically insert its results into the draft DBM. The WEI team will also incorporate results from other completed optimization / design studies performed by or for Trans-Sahara as they are made available. A DBM "design freeze" meeting will be conducted to finalize and agree on DBM input. This meeting will be a major milestone for the Feasibility Study.

Development of Functional and Project-Specific Specifications

The WEI team will prepare functional as well as a number of project specific technical specifications with adaptation to each unique segment of the work while seeking to have commonality of specifications where possible to provide an immediate baseline for the study, simplify procurement and reduce future maintenance costs. WEI will also utilize many of it's in-house specifications to avoid duplicity of work and to assist in expediting the conceptual dsesign.

The planning of the specification development work will take into account that completion of such specifications is required at such a time as to allow them to be a part of requests for vendor budgetary quotations for all major equipment and materials pricing.

Constructability Reviews

A formal conceptual constructability review will be planned for the Feasibility Study. Our work execution will include continuing participation in the design of constructability experts. We believe that optimal benefits from constructability input arise from continuous interchange of perspectives between the design team and the constructability specialists. The ultimate goal of such reviews is to provide the basis for detail design, procurement and installation of safe, environmentally compliant, and cost-effective world class facilities.

Environmental Support

WEI will provide the necessary technical input to support the Environmental Impact Assessment (EIA) work to be performed for the Trans-Sahara project in order to comply with the regulatory requirements of Nigeria, Niger, and Algeria. Initial emission inventory of discharges and emissions components will be qualified and quantified.

WEI understands that the EIA and environmental permits are important to the construction of the Project, and has identified the following potential environmental impact issues:

- Air emissions from process facilities, construction camp, construction operations, mobile equipment, and logistics
- Toxicity of the production processes.
- Water supply for process facilities, construction camps, and construction operations
- Sanitary waste disposal from construction camps
- Spillage of oil, lubricants, chemicals, fuels, and other potentially harmful materials
- Solid waste disposal from camp and construction operations
- Protected and endangered species native to or migrating through this region
- Proximity of Nature Preserve
- Protection of native vegetation and restoration of disturbed areas
- Identification and protection of cultural and archaeological sites
- Road traffic, noise, and socio-economic impacts

During the Feasibility Study, an environmental engineering and management team will perform all necessary environmental engineering controls and studies so that all preliminary environmental work required for the eventual granting of permits can be applied which will result in an acceleration of the environmental permits required to be obtained from the three country governments for the construction of the Trans-Sahara Project.

Environmental permit requirements will be the primary function of the entire environmental engineering and management team during the Feasibility Study. To successfully execute the environmental activities, WEI will implement the following plans and steps:

Develop a comprehensive permit strategy

With this plan, WEI utilize Trans-Sahara expertise and its environmental consultants as a consolidated team to deal with all the environmental issues of this Project. We will seek to establish the general and specific permitting strategy and requirements of the three countries. This environmental strategy will be reviewed at the very beginning of the project to develop a comprehensive implementation strategy.

At this stage, the input requirements for all necessary environmental permits will be identified and a plan developed to provide it. We expect permits in the following areas:

– Air permit

- Raw water supply permit
- Wastewater Discharge permit
- Land use permit
- Solid and Hazardous waste land disposal permits.

Other permits will be required for pipelines, use of right of ways, facilities construction, and building permits, etc.

Assist with waste handling strategies

WEI will perform all necessary studies for pollution engineering controls, identification of best available control technology, environmental risk management, develop spill prevention plans, controls and counter measures, air emission inventory, wastewater effluent quantity and quality, solid and hazardous waste handling and disposal.

For complete details of how WEI will address various project related environmental issues, see Section 3, Environmental Issues.

Onshore Facilities Engineering Execution Plan

Work Summary

The conceptual design will be developed and will form the basis for the Field Development Plan (FDP) and associated cost optimization work.

WEI will prepare the following items:

- Design Basis Memorandum,
- EPC Project Execution Plan,
- Project Cost Estimate,
- Integrated Project Schedule, and
- Estimate Confidence Package.
- Identification of long-lead items
- Identification of technical documents needed for an EPC tender package

General

WEI recognizes that the level of engineering activities required varies within each of the Project components. Four key factors significantly affect the level of engineering required for each component:

- Component complexity,
- Engineering definition required,
- Class III estimate requirements, and
- Contracting strategy for the follow on EPC contract.

WEI will perform those services that will result in the optimum Field Development Plan (FDP) and the development of a Design Basis Memorandum (DBM) with a level of definition necessary to support a Class III cost estimate at a +/- 20% accuracy.

In addition, certain technical specifications will be developed for the EPC tender package to minimize execution risk during the EPC phase. In summary, the services principally consist of the following:

- Implement a structured Value Engineering program to systematically identify, evaluate and justify savings for the Project.

- Gather, analyze and use worldwide knowledge of desert and jungle, remote locations and Nigerian, Niger, and Algerian projects to refine the FDP design to increase quality, reliability, operability and cost effectiveness. [CONSTRUCTABILITY]

- Resolve critical design issues and make the recommendations for all major engineering decisions that are necessary prior to the FEED stage.

- Receive and effectively use the results from those specialist contractors that are carrying out field reconnaissance, surveys, and environmental studies.

- Identify, progress and develop specifications, design methods, etc. to improve engineering productivity and ease of fabrication while complying with Project objectives and regulatory authorities.

- Carry out risk assessments and summarize into technical/execution issues with a mitigation plan that presents the cost and schedule impact.

- Develop the DBM for the Pipeline and Facilities with the level of definition necessary to produce a Class III cost estimate and schedule.

- Support any required Trans-Sahara Independent Project Review (IPR) and Constructability/ Operability reviews and incorporate comments into the engineering deliverables and cost and schedule estimates.

- Provide input to the Estimate Basis Memorandum, the Class III Cost Estimate and the Project Execution Plan.

- Identify all long lead major equipment and materials within the Pipeline and Facilities scopes of work.

PDM Development

The PDM will be developed in order to define the design bases, criteria, philosophies, and other technical details of the Project. Soon after the PDM development, WEI begin will conduct preliminary engineering in order to upgrade the PDM into a draft DBM for the basis of the Pipeline and Facilities.

WEI will deliver to Trans-Sahara a DBM for approval and verify that use of the DBM will result in facilities that meet the functional (including reliability, availability), operational, construction and regulatory requirements of the Project.

Lessons Learned
WEI will incorporate applicable lessons learned from previous projects, including those provided by Trans-Sahara. To ensure timely implementation, a lessons-learned plan will be developed which allows for, and integrates into the design process.

Conceptual Engineering
The following information is a summary listing of the discipline engineering activities to be performed during the conceptual engineering phase.

General Engineering Requirements – Pipeline and Facilities
WEI will perform the following general engineering activities.

Engineering Lists, Plans, Assessments and Reports
WEI will prepare lists, plans, and reports, as well as assist in assessments. These items include, but are not limited to, the following:

- Equipment lists (including weights)
- Weight control plan and weight reports (weights by commodity)
- Equipment sizing basis and calculations
- Pipeline sizings, coatings, MLV spacings, etc.
- Testing and Commissioning
- Cathodic Protection system
- SCADA / Communications systems
- System descriptions
- Facilities descriptions, including compressor stations, regulator/meter stations, CTF, etc.
- Drawing register
- Interface register

Functional Specifications
Functional specifications are not project-specific specifications, and in this context mean a specification of all technical equipment requirements necessary for the selected EPC contractor or equipment manufacturer to perform detailed engineering. The content of the functional specifications will be based on WEI functional equipment specifications augmented by additional input from Trans-Sahara.

WEI has the obligation to include in the functional specification, requirements that assure a quality product for the design lifetime. The functional specification will reflect lessons learned by WEI, and the industry worldwide to assure the latest available design and quality product.

Key Definition Drawings
WEI will complete key definition drawings. These drawings include, the following:

- General conceptual development layouts

- Layouts and equipment arrangements (including facility site layouts)
- PFDs,
- Preliminary P&IDs
- Electrical one-lines
- Area classifications/drawings
- Control and safety system concept block diagrams
- Pipeline Layout drawings

Specific Pipeline and Facilities Engineering
WEI will progress the conceptual design of the pipeline and facilities in order to produce the required deliverables. Furthermore, the level of definition for each component will be consistent with the estimated relative value of the system/sub-system compared to the facility as a whole to support the Class III estimate.

Documents will not be produced to AFD (Approved for Design) status but rather will be only as detailed as required to support the Class III estimate.

As part of Feasibility Study, WEI will perform the following Discipline Engineering activities. The time frame for these deliverables will be presented in the Feasibility Study schedule.

System Design and Layout
System Design and Layout encompasses the tasks necessary to make final selections of the elementary pipeline system components – pipe diameter, along with corresponding pumping requirements and locations.

Operating conditions, such as pressure and temperature regimes also are predictable, and dictate final equipment performance requirements for drivers, heaters and other major equipment. Control, Supervisory and Safety/Shutdown equipment performance requirements are identified, and the system design basis completed to document the work.

System Hydraulics
The System Hydraulics represent the computations required to determine the effects of fluid flow on pressure and, ultimately, the energy requirements for the specified operating conditions.

Model Development/Calibration
Establish physical X, Y, Z data for the route(s) to be evaluated, along with:

- product properties
- pipe properties
- internal pipe roughness for coating and coated vs. uncoated
- heat transfer with soil

The model is to be calibrated against other systems with similar operating parameters.

Pressure versus Capacity Calculations
Complete analysis to identify pressure versus flow for a range of pipe diameters and a range of desired thermal conditions along the pipeline.

J-Curve Analysis
J-Curve Analysis characterizes the cost versus capacity information for various pipe diameters and their corresponding horse-power requirements. In doing so, the most economical range of operation for each pipe diameter is identified.

Cost Indices
Develop unit cost data for installed pipelines as a function of pipe diameter, horsepower, other station capital requirements, and operations/maintenance requirements to identify overall cost factors as input to the study.

Technical/Economic Analysis
Compile the costs per unit of flow data for a variety of pipe diameters and configurations to adequately cover flowrates ranging from 10 to 100% of maximum flow (maximum flow based on maximum pressure differential). Chart this information against flowrate to identify the economic performance of the systems sizes under analysis.

Line Size Selection
Determine the desired line size by collecting and evaluating several information sources in concert with the information illustrated by the J-Curves. A primary driver is predictions for long term capacity needs. However, the pipeline must be cost effective at lower initial flows (if forecast). Additionally, the line size is also dependent on the Pipe Grade Selection and resulting wall thickness requirements for full confirmation. See Line Pipe Selection for supporting information.

Power Requirements
Based on Line Size Selection, evaluate the power required for the foreseen operating ranges to support Equipment Selection Efforts for the drivers.

Pipeline and Stations Effective Performance Range
Based on the pipe diameter and drivers selected, refine the unit cost data for the specific equipment performance factors throughout the range of expected and potential flow rates. In terms of a potential scenario for the system, this would be considered the base case scenario.

Ancillary Facilities Identification
Identify the equipment outside of the primary functions (Line Pipe, Drivers) that controls, monitors, supports maintenance and provides for safe shutdown.

Block Valve Placement
Locate valves in accordance with Code Location requirements and considerations for route conditions in the local area, access, and other applicable criteria.

Maintenance/Smart Pig Facilities Requirements
Finalize and document Facilities and Information required for effective and efficient use of maintenance, routine pigging, and smart pig technology.

Metering and Custody Transfer Facility Requirements
Identify the type, size and location of meters for line control, custody transfer, leak detection.

Venting and Relief
Determine the need for safe evacuation of the system.

Leak Detection
Evaluate technologies for leak detection, including a "look forward" at potential technological advances which may be attained by the time of system installation. Identify minimum detectable leak range for the current state of the art technology.

Develop a plan forward for final selection of leak detection system.

Preliminary Transient Analysis
Although significant transient analysis will need to be completed in future phases of the project, conceptual efforts require review of various components and events to ensure the parameters are within predictable operations. These studies are identified below.

Ramp-Up Facilities Requirements Review
Establish timing requirements for the addition of horsepower concurrent with the anticipated build-up of the flowrate.

Failure Analysis
Analyze potential leak events, and the effect on surroundings and the pipeline system.

Minimum Detectable Threshold Analysis
Determine the effects of a low volume, long-term leak situation on pipe integrity, Right-of-Way Conditions, human life and the environment. Document general characterization of system repair requirements and expected impact to normal operations.

Catastrophic Events
Determine the safety, system integrity and environmental damage issues associated with catastrophic leak situations, and the effect on the system components. Identify Repair Requirements and impacts to operations.

System Design Basis Document
Document the system design requirements, expected performance ranges, and back-up studies as defined by the above tasks in a detailed project design basis.

Pipeline Engineering

A. Line Pipe Selection

Investigate the availability and suitability of the physical characteristics of various line pipe grades.

Pipe Grade Selection
The line pipe selection process must carefully consider the various grades of line pipe that are currently available from manufacturers. Selection of the pipe grade depends on steel properties that are usually outside normal pipeline specifications due to the nature of the Limit State criteria required to economically address geohazards.

Pipe Grade Survey

Develop the optimum pipe grade taking into consideration pipeline construction methods, wall thickness requirements, cost of steel, etc.

Allowable Strain Relationships
Develop allowable strain relationships and requirements for project acceptance from fabricators. This criteria will need to be further developed using actual data, modeling, and possibly lab testing. The allowable values will then need to be tied to the purchase specifications for acceptable ranges of test values (i.e. for yield, ultimate, yield/ultimate ratio and toughness).

Welding Considerations
Develop special requirements for girth welds, both double jointing and field welds, as required.

Recommended Action
Prepare a final report detailing the data collected, comparison matrix of pipe grades, and a recommendation for the pipe grade(s) to be used as the base case for preliminary engineering, as well as the plan for detailed verification of properties.

Preliminary Material Specification
Prepare a preliminary material specification.

B. Pipeline Design

Develop design concepts, tools and procedures, and identify additional tools and processes that may be required for the design of the pipeline.

Geotechnical Design
The project geotechnical needs will be dependent on which route is selected. If the route is within an existing alignment, many of the geotechnical features will have been determined either through geotechnical explorations or from observations of the performance in various locations along the alignment. Aerial photography, landform maps, boring logs, ditch logs, geophysical data, and many other data sources will be utilized, as available.

Subsurface Investigation
Determine areas where additional Subsurface Investigation is required to determine physical conditions/characteristics of the substrata, determine thermal conditions/characteristics of the substrata, and evaluate groundwater conditions. No field programs to collect the necessary information are envisioned.

Design Geotechnical Sections
Develop a limited number of Design Geotechnical Sections each of which would have unique foundation support conditions of significance for a buried pipeline or would have unique constructability characteristics. These Design Geotechnical Sections would consider, as a minimum:

- In-situ density and moisture conditions

- Active layer depth
- Existence of permafrost and ground temperature range
- Bedrock depth and condition
- Availability of inflowing water
- Thawed surface strength for constructability/trafficability
- Special excavation characteristics (e.g., blasting)

Assign the Design Geotechnical Sections to the pipeline alignment on a mile-by-mile basis based on available data.

Design Requirements
Thermal analysis/prediction tools will be used in the pipeline design. The tools will include the effects of the change in temperature of the product along the line.

Mitigative modalities will be used to develop the life cycle cost model, a series of mitigative techniques used to address the effects of pipe distress due to geohazards and should be addressed and costed.

Develop Data Acquisition Plan
The associated data to allow analysis must be outline in general for any terrain unit and land province. This would include surface data such as climatic input, as well as subsurface data such as borehole results. Missing data should be prioritized and a cost analysis completed for gathering the required missing data.

Pipe Stress

- **Develop Load Combination Matrix**
  The load combination matrix defines the credible loading sequences and combinations required for completion of pipe design.

- **Develop Seismic Zone Designations as Applicable**
  The overland route may traverse seismic zones. If so, in-depth studies might be required for the high seismicity zones.

- **Develop Design Motions for Fault Crossings**
  In addition to identifying fault lines along the route, associated design motions at various return intervals must be assessed as well as their expected direction of motion.

- **Limit State Reliability Approach for Secondary Loads**
  Define appropriate Limit States – This will include a limit compressive strain and tensile strain for the two level approach – operating loadings and contingency loadings. Other limits to be considered include displacement (e.g. at sidebends), ovality, and possibly other construction limit states.

  Develop criteria for each Limit State – By reviewing the available testing and literature, the strain limits for the project will be finalized for conceptual design. In

addition, a testing program and/or other data acquisition system will be recommended to gather additional data to improve confidence and/or lower the limit state values for design.

Develop seismic load requirements and Criteria – Limit states for seismic criteria will be separately handled, reflecting both the dynamic nature of the loading and response as well as the infrequent nature of the loading. As per current practice, there will be two defined loadings – an operating earthquake and a contingency earthquake. The operating earthquake is expected to be experienced during the design life and must be considered in combination with other operating loads, with the pipeline experiencing no undue distress. The contingency earthquake is more severe, and the pipeline is to be designed to withstand the earthquake, with no loss of product or threat to life.

- **Allowable Stress Design for Primary Loads**
  Develop interaction criteria for primary and secondary loading – Primary loads are those, which are not self-limiting, such as internal pressure, and are assessed against elastic limits of the material, in general. On the other hand, secondary loads, such as that displacement, are self-limiting and are assessed against strain limits. A careful approach to design situations wherein both types of loading are present and are nearing limits, must be addressed and included in the design approach.

Corrosion/Cathodic Protection
Develop requirements for Corrosion/Cathodic Protection including, but not limited to, the following:

- **Extreme Weather and Climate Considerations**
  Identify via documentation search and expert input the current state of active corrosion control methods, and requirements for systems in extreme temperature and climate operation.

- **Coating Criteria**
  Develop design criteria for external corrosion and mechanical protection pipeline coatings.

- **Coating Survey**
  Conduct a survey of potential pipeline coating systems for external corrosion and mechanical protection use.

- **Field Bending Assessment of Coated Pipe**
  Develop a Field Bending Assessment of Coated Pipe. This assessment should cover both external corrosion and mechanical protection coatings, should give special consideration to UV aged (1-2 years) coated pipe and should include several efforts to determine integrity for the project application.

Process Engineering

WEI will be responsible for the necessary Process Engineering and Design activities. Initial development through Process Flow Diagrams will be on the basis of the data provided by Trans-Sahara, including hard copy and electronic versions of Development Stage process documents such as simulations, process flow diagrams and equipment lists.

These will be the starting point for WEI process engineers. Upon completion of PFD's, emphasis will shift for a period of time to development of basic P&ID's for the pipeline and facilities.

Fire, Safety, and Loss-Prevention Engineering (coordinated by Process Engineering)

WEI overall scope related to Fire, Safety and Loss-Prevention Engineering is summarized as follows:

- Review process and utility flow diagrams and P&ID's for appropriate safety, loss control, and environmental considerations.
- Develop philosophies for all fire protection and safety-related systems and equipment.
- Develop and maintain lists of all credible scenarios for fluid releases or loss of containment
- Perform safety related analyses of gas dispersion, explosions, radiation, jet fires, etc. as necessary
- Coordinate all risk-related activities required to support development of the pipeline and facilities.

Deliverables resulting from these activities will include, but not be limited to, the following:

- Safety system and design philosophies
- Firewater system sizing
- Provisional escape route and safety equipment layout drawings
- Blast resistant requirements.
- Firewater and fire suppression systems P&ID's
- Gas dispersion, explosion, and radiant heat calculations
- Provisional fire fighting equipment layouts
- Provisional fire and gas detection equipment layouts
- Risk assessments and HAZOP reports

Mechanical Engineering

WEI will perform overall mechanical system design for all process and utility systems including the review and establishment of specifications and equipment type selection. In addition, this discipline will also be responsible for defining all equipment handling and transfer requirements. Deliverables resulting from these activities will include, but not be limited to, the following:

- Design philosophies
- Major rotating equipment control philosophy
- Specification and location of corrosion control equipment
- Compressor trains and main power generator driver selection study

- Initial start-up/black start philosophy (shared w/Process)
- Equipment functional specifications
- Master equipment list (expanded from Process List)
- Identification of long lead equipment items.
- Input for mechanical equipment data sheets for long lead equipment
- Utilities load lists (provide inputs from vendors)
- Compressor sizing and layout study

Instrumentation and Controls Engineering

WEI will be responsible for the necessary Instrumentation and Controls Engineering and Design activities. Deliverables will include, but not be limited to, the following:

- Process monitoring and control systems philosophy
- ESD Emergency shutdown philosophy
- Process shutdown philosophy.
- Power system control and monitoring philosophy (i.e. load shedding,)
- Fire & gas detection philosophy
- Pipeline Integrity monitoring
- Gas metering design basis
- Security systems philosophy (i.e. CCTV, etc.)
- Control systems block diagrams
- Safety systems block diagrams
- Preliminary master instrument list
- Instrument design philosophy and specifications
- Preliminary Control room/instrument rooms arrangement/layout drawings
- Instrument legends and symbols drawings
- Safety system design requirements specifications
- Preliminary cause and effect drawings for non-process shutdown systems
- Main control valve sizing

Telecommunication Engineering (coordinated by Instrumentation and Controls Engineering)

WEI will be responsible for the necessary design of the public address and alarm systems. WEI will also provide telecommunication engineering for pipeline design and potentially for construction execution and/or operations, including:

- System specifications
- Equipment and material specifications
- System block diagrams
- Telecommunications index
- Telecommunication documentation
- SCADA

Electrical Engineering

WEI will be responsible for the necessary Electrical Engineering and Design activities. Deliverables will include, but not be limited to, the following:

- Listing of all applicable electrical codes and regulations
- Electrical design philosophies and specifications
- Preliminary electrical load lists
- Power generation sizing initial and future
- Load shedding philosophy
- Power system configuration study (address main, essential, and emergency distribution)
- Single-line diagrams
- Power system component sizing basis document
- Power system protection schemes
- Power generation black start philosophy
- Preliminary master electrical equipment list
- Area classification drawings
- Electrical legends and symbols drawings
- Packaged equipment I&E interface philosophy
- Tagging Philosophy (Cable, Conduit, Equipment, Wire)

Piping and Layout Engineering

WEI will be responsible for the necessary Plant layout and piping design and inter discipline CAD co-ordination. Deliverables resulting from these activities will include, but not be limited to, the following:

- Design philosophies
- Key plans and plot plans for the various facilitates locations
- Equipment layouts for the various facilitates locations
- Main line list/line sizing summary - 8" and larger (Complete from Process input)
- Preliminary pipe rack sizing
- Module layouts (based on constructability analysis)
- 3D CAD Visualization model for each location based on final layout and P&ID's
- Preliminary Piping specifications
- Provisional Piping MTO
- Line sizing wall thickness design basis and calculations
- Pipe stress philosophy, including seismic design criteria and design methods
- Safety equipment location drawings

Civil and Structural Engineering

WEI will be responsible for the necessary Structural Engineering and Civil Design activities. Deliverables resulting from these activities will include, but not be limited to, the following:

Design philosophies
Desktop topography studies - all sites
Preliminary Piling and Foundation design

Preliminary structural drawings of modules for primary and secondary steel.
Helicopter landing facilities

HVAC Engineering (coordinated by Civil and Structural Engineering)

WEI will be responsible for the necessary HVAC Engineering and Design activities. Deliverables resulting from these activities will include, but not be limited to, the following:

- Data sheets
- Equipment and material functional specifications
- Preliminary HVAC layout and arrangement
- Air quality, ventilation, and pressurization design philosophy
- Preliminary HVAC load and design requirements

3. Pipeline / Infrastructure

Introduction

This document provides an overall summary of Willbros Engineering, Inc's (WEI) execution plan for the Trans-Saharan's Gas Pipeline Project's Pipeline Infrastructure Services. A more detailed description of project execution and management procedures will be developed upon contract award.

Scope

The Pipeline Infrastructure Services scope of work to be performed by WEI will be to develop three viable pipeline route alternatives, which will form a key portion of the Trans-Saharan Field Development Plan (FDP) and associated cost optimization work.

WEI will perform the following tasks that are directly related to the development of the pipeline infrastructure definition of the project:

- Develop Three Pipeline Route Alternatives
- Characterize the constructability, including special crossings, environmental conditions, etc. of the three pipeline routes through the use of historical data, maps, aerial photos, and field reconnaissance.
- Provide detailed information to Trans-Sahara to facilitate the final selection of optimum route.
- Provide an indication of the amount of resources and level of effort to construct the pipeline systems, including the amount of land take required for the pipeline ROW, facilities, pipe coating and laydown areas, extra work spaces, etc.
- Verify the feasibility of the construction schedule versus the difficulty of the proposed routes.
- Project Cost Estimate
- Provide input to the Estimate Confidence Package

Execution Overview

General

A WEI led team will execute the Pipeline Infrastructure portion of the scope of work using experience and unique technologies both for desert and jungle/rainforest environments.

The primary objective of pipeline infrastructure task is to develop a cost effective and constructible pipeline route that achieves the project objectives. The logistics portion of construction execution phase will be considered in detail as a material management plan must be able to be tailored to meet the requirements of the schedule. This is particularly important when dealing with a remote job site with limited infrastructure.

Specific construction mode(s) will be considered and selected that will best suit each of the respective pipeline route alternatives so that each route will be individually optimized. The development of the construction mode(s) will identify a number of project development scenarios.

From these scenarios the construction execution team will select an approach that balances the economics with practicality, contracting philosophy and a reasoned construction approach. The selected construction mode(s) will provide optimum construction installation performance, utmost utilization of material and equipment while maximizing the use of existing in-country resources and infrastructure.

The team of pipeline specialists will be assigned a defined scope of work consistent with the requirements of the Study. All of these specialists will be Task Forced in one area allowing for prompt communications transfer of technology, experience, and avoidance of duplicated effort.

The Pipeline Infrastructure Lead will report to the Study Manager and account for the team's deliverables, which allows the needed flexibility to share technologies and maintain schedule ending in the selection of three pipeline route alternatives. The paragraphs that follow define important elements of the pipeline infrastructure execution plan including many unique considerations. The following is a breakdown of the tasks proposed for pipeline infrastructure deliverables (tasks).

Pipeline Infrastructure Execution

The Execution phase will focus on the growth of the project concepts and forward the project to the development of the three pipeline alternatives. This includes the development of the scope of work and cost estimates which will represent an objective assessment of what is the real cost of constructing each of the three alternative routes. The construction team will also work with engineering to determine what is required to maintain the project timelines and provide basis to support project technical, economic and permitting/ regulatory decisions.

A Pipeline Screening Study will be performed which will determine the three primary pipeline route alternatives.

Upon completion of the Study, a Pipeline Route Optimization effort will be undertaken whereby the routes will be further refined and optimized. This optimization will include a number of construction related details that can be found in Section B below – Route Optimization.

Operations and maintenance activities and issues for the pipeline system will be reviewed and developed.

Pipeline Infrastructure Interface with Engineering

The construction team will interface and coordinate with engineering in the conceptual design effort requiring evaluation of the routes and systems. The construction team will support the technical objectives for conceptual engineering, which are to develop a conceptual design to include those requirements for technology verification, constructability, and provide sufficient detail to confirm the ability to obtain final concurrence on major permit decisions. Conceptual design for the pipeline effort is estimated to take __ months based on the level of effort envisioned for this study.

Subsequent efforts will be required beyond conceptual design to provide verification of construction mode(s), proposed technologies and provide necessary information for completion

of Preliminary Engineering. Most notable are geohazard/seismic hazard evaluation, pipe steel selection, construction technology development and additional route data. Many other factors, to be developed as a part of conceptual design by other efforts (regulatory, environmental) will determine the ultimate requirements for pipeline conceptual design.

These factors may require other efforts to be completed earlier or later dependent on the overall project timeline and the timing for the record of decision by the regulatory agencies in the overall project development effort.

Detail of Pipeline Infrastructure Tasks

A. Route Selection Screening Study - Route Conditions Investigation

Review route conditions based on the project design and construction efforts, the local environmental effects, cost and demographic considerations. This will be illustrated to show the relative differences and magnitudes of the impacts.

Available Design Data

Compare the level of design data available (and required), and the costs associated with collecting additional data, for the system based on the route alternatives and the effect on project design/ development schedule.

Geotechnical Characterization

Identify the relative merits of each route based on amount of wetlands, special crossings, and other difficult conditions, suitable materials for civil construction, benefit or impairment to long term operations and siting of various facilities (Stations and Support Facilities).

Geographical Characterization

Compare and catalog the physical extremes of the route option, and the various impacts to proximate natural habitat, wildlife and human demographics.

Route Field Reconnaissance

Review and evaluate each route alternative using an on the ground multi-disciplinary teams.

Land Ownership Issues

Compare the major landowner issues and the area of land owned by private or small landowners.

Construction and Operations Infrastructure

Evaluate the ability to mobilize efficiently, inexpensively and with least new infrastructure impact for each route. Assess information in terms of the effect on permanent and temporary infrastructure requirements.

Construction Hazards

Consider conditions, which affect construction efficiency, such as terrain difficulty, frozen soils, staging and access, special environmental stipulations affecting construction, or special design areas breaking up construction cadence to determine impact on project productivity.

Special Design Requirements Comparison

Inventory areas requiring consideration beyond open-country right-of-way construction to assess impact on cost, permitting and construction timing will be conducted. These areas include, but are not limited to the following:

- Fault Zones
- River/Stream Crossings
- Roads/Utility Crossings
- Wetlands / swamps
- Difficult Terrain

Support of Environmental and Regulatory Issues
Consider the major environmental features of each route and its effect on engineering cost in support of the regulatory approval process.

Major Environmental Features
Document the Major Features of the land, including the use for alternative purposes, national historic and recreational value, wildlife/habitat considerations and effect on human demographics for Route Comparison.

Regulatory Impacts
Identify the effects of the Major Environmental Features on the ability to permit the project within reasonable time and expense.

Permitting Time Line Comparison
Perform a schedule analysis of the Regulatory Impacts to assess effect of the Environmental Issues on each route.

Economic Evaluation
Identify the effect of the above evaluations on project cost, development, constructability and ability to complete the project in the time frame necessary to meet market needs.

Constructability and Construction Costs
Identify the merits of each route from perspectives of relative difficulty, number of special requirements, labor and equipment levels of effort, and the appropriate construction windows.

Project Development Issues
Identify the costs and timing impacts of the variations to complete data acquisition, permitting, engineering and right-of-way acquisition based on the alternates' environmental, urban, and political factors.

Schedule Comparison
Summarize the effects of variations in schedule due to alternate development and construction requirements for impact on indirect costs.

Technical Issues

Review factors identifying the relative ease or difficulty of the design, construction and operation conditions for each route and site alternate.

Environmental/Regulatory Support
Identify the major impacts to the route alternates as a result of pipeline system installation and operation, and the effects on the project as a result of the regulatory requirements and special design considerations.

Cost and Schedule
Summarize the input data to project cost and schedule relative to route alternative.

Summary
Prepare a report summarizing the results of the Route Selection Screening Study, accumulating the information obtained in the above evaluations and observations.

B. Route Optimization

Based on the results of the Route Selection Screening Study, an in-depth process will be initiated to further optimize the proposed alignment. This process is directed toward the gathering of information about the route and organizing the information for future use. This includes a significant of inventorying and organizing existing data and acquisition of information in other areas identified as necessary to achieve desired level of project confidence.

Inventory Existing Route Data
Evaluate and document existing data pertinent to the selected alignment. This data should include information from all available sources including, but not limited to, the following areas.

Geographical
Evaluate appropriate geographical data (e.g., topographic/geological mapping, aerial photography, etc.) along the proposed alignment to identify potential natural obstacles to pipeline construction.

Geotechnical
Evaluate existing geotechnical data for use in characterizing the subsurface conditions along the proposed alignment. The following data should be available is planned to be used:

- Ground Temperature Data
- Landform Profiles
- Seismic Characteristics

Hydrological
Analyze hydrology data for evaluation of river and stream crossings, surface and subsurface water flow conditions along the proposed alignment.

Meteorological
Evaluate meteorological data along the proposed alignment for use in establishing appropriate design parameter and construction scheduling.

Information in the following areas is required to complete Route Selection and Optimization, but will be addressed under the environmental scope and provided by others.

Cultural
Review information for use in evaluating potential cultural impacts such as archeological sites and subsistence hunting/fishing.

Habitat
Review information on wildlife habitat along the proposed alignment for evaluation of potential project impacts.

Wildlife
Review information on wildlife populations along the proposed alignment, including migratory patterns and presence of endangered/protected species, and evaluate potential project impacts.

Identification of New Data Requirements
Evaluate information gathered under the previous task to identify areas where additional data is required for project development, and prioritize to identify the efforts required in Conceptual Design.

New Route Field Data Requirements - Acquisition Plans and Programs
Based on the results of the previous task, develop plans and programs to collect additional information including, but not limited to, the following areas:

- Mapping/Survey/Photography
- Geotechnical
- Hydrological
- Landform/Habitat
- Meteorological

Route Optimization
Once sufficient route data has been collected and evaluated, refinements to the route will be made to obtain the most optimum alignment. This process should consider maximum use of existing facilities and infrastructure, plus impact on public/private roadways and other facilities. And will include the following major tasks.

- **Routing Criteria**
  Establish preliminary criteria for routing (e.g., maximum slopes to be traversed, longitudinal and cross; acceptable foundation soil classifications; etc.).

- **Class Location Requirements**
  Identify Class Locations along the proposed alignment

- **Geotechnical Considerations**

Evaluate geotechnical/geothermal data to identify geohazard areas that may be a concern and estimate severity. Analyze options for routing around vs. routing through the susceptible areas.

- **Photography/Map Review**
  Conduct reviews of aerial photography and maps to help refine the preliminary route through identification of optimum points to cross various natural obstacles.

- **Route Reconnaissance**
  Conduct field reconnaissance of the route with a multi-disciplinary.

- **Preliminary Route Documentation**
  Document the preliminary optimized route for use in future phases of work. This documentation will consist of, but not be limited to, the following items, subject to permitting and regulatory approval.
  - Preliminary Profile Survey
  - Base Sheets Preparation
  - Concept Alignment Sheets
  - Photography/Video Library

- **Route Review**
  Conduct a final route review once the preliminary optimized route is adequately defined and documented. This final review will consist of the following tasks.
  - Team Review
  - Stakeholder Review
  - Route Documentation Editing/Revision

C. Pipeline Construction Analysis

Moding Analysis

Perform a Moding Analysis to determine the optimum pipeline mode. The design should have a number of design mode options that are recognized as acceptable, and have design approaches that are particularly apt in specific design problem areas.

Along the alignment, it is proposed to develop design geotechnical sections (or modes). These would be developed by gathering the numerous landforms used in the past into a limited number of design geotechnical sections, each of which would have unique foundation support conditions of significance for a cool buried pipeline or would have unique constructability characteristics.

Several of these geotechnical sections could define the pipeline alignment and these would be very helpful in fine tuning costing and planning once they have been developed. The relevant design geotechnical sections would consider:

- In-situ density and moisture conditions
- Active layer depth
- Bedrock depth and condition

- Availability of inflowing water
- Special Excavation characteristics - such as blasting
- Others to be determined

Once the sections have been defined by characterization and then assigned to specific mileposts, a field check could further refine their specific limits along the route. The moding exercise may consider, but is not limited to, the following.

Aboveground versus Below Ground
In some situations, it may be economical to consider the use of aboveground placement as opposed to extraordinary measures to mitigate the effect of a geohazard.

Special Construction Areas
The following are considered special construction areas or areas that cause concern and will be looked at in detail as part of the route optimization effort.

- Faults
- River Crossings
- Small Streams
- Liquifiable Soils
- Cross Slopes
- Road Crossings
- Deep Burial
- Select Backfill
- Over-excavation
- Proximity Issues
- Failing/unstable slope

Right of Way Civil Design and Construction

Erosion Control/Drainage
Evaluate the effects of both normal erosion and drainage. Drainage concerns include low-water crossings and damming of existing drainage patterns. Other issues for ROW civil design and construction that will be considered include:

- Buoyancy Control
- ROW Grading
- Existing Workpad Upgrading
- Access Roads
- Upgrade Existing Roads
- Develop New Access Roads

Construction Technology/Techniques

Improvements in various Construction Technology/Techniques are necessary to attain the required cost goals for conceptual engineering. In addition benefits may effect overall schedule. The following areas will be investigated and potential impacts to the project will be quantified.

Right-of-Way Damage Mitigation

Develop a cost-effective strategy for restoring grade and cross slopes for ROW disturbance, including considerations of cross sheet flow, effectiveness of ditch plugs, and ongoing maintenance program.

Welding
Evaluate automatic welding systems, as well as conventional welding techniques, for use on the project. As part of the evaluation a comparison of the various methods will be conducted to document any cost or scheduling benefits that might be attained through use of one technique over another or through combinations of the various techniques.

Procedure Development
Develop preliminary welding procedures for use on the pipe diameter, wall thickness and steel grade combinations determined by the System Design and Layout and Line Pipe Selection tasks.

Labor Resources/Requirements/Training
Welder resources, requirements and training for safe, efficient and economical welding will be identified.

Inspection and Acceptance
Evaluate use of Fitness for Purpose criteria vs. standard 1104 inspection. Determine approval standards, applicable codes and alternatives thereof, and acceptance procedures for selected method(s).

Ditching
Evaluate various ditching techniques to determine potential cost and schedule impacts. Determine whether actual field testing should be conducted and, if so, prepare testing plans and procedures.

Ditching/Trenching Machines
Evaluate chain ditchers (e.g., Rock Saw) and heavy duty bucket trenchers (e.g., JETCO) for suitability with soil and terrain types expected along the proposed alignment.

Blasting Methods
Develop preliminary blasting procedures. Special attention should be given to possible blasting in close proximity to other existing facilities.

Production rates
Compare predicted production rates of the ditching methods evaluated.

Mass Miners
Evaluate the potential use of Mass Miners for material site excavation.

Pipeline Padders
Evaluate the feasibility of using Pipeline Padders (e.g., Ozzie Pad Master) for project conditions. Quantify potential cost, quality and schedule impacts.

Organic Mat Recovery

Develop a field program including observations & documentation of existing disturbed areas, and revegetation options as recommended in the Geotechnical Studies report.

Horizontal Directional Drilling
Evaluate the use of Horizontal Directional Drilling and identify areas (e.g., river/stream crossings, railroad, highway/utility crossings, etc.) where use is feasible.

Temporary Roads
Evaluate the use of Temporary Roads (e.g., board roads, landing mats, etc.) in place of gravel pads for summer construction and shoulder month, and document potential cost and schedule impacts.

Field Coating Systems
Conduct a survey of Field Coating Systems. Special consideration should be given to compatibility with desert, wetland/rain forest construction and preferred coating systems.

Pipe Bending
Conduct a survey of available bending machines, their capability, productivity and experience with high strength pipe. Produce test plans and procedures as required.

Vegetation Repair and Rehabilitation
Document past techniques that have been used for ROW repair and rehabilitation, concentrating on the effectiveness of the vegetative mix.

D. Construction Planning

The size of the pipeline construction effort requires an early look at planning to minimize indirect costs. Several areas for support of construction personnel and equipment, material site logistics, summer versus winter construction trade-offs, etc, are to be reviewed to make the effort as efficient as possible.

Staging Areas / Access Road Requirements
Identify placement of staging areas and access requirements for the construction effort.

Camps Assessment
Identify the Optimum Bed spacing and location requirements, and identify any advantages to use of mobile or modular (semi-mobile) housing.

Construction Personnel Logistics
Identify requirements for transporting personnel and life support requirements into and out of the project area, and the facilities requirements for associated project infrastructure.

Materials Sites Identification
Identify material site locations and extraction requirements (equipment, personnel, etc.).

Hydrostatic Testing Review
Complete a plan for hydrostatic testing, with identification of test sections, water requirements and disposal plans.

Special Construction Areas

Identify areas where special construction techniques are necessary due to terrain, proximity or other concerns, and develop preliminary plans for construction of the section to identify special equipment and expertise. (Areas may include tunnels, Horizontal Directional Drilling steep terrain, etc).

Construction Optimization
Optimize the construction plans of the system to improve overall execution. Effort will include, as a minimum, the following:

Weather Windows and Rainy Season Construction
Determine weather windows and rainy season versus dry season construction requirements based on schedule, productivity, minimum length of construction that is considered economical, and construction methods/materials requirements.

Construction Spreads
Determine the optimum number and size of construction spreads, based on cost and scheduling.

Labor Requirements/Sources
Identify manpower requirements by discipline and expertise. Review potential sources for resources, and identify advantages of union vs. open shop, import labor opportunities, and other possible sources.

Equipment Inventory
Identify equipment requirements, contractors base for available existing equipment, and new equipment requirements required completing the project. Review production capacity of equipment manufacturers to determine lead time for equipment procurement.

Contracting Strategy
Develop a contracting strategy in preliminary form for acquiring, contracting and providing incentives for contractors.

Construction Cost Estimate
Based on the above baseline and optimization works, assist in the development of an estimate for construction direct and indirect costs on the project.

Infrastructure and Logistics Study (coordinated by Construction and including Civil and Structural Engineering)

WEI will be responsible for the identification of all infrastructure requirements and logistics activities. Deliverables resulting from these activities will include, but not be limited to, the following:

- Agree optimum site manning levels for both permanent and temporary accommodation modules.
- Temporary power supply design
- Survey of existing road and rail links and recommended upgrade requirements.

- Module transportation philosophy
- Supply base and re-supply philosophy
- Marshaling yard philosophy
- Characterize the environmental conditions of the existing roads through the use of historical data pertaining to seasonal weight restrictions in the various regions.
- Facilitate the selection of transportation modes used to deliver pipe and equipment from origin to the R-O-W.
- Provide an indication of the amount of transport equipment required to perform the logistics plan and the amount of land take required for pipe coating and laydown areas.

Verify the feasibility of the construction schedule and provide an indication of material and equipment procurement requirements.

4. Environmental Issues

Introduction

This document provides an overall summary of Willbros Engineering, Inc's (WEI) execution plan for the Trans-Saharan Gas Pipeline Project's Environmental Issues Assessment. A more detailed description of the Environmental Issues Assessment, including applicable procedures will be developed upon contract award.

The purpose of this section is to provide a methodology for developing an assessment of the general environmental and regulatory conditions with consideration of their impact on the Project.

Scope

The scope of work of the development of the Project Environmental Issues is to define how the Project may maximize the beneficial impacts of its activities on the local environment, avoid or minimize adverse impacts, and mitigate those environmental impacts that cannot be avoided to acceptable levels.

In order to ensure that the activities associated with the Project are undertaken in the required environmentally responsible manner, WEI will investigate what is required in order to put in place:

- Identify critical environmental issues and problem areas;
- Strategies to appropriately mitigate the impacts of its activities on the environment;
- Investigate and identify the regulatory frameworks that are involved and that will need to be addressed;
- Recommendations for a plan forward on developing a Project Environmental Impact Assessment (EIA);
- Suggested methodologies for the identification, reporting/documentation, and implementation of mitigation and remedial actions with regard to national and international adherence to EMP compliance initiatives and non-compliance situations; and
- Develop a draft recording and reporting system to capture required environmental management-type observations, findings, and data.

Early Environmental Impact Assessment

WEI will establish an Environmental Management Organization (EMO) within its Study team. The EMO will form an integral part of the Study Team and will report directly to the Study Manager. The Environmental Manager will be responsible for ensuring that the implementation of the environmental aspects of all activities envisioned to be undertaken in the Project will occur in a manner that is compliant with the applicable laws and regulations of the Nigeria, Niger, and Algeria and will be incorporated into the technical specifications and requirements.

Additionally, the EMO is responsible for providing technical advice to the WEI engineering and construction groups to allow for all requirements to be incorporated into the Study in an acceptable manner.

Environmental Issues Study Details

An extensive environmental desk top study will be conducted in parallel and complimenting the engineering and construction infrastructure activities. This process will ensure that the EMO is involved in engineering and pipeline infrastructure planning. This desk top study and subsequent integration process will also support many of the mitigation recommendations that will be developed.

In conjunction with the engineering and pipeline infrastructure activities, the existing environmental conditions at specific sites within the three proposed pipeline corridor alternatives and land allocation boundaries shall be studied as part of the environmental issues study.

By performing environmental desk top studies, WEI will be able to identify critical site work planning process and related environmental issues. Based on the results generated by such studies the proposed mitigation strategy outlined below may be developed.

The comprehensive desktop study process will include:

- Regular meetings attended by engineering and construction. The primary goal of these meetings is coordination of planned scopes and schedules of work, and impacts to the design and cost estimate.
- Analysis of available environmental status data for specific construction sites.
- Acquisition of additional site baseline information by the Environmental Issues group.
- Based on the available data, acquired data and the data obtained during said studies, WEI will prepare an Environmental Issues Report. The report shall include without limitation the following issues:
  - Evaluation of the proposed environmental components and their ability to withstand impacts caused by the proposed work.
  - Documentary confirmation of existing conditions within the sites and adjacent areas (photographs, maps, diagrams).
  - Recommendations for prevention of negative and undesirable environmental impacts.
  - Proposals for developing an Environmental Impact Assessment and monitoring protection activities.

The Environmental Issues Report shall be prepared and completed prior to the completion of engineering and the cost estimate preparation. The data incorporated into the report shall determine the level of detail and the need to include additional impact mitigation measures and related costs into the Feasibility Study.

The EMO will meet regularly during the course of study to discuss the planned array of activities, including engineering, design construction planning and schedule development.

The Environmental Issues Report will identify potential impacts will recommend mitigation measures to be implemented for each type of construction related activity, including those listed below.

Land Use/Consumption

This will involve seeking to minimize the use and disturbance of land, in particular during construction and start up activities. The implementation of this concept begins in the design process. The design footprint of each major site will be minimized to the maximum extent practical.

Design measures will be implemented to limit land use and consumption. During conceptual design WEI will seek to locate the site or facilities as close to existing roads as practical, considering all other site requirements. This limits impact on less disturbed habitats and tends to reduce the area affected by any access road. WEI will implement the following general practices to minimize land disturbance:

- Work site traffic and access will be restricted to:
  - Existing roads, access roads, railroads, and waterways that can be approved;
  - Road and pipeline right-of-ways (ROW); and,
  - Storage areas, laydown areas, and permanent facility sites.
- With the exception of certain other non-intrusive construction activities (i.e. surveys), work activities and equipment storage will be restricted to:
  - Approved roads,
  - Designated access roads,
  - Pipeline right-of-way,
  - Storage, staging and parking areas, and
  - Other approved work site areas.
- Refueling, refilling, storage and maintenance activities involving hazardous materials will be conducted in previously disturbed areas where possible.

Roads and Access Roads

WEI will make reasonable efforts to avoid adverse impacts to additional habitat during the selection of proposed roads and access roads. Land use and the associated impacts from these roads will be limited by including the following guidelines into the EIA:

- The construction and non-construction activities will utilize existing roads and bridges to gain access to work sites, wherever practical.

- Roads and bridges will be upgraded only with prior approval.
- New access roads will only be constructed with prior approval.
- The placement of new access roads to avoid or minimize detrimental effects on sensitive resources.
- All road construction activities will be confined to previously agreed ROW(s).

Work sites and Facilities

WEI will investigate proposed site areas in order to avoid adverse impacts to additional habitat during construction. WEI will adhere to the following practices in this regard:

- During site design, WEI will attempt to minimize the footprint of the facility or work site, while still achieving efficient and safe use of the available space.
- Areas to be cleared will be minimized.
- A work area at any water and wetland crossing will be minimized as much as possible. The adjacent impacted area will also be kept to the minimum necessary.

Camps and Storage Yards

WEI will provide input into the plot plans of temporary work sites taking into account existing features such as roads, fences, structures, drainage and elevation, utilities, etc. for appropriate planning.

Procedures for Preserving Cultural Resources and Culturally Sensitive Areas

WEI will seek to identify cultural sites, and sensitive areas located at or near work sites. Cultural sites are to be identified in the environmental desk top study and clearly marked for exclusion.

Fertile Topsoil Removal and Management

WEI will identify those areas requiring topsoil segregation and develop recommendations as far as topsoil removal techniques, storage, and return.

Siting of Borrow Pits

WEI will use the following guidelines in selecting alternative sites for borrow pits:

- The preferred borrow pit will be that which can be:
  1. Developed with the least environmental impacts, and
  2. Operated and managed using standard construction techniques and reclamation practices.
- Borrow pits will be located away from flowing water to the extent possible.

General Principles Regarding Water Consumption

For non-potable water consumption, WEI will develop guidelines that will preferentially utilize surface water, when the available supply will support the anticipated demand without:

- Negatively impacting the water supply of nearby towns or villages;
- Appreciably altering the natural flow of watercourse;
- Affecting the level of water bodies, or
- Significantly impacting aquatic life.

Regulatory/Legal System

One of the key project execution issues will be regulatory approvals and permits. The sequential nature of the approvals process, coupled with coordinating multi-country requirements creates the potential for schedule delays and added cost.

Understanding of the Project regulatory process will be paramount to the success of the Project. This process will continue to evolve as the Project gains definition, and various government relations are expanded.

Near-term regulatory activities and the understanding of the implications and requirements are key to this Study as they are seen as critical to the Project. The regulatory rule-making process for each of the three countries will be investigated.

WEI will develop an initial a draft Regulatory Compliance Plan and will provide the following:

- Overview of the regulatory structure, and the legislative and regulatory framework for Nigeria, Niger, and Algeria,
- Legislation and legal requirements that affect the Trans-Saharan Pipeline Project
- Traditional permitting process for approvals of large projects and country-specific normative documents that regulate this process,
- A proposed work process to be followed to develop the Project Regulatory Compliance Plan and Permitting Checklist.

This approach will create significant advantages for Trans-Sahara in facing the challenges to obtain all necessary approvals, concurrences and permits in accordance with the schedule for the project.

5. Project Cost Estimates

Introduction

This document provides an overall summary of Willbros Engineering, Inc's (WEI) execution plan for the Trans-Saharan Gas Pipeline Project's Pipeline Cost Estimate preparation. A more detailed description of the Project Cost Estimate development, including applicable procedures will be developed upon contract award.

Scope

Prior to initiating the estimating work, WEI will jointly develop guidelines for preparation of the estimates. These include format, procedures and methodology, which will be contained in an Estimate Basis Memorandum (EBM).

During conceptual engineering the Project Team Members will obtain bids and budgetary quotes for tagged equipment and systems, pipe, fabrication of such facilities, operations and equipment, installation and HUC of the facilities pertaining to the pipeline system.

Equipment costs will be based on data sheets and other design information prepared during the conceptual engineering phase.

In addition, quantities for bulk materials will be established by commodity through MTO's from layout and other design drawings developed during preliminary engineering. Appropriate quantity factors and allowances will be applied. Unit material costs will be applied where appropriate.

Fabrication costs will be estimated based on current and historical data. All data sources and assumptions made will be documented for review, reference and audit purposes. The estimates will also include costs for home office engineering and project management.

All costs will be expressed in both constant and nominal US dollars, explicitly documenting foreign exchange rates where foreign currencies are converted.

In addition to preparation of the relevant Project Cost Estimates, an Estimate Confidence Package will be developed to assist in determining the optimum route selection.

Estimate Confidence Package

The Estimate Confidence Package (ECP) will provide supporting documentation and validation of the major cost and schedule assumptions made. An ECP will be prepared for each of the alternative routes so that each can be compared favorably and consistently.

The Estimate Confidence package will address the following key components:

- Estimating Methodology Basis.
- A brief description of the tools and techniques applied to establish the cost estimates and the execution basis

- Historical Cost performance
- The Project Team Members will document productivity and cost performance based on historical data and previously completed work similar to the Trans-Saharan Gas Pipeline Project.
- Project Cost Summary.
- A cost estimate breakdown for each major component.
- Cost level/Market Analysis and Basis.
- Back up documents (from market analysis) for major cost components, such as design, materials, fabrication, labor associated with the development of the three packages. Specific knowledge of projects completed in the relevant climates and environments will be utilized to the maximum extent possible.
- Productivity/Unit rate Assumptions.
- Design and Estimating allowances.
- Project Schedule.

The Estimate Confidence Package will be prepared concurrently with the Project Cost Estimate.

Operations Planning Study

In addition to the tasks and responsibilities set forth in previous sections that encompass the scope of work for the Feasibility Study, in order for WEI to develop a comprehensive cost estimate, that will include operational costs, will be necessary to perform an Operations Planning Study. The study will involve the following tasks.

Operations Planning
Operations planning for the pipeline system will be undertaken to assess the cost of operating and maintaining the system to a level of integrity sufficient to maintain the reliability and on line capability required by the market and project economic trade-offs. The effort will include assessment of personnel requirements for the pipeline and stations.

Requirements for automation will be developed to determine the level of automation vs. local manned support for operations and maintenance. Surveillance requirements to monitor and maintain integrity of the system will be developed for estimating.

Regulatory Compliance will be assessed and, along with the other operations plans and programs.

Pipeline Integrity Monitoring
Integrity monitoring of the pipeline will be recommended to monitor for corrosion, ground movement, general security and surveillance. Corrosion and geometry modeling will both investigated. For the latter task, the operational requirements for accuracy must be developed. A possibility to be investigated is the use of laser transducers for pig position and orientation.

Corrosion (Smart Pig, Other) Monitoring

Corrosion monitoring will be done to ensure the pipeline minimizes potential wall loss in the pipeline and station facilities. Monitoring will include smart pig monitoring, and corrosion coupon, along with office evaluation of information for recommendation of mitigation, repair or replacement.

Movement (Smart Pig and Site Specific Location) Monitoring
Geopigs use, along with other site specific methods will be planned to monitor overall pipeline position relative to baseline conditions. Office evaluation will be included to identify requirements for field mitigation, repair or replacement.

Security (General Aerial and Surface Surveillance, Remote Monitoring)
Evaluate regulatory requirements for system observation and surveillance, along with the cost of technology to identify the plans for remote monitoring and security/surveillance.

System Operation Mitigation Repair Scenarios & Methods
Develop concepts for operational repairs.

Personnel Requirements
Identify the personnel requirements to operate the pipeline system.

Day to Day Operations
Develop the organizational structure and job descriptions required for operation. This group includes the personnel requirements to direct maintenance efforts for the pipeline system.

Administration
Develop the organization structure to support the administrative responsibilities identified below.

- Pipeline Accounting
- Executive
- Regulatory Interface

Operations Engineering
Identify the personnel requirements for operations engineering based on experience and engineering constraints.

Field Maintenance
Identify contract personnel requirements for maintenance of the system.

Operating Supplies
Identify and estimate the chemicals, supplies and myriad other ongoing requirements which must be purchased for the operation of the system.

O&M Annual Costs
Accumulate the above-mentioned personnel, equipment, contract maintenance and supplies into an annualized budget estimate of all operations costs.

Abandonment & Restoration

Identify requirements for abandoning or removing the system, and restoring the right-of-way to a satisfactory condition.

6. Level of Effort for In-Country Field Reconnaissance

The level of effort estimate presented below represents the authors experience and should be used as a guideline. The effort includes a team comprised of the following specialist personnel:

- Construction Manager – Team Leader
- Pipeline Construction Superintendent
- Field Engineer
- Geotechnical Specialist
- Environmental Specialist
- Logistics Specialist

The level of effort only takes into account the resources needed to make the reconnaissance trip in-country(s) and for the work to be done while in-country(s) to select three pipeline route alternatives, to gather the related information required in doing final route assessments, i.e. geotechnical, environmental, site data, etc, and to write draft reports.

The level of effort includes all travel, including international and in-country flights, ground transportation, accommodations, helicopter recon flights, and a security detail from a reputable security provider assigned to the team for the duration. It is assumed the team will be in-country for a total of six weeks.

There are some additional hours shown to cover interfaces with engineering & design that relate to the field trip as well as route report preparation, but it is shown as a minimum, the remainder of the "office" time is assumed to be included in the overall cost estimate.

A contingency of 20% has been included to deal with the normal inefficiencies encountered in North and Sub-Saharan Africa, including crossing borders, transportation difficulties, potential civil unrest, vague local "requirements", etc.

A Summary of the Cost Totals estimated for the in-country effort are shown below, a detailed spreadsheet will be sent under separate cover.

Cost Totals	**Bill Rate**	May	Jun	Jul	**Total**
Man-Hour Cost	$ 125	$156,000	$126,000	$27,875	**$309,875**
Trip Cost		$45,000	$0	$0	**$45,000**
Other Cost		$168,000	$84,000	$0	**$252,000**
Estimated Cost		$369,000	$210,000	$27,875	**$606,875**
Contingency	20%	$73,800	$42,000	$5,575	**$121,375**
Total Cost		$442,800	$252,000	$33,450	**$728,250**