Oil & Natural Gas Technology

Comprehensive Lifecycle Planning And Management System For Addressing Water Issues Associated With Shale Gas Development In New York, Pennsylvania, And West Virginia

Final Scientific/Technical Report

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ABSTRACT

Comprehensive Lifecycle Planning And Management System For Addressing Water Issues Associated With Shale Gas Development In New York, Pennsylvania, And West Virginia

The objective of this project is to develop a modeling system to allow operators and regulators to plan all aspects of water management activities associated with shale gas development in the target project area of New York, Pennsylvania, and West Virginia ("target area"), including water supply, transport, storage, use, recycling, and disposal and which can be used for planning, managing, forecasting, permit tracking, and compliance monitoring.

The proposed project is a breakthrough approach to represent the entire shale gas water lifecycle in one comprehensive system with the capability to analyze impacts and options for operational efficiency and regulatory tracking and compliance, and to plan for future water use and disposition. It will address all of the major water-related issues of concern associated with shale gas development in the target area, including water withdrawal, transport, storage, use, treatment, recycling, and disposal. It will analyze the costs, water use, and wastes associated with the available options, and incorporate constraints presented by permit requirements, agreements, local and state regulations, equipment and material availability, etc.

By using the system to examine the water lifecycle from withdrawals through disposal, users will be able to perform scenario analysis to answer "what if" questions for various situations. The system will include regulatory requirements of the appropriate state and regional agencies and facilitate reporting and permit applications and tracking. These features will allow operators to plan for more cost effective resource production. Regulators will be able to analyze impacts of development over an entire area. Regulators can then make informed decisions about the protections and practices that should be required as development proceeds.

This modeling system will have myriad benefits for industry, government, and the public. For industry, it will allow planning all water management operations for a project or an area as one entity to optimize water use and minimize costs subject to regulatory and other constraints. It will facilitate analysis of options and tradeoffs, and will also simplify permitting and reporting to regulatory agencies. The system will help regulators study cumulative impacts of development, conserve water resources, and manage disposal options across a region. It will also allow them to track permits and monitor compliance. The public will benefit from water conservation, improved environmental performance as better system wide decisions are made, and greater supply of natural gas, with attendant lower prices, as costs are reduced and development is assisted through better planning and scheduling. Altogether, better economics and fewer barriers will facilitate recovery of the more than 300 trillion cubic feet of estimated recoverable natural gas resource in the Marcellus Shale in a manner that protects the environment.

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Executive Summary

The objective of this project is to develop a modeling system to allow operators and regulators to plan all aspects of water management activities associated with shale gas development in the target project area of New York, Pennsylvania, and West Virginia ("target area"), including water supply, transport, storage, use, recycling, and disposal and which can be used for planning, managing, forecasting, permit tracking, and compliance monitoring.

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To ensure the success of this project, it has been segmented into nine tasks conducted in three phases over a three year period. The tasks will be overseen by a Project Advisory Council (PAC) made up of stakeholders including state and federal agency representatives and industry representatives. ALL Consulting (ALL) will make the Lifecycle Water Management Module available on the Internet for the final year of the project.

The second quarter of the second budget period, work was halted based on the March 18, 2011 budget availability; however project deliverables for previous quarters were submitted on time. NETL did not provide additional funds and work on the project stopped on March 18, 2011. NETL ended the project on March 31, 2012.

Report Details
The following addresses results and discussions, as well as the conclusion.

Approach

The following Task descriptions identify the approach and methods that will be employed to achieve the project objectives.

YEAR 1

Task 1.0 – Project Management Plan (PMP)—Revision of the Project Management Plan and Technology Status Assessment—Initial Technology Status Assessment

Task 2.0 – Research Water Issues in the Target Area, Initial System Design and Establish Project Advisory Committee
- Subtask 2.1 – Issue Identification and Analysis
- Subtask 2.2 – Initial System Design and Development
- Subtask 2.3 – Project Advisory Committee

Task 3.0 – Data Gathering and Field Site Visits

Task 4.0 – Technology Transfer (This task will be performed throughout all phases of the project)
- Subtask 4.1 – Establish Project Web Site
- Subtask 4.2 – Presentations and Papers

YEAR 2

Task 5.0 – Final System Requirements
- Subtask 5.1 – System Design
- Subtask 5.2 – Review and Documentation of System Design

Task 6.0 – Model Development and Testing
- Subtask 6.1 – Model Development
- Subtask 6.2 – System Testing

Task 7.0 – Continuation of Technology Transfer (As originally defined in Task 4.0)

YEAR 3

Task 8.0 – Pilot Testing and Model Distribution
- Subtask 8.1 – Pilot Testing
- Subtask 8.2 – Model Distribution and Support

Task 9.0 – Continuation of Technology Transfer (As originally defined in Task 4.0)

Approach Discussion

To gather information on water issues and water management needs of both regulators and operators, ALL Consulting conducted more than 12 site visits within the targeted Marcellus shale states of New York, Pennsylvania, and West Virginia. These site visits included visits to water treatment plants, water disposal facilities, well-sites, and discussions with service companies. The well-site visits included observation of water withdrawal and storage facilities, pre-completion activities, and post-completion management of produced water. ALL met with state regulators and River Basin Commission personnel, both in person and via telephone. ALL also met with individual land-owners, land-owner organizations, and industry organizations. In addition, ALL leveraged other NETL project activities to gather information about shale gas water issues in general from visits to numerous regulatory agencies and production sites in other shale gas basins as well.

The meetings and visits took place over the course of the first year of the project. The meetings and visits in the Marcellus included:

- New York State Energy Research Development Authority (NYSERDA)
- Susquehanna River Basin Commission (SRBC)
- Delaware River Basin Commission (DRBC)
- New York Department of Environmental Conservation (NY DEC)
- Pennsylvania Department of Environmental Protection (PA DEP)
- West Virginia Department of Environmental Protection, Office of Oil and Gas (WV OOG)
- Independent Oil and Gas Association of New York (IOGA NY)
- Independent Oil and Gas Association of West Virginia (IOGA WV)
- Pennsylvania Land Trust Association (PALTA)
- National Association of Royalty Owners (NARO)
- Chesapeake Energy
- Hess Natural Gas
- Universal Well Services, and
- BJ Services

The information from these visits was compiled and analyzed to understand the water management lifecycle, to identify the important water issues, and to identify the management needs that could be addressed by the model. These issues and needs were then reviewed to develop the initial system design for the model **(see Appendix A)**.

Results/Conclusion

Based on work completed in the first Budget Period, the final system requirements and design for the Lifecycle model were created **(see Appendix A)**. This work would guide the actual programming and data entry required to construct the model. Research into the water issues and needs confirmed the strong necessity for the Lifecycle model. All work under the project had progressed as planned, and the model would provide a much needed tool to help ensure that the Marcellus Shale is developed in a way that brings this important resource to market while protecting human health and the environment. However, due to the suspension of funding by NETL on March 18, 2011 short of Milestone 8 ("complete model development and internal testing") the application was not developed.

Technology Transfer Presentations and Papers

- *Water Resource Issues in the Marcellus Shale Region*, presented at American Institute of Professional Geologists, Pittsburgh, PA May 5-6, 2010.
- *An Environmental Discussion of Hydraulic Fracturing in the Marcellus Shale*, presented at American Institute of Professional Geologists, Pittsburgh, PA May 5-6, 2010.
- *Managing Marcellus Shale Water: A Lifecycle Model*, New York Water Environment Association, Inc.; Clear Waters, Vol. 40, No. 4. Winter 2010.
- *Lifecycle Water Management: Considerations & Challenges for Marcellus Shale Gas Development*, presented at The 16th International Petroleum and BioFuels Environmental Conference, November 4, 2009.
- *Water Resource Issues in the Marcellus Shale Region*, presented at the International Petroleum Environmental Conference, August 31-September 2, 2010.
- *Comprehensive Lifecycle Planning and Management System for Addressing Water Issues Associated With Shale Gas Development in New York, Pennsylvania, and West Virginia*, presented at Ground Water Protection Council's Risk Based Data Management System, April 28, 2010.
- *R&D of Tools for Managing and Analyzing Produced Water Associated with Marcellus Gas Shales,* presented at The Independent Oil &Gas Association of New York, November 5, 2009.
- *Environmental Best Practices for Shale Gas Development*, presented at the Annual Meeting of the Independent Petroleum Association of New York, July 8, 2009.

Milestone Status Table

Budget Period/ Milestone No.	Milestone Description	Planned Completion Date	Actual Completion Date
I			
1	Completion of PMP	12/04/09	12/01/09
2	Completion of Technology Status Assessment	11/14/09	11/14/09
3	Develop project web-site	12/04/09	12/04/09
4	Completion of Initial Issue Analysis	03/30/10	03/29/10
5	Complete Site Visits	09/30/10	9/26/10
II			
6	Deliver topical report	10/30/10	10/29/10
7	Complete final system requirements and deliver topical report with final system requirements and design	4/30/2011	4/29/2011
8	Complete model development and internal company testing	9/30/2011	Cancelled
9	Deliver draft operating water management modeling system for testing	9/30/2011	Cancelled
III			
10	Deliver final operating water management model	3/31/2012	Cancelled
11	Complete delivery of five conference papers and presentations	9/30/2012	Cancelled

List of Acronyms and Abbreviations

ALL	ALL Consulting, LLC
GIS	Geographic Information System
NETL	National Energy Technology Laboratory
PAC	Project Advisory Council
PMP	Project Management Plan

Appendix A

1. System Overview
2. System Requirements
3. System Design
4. Technical Specifications

DE-FE0000797

COMPREHENSIVE LIFECYCLE PLANNING AND MANAGEMENT SYSTEM FOR ADDRESSING WATER ISSUES ASSOCIATED WITH SHALE GAS DEVELOPMENT IN NEW YORK, PENNSYLVANIA, AND WEST VIRGINIA

1. System Overview:

After analyzing the known water management issues associated with Marcellus Shale development in the target area, a design of the Lifecycle Water Management Model was created based on user needs. In crafting the design, consideration was given to using readily available platforms that would facilitate creating and using the model as well as allowing future modifications by third parties. In addition, it was determined that the application would not be web-based in order to avoid data security issues for proprietary information. The system design includes modules and their interactions, input and output requirements, user interfaces, data structures, modeling requirements, development software, and hardware requirements.

2. System Requirements:

The following system requirements were developed through site visits and interviews with operators, regulators, and service companies. These requirements focused on planning and permitting management for water withdrawals, compliance tracking during the water lifecycle (source, transport, use, storage, treatment, and disposal), economic planning and management for volumes, costs, and influences on development strategies.

These requirements will provide an application to track the lifecycle/use of water in oil and gas processes for the Marcellus Shale development. Operators will have a means to plan for future water needs and manage available water and capacities to accomplish their goals of drilling and completing wells. The system would assist operators in meeting the goals in a timely (scheduling) and cost effective manner (focused only on water management costs). Additionally, the application will provide components that analyze the stored and updated data for compliance, reporting, projection and other planning and operational aspects.

The Well Drilling and Water Use Prognosis component will be used to estimate when wells will be drilled, the number of wells to be drilled, where they will be located, etc. In addition to tracking the wells to be drilled it will also track the estimated water needs for each well proposed in the prognosis as well as allowing the operator to estimate permitting and transportation costs based on various take-point scenarios. This component will facilitate the ability to track refractures as well.

3. System Design:

The system is designed to be used in both stand-alone and client/server installations. The stand-alone application would be downloaded and installed on a single work station, while the client server application would use a backend (XML database) installed on a centralized server and the applications installed on workstations are networked to the database. The client/server installation would allow larger companies with multiple workstations to coordinate plans ensuring that water from take-points or in impoundments is not committed to different wells by different in-house engineers.

The application is designed to consist of modules related to well drilling programs, water sourcing, transportation tracking, water treatment, water disposal, and program defaults. Using a "switchboard" menu screen, the model will track water through all phases of the water management lifecycle and will allow users to specify input parameters, objectives, schedules, etc. Each of the modules will interact by transferring results or parameters to the other modules as needed. A Program Defaults module will be created to house reference tables used to populate drop-down boxes for default values that allow for data consistency and expert user interfaces which will help validate data entry and provide key tables for linking of data records. A maintenance user interface will allow for customization and updates of the data in the Program Defaults module.

Inputs and results will be stored in the database that each module will draw from for population of data in other modules. The database will be relational to the extent that each module will draw from common data elements and if new data needs to be collected for that module, then a user input form will be presented for data which will then store the data in the database. The model will allow users to input water volume needs in the sourcing module and see the expected water volume that will require re-use, discharge, or disposal at the end of the lifecycle. Scenario analysis will allow users to compare the effect on water needs of various alternatives such as pace of development, central vs. distributed facilities, and reuse vs. disposal or treatment options. A permit module will also be incorporated to allow tracking of planned and existing withdrawal permits. Tracked data elements will include, at a minimum, the permit number, the permit period, take point location, and permitted volumes.

An additional module will be provided to operators to have the ability to adjust well drilling programs easily in time by shifting start and end dates of proposed wells for scenario testing. For operator and regulatory support, the module will include the ability to add a proposed number of wells by watershed with a specified water need per well to assess water demand versus supply. This module will use GIS technology that will interface with agency data and GIS systems as well as providing GIS viewing capability independent of the agency systems. Safety factors will be built in on water take points to adjust maximum allowable withdraw and allow for the safety factors to be adjusted as needed.

This module will also allow, through the use of GIS technology, the ability for operators to determine the optimum placement of future take points and the optimum use of existing take-points. The system will calculate road-miles between pads and take points and will calculate a cost based on the truck trips required to provide the needed water to a given location.
The following is the base set of data components for each module (note: tables will have keys which enable linking to records in other modules to maintain data integrity and consistent query results):

- Well Drilling Program = listing of proposed wells to be drilled, structure the well data by well pad
    - Location (Long/Lat) – Group by Pad
    - List of Wells to be drilled from Pad
    - Estimated Water Needs
        - Drilling
        - Completion (HF)
    - Estimated time to start

  - Estimated time to TD
  - Estimated Completion Start and End Dates (HF) – May be multiple events
  - Water Transport Methods/Truck Hauling Capacity
  - Water Storage Capacity on Pad
  - Estimated Water Return Percentage (Provide application default but allow by well adjustment)
  - Time of Water Return Production
  - Basin/Watershed
  - Default Program and Cost Data – Edit from program default

- Water Sources = listing of the water sources available to supply water to a well pad (Include storage facilities as a source, if a water source feeds a storage facility then its water may not be available for well delivery except through the storage facility)
  - Type of Water Source
  - Volume available (Permit Volumes – Daily Values)
  - Location of Source (Long/Lat)
  - Safety Factor on withdraw
  - Permit Restrictions
  - Permit Duration
  - Basin/Watershed

- Water Treatment Facilities = listing of water facilities where treatment can occur, these facilities may be included as water sources in the final design or provide links to vendors which have operations in the area of the target project
  - Type of Water Treatment Facility
  - Volume available to Treat (Permit Volumes – Daily Values)
  - Location of Facility (Long/Lat)
  - Basin/Watershed
  - Water Volume available as a source

- Water Disposal Facilities = listing of the available facilities where produced water or treatment reject can be disposed
  - Type of Facility
  - Volume/Capacity available to be disposed
  - Location of Facility (Long/Lat)
  - Basin/Watershed

- Trucks/Water Haulers = Available trucks that can be used to haul water
  - Number of Trucks of a particular size
  - Truck Size
  - Area Location of truck availability

- Program Defaults = Set of data elements that can be adjusted but provide default values for initial data entry and regional settings
    - Estimated Produced Water Return Percentage
    - Monthly Averaged Stream flow data by watershed – used to estimate take volumes for permits
    - Default radial distance to consider water sources
    - Costs
        - Upper limit cost of water per barrel for delivery to well
        - Transportation cost per mile per barrel of water
            - Trucking – Multiple trucks tracked by size of truck
            - Pipeline – Permanent
            - Pipeline – Temporary
        - Water Cost per Barrel by Type – Default values
            - Municipal
            - Surface Take Point
            - Groundwater
        - Water Treatment Cost per Barrel by Type – Default values
            - RO
            - Polish/Filter
            - Etc.
        - Water Disposal Cost per Barrel – Default values
            - Disposal Well
            - Commercial Treatment Facility
            - Waste Water Treatment Plant

Reports will be generated by the data stored in the database. The reports will either be specific to a module or may, at the user's discretion, be generated as a single report broken down by module. The reports will list inputs and results and will be available in a variety of formats (MS Excel, PDF, CSV or other common outputs).

The expected reporting outputs are as follows, however in the final development of the system these may be altered, such as combining reports and the addition of other data points or analysis.

- Plot of Estimated water need versus time based on drilling program (Not limited by Location, whole system)
- Plot of Estimated available water versus time based on water sources available to the operator (Not limited by Location, whole system, includes both fresh and produced water)
- Plot of Estimated water need versus time based on drilling program (Limited by Location/Selected Well(s)/Pad(s))

- Plot of Estimated available water versus time based on water sources available to the operator (Limited by Location/Selected Water Source(s) , includes both fresh and produced water)
- Plot of Combination of Estimated Need and Estimated Available water plots versus time – Identify discrepancies
- Report on Estimated Water Discrepancies based on water available to be delivered to site
- Report on Estimated Water Acquisition Costs by source (e.g. Groundwater, surface, municipal, or PW) on a per well/pad location basis and water need identified
- Report on Estimated Water Transportation Costs on a per well/pad location basis and water need identified
- Report on Estimated Water Volume Needs, Water Acquisition Cost, and Transportation Cost differences based on reuse of produced water
- Report on Estimated Water Disposal Needs versus time
- Report on Estimated Water Take Schedule from a Take Point based on Permit conditions and/or Contract (If stream take point consider permit conditions and stream flow restrictions)
- Report on Estimated Water Balance Summary (Whole System and by Well Pad)

4. System Architectural Technical Specifications:

Programming of the application will be based on Microsoft's dotNet studio which will allow for rapid application development and flexibility in making modifications. Additionally, using a dotNet development strategy will produce an application that is operating system agnostic. The application will be packaged in an '.exe' that the user will download and install through the use of a "wizard".

The XML database will be developed in accordance with the standards set forth by the W3C using XML 1.0 and Namespaces. For the stand alone installations the database will reside resident on the user's computer and for the client-server installation, the database will reside on a centralized server. Record locking and data integrity protocols will be enforced for the data sets.

Target User System Requirements

The following is the target workstation computer system required by the user to install and run the application. Please note that these requirements are common on computer systems purchased within the last few years, therefore the user bases' machines should have, at a minimum, a system that would support this application.

Computer Processor: 1 GHz or faster
Memory: 512 MB or more
Graphics (recommended): Enhanced graphics card with expanded video memory
Operating System (OS): Windows® XP with Service Pack 3 (SP3) 32-bit operating system only; Windows© Vista® with SP1; or Windows® 7 or later 32- or 64-bit OS.
Microsoft.Net: Framework 3.5

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