

**NRMRL QUALITY ASSURANCE PROJECT PLAN**

**Office of Research and Development**

**National Risk Management Research Laboratory**

*Land and Materials Management Division*

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***Research Model Development Project | QA Category B***

***Extramural Research***

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**Prepared by:**

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***QA Tracking ID****:* G-LRPCD-0030107-QP-1-1



**TITLE AND APPROVAL SHEET**

**Quality Assurance Project Plan for**

**Revision No. 1**

**WA 03-18, Impact of Materials Management Applications**

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| --- | --- | --- |
| **QA Project Plan Title:** | Hydrologic Evaluation of Landfill Performance (HELP) Model | |
| **NRMRL QA Tracking ID:** | G-LRPCD-0030107-QP-1-1 | |
| **EPA NRMRL Project Approvals** | | |
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# Project Description and Objectives

## Background

Historically, materials management in the United States has been handled through a variety of options that include disposal, recycling, or some form of treatment. Given the increased need to institute waste management practices that are sustainable and acknowledge critical environmental, social, and economic considerations (the three pillars of sustainability, also referred to as the triple bottom line), an examination of well-established as well as emerging waste management methods is warranted to facilitate decision making.

Regulations that help manage our nation’s solid waste stream are almost 30 years old if not more. Since that time, a large volume of data has been generated on the performance of waste management facilities and is beneficial in evaluating their containment robustness into the future.

The purpose of Work Assignment 04-18, “Impact of Materials Management Applications,” is to evaluate the impact of sustainable materials management (SMM) on the environment including groundwater. The project will provide information that enhances the capacity of the U.S. Environmental Protection Agency (EPA), states and communities to implement decision making with regards to SMM.

The intended audience of this work assignment includes EPA’s Office of Land and Emergency Management, regional offices and other federal agencies. This project supports programmatic support needs related to our national all hazards homeland security responsibilities by providing data and information that will lead to an accurate accounting of our solid waste management systems and lead to increased resiliency in our materials management systems.

Work Assignment 04-18 consists of nine separate technical tasks in support of the EPA Office of Research and Development (ORD), National Risk Management Research Laboratory (NRMRL), Land and Materials Management Division (LMMD). This quality assurance project plan (QAPP) applies to Task 8, Hydrologic Evaluation of Landfill Performance (HELP) Model.

The latest existing version this model is a computer program that computes estimates of water balances for municipal landfills, Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, i.e., Superfund) facilities, and other land disposal systems, including Confined Disposal Facilities (CDFs) for dredged material disposal. A user's guide and a documentation report are available in Word Perfect 5.1 and Adobe Acrobat formats. The model is available for IBM-compatible personal computers.

The model accepts weather, soil, and design data and uses solution techniques that account for the effects of surface storage, snowmelt, frozen soil, runoff, infiltration, evapotranspiration, vegetative growth, soil moisture storage, lateral subsurface drainage, leachate recirculation, unsaturated vertical drainage, and leakage through soil, geomembrane, or composite liners.

For climate data requirements, the HELP model includes: general evapotranspiration data and daily values of precipitation, temperature, and solar radiation. The HELP model has a default evapotranspiration database for 183 U.S. cities, containing data for latitude, evaporative zone depths, leaf area indices, growing season, average wind speed, and average quarterly relative humidities. A default precipitation database is included, containing 5 years of daily values for 102 cities throughout the United States. The model also has a synthetic weather generator with coefficients for 139 cities for daily precipitation data generation and for 183 cities for daily temperature and solar radiation data generation. The user interface also contains a number of utility routines to import weather data from other databases.

For soil data requirements, the model includes: porosity, field capacity, wilting point, initial moisture content, and saturated hydraulic conductivity of up to 20 layers of materials. The model contains a default soil database of characteristics for 42 types of materials (soils, waste, and geosynthetics). Design data requirements include the AMC-II runoff curve number for the site, a description of the vegetation, a description of the function of each layer of material, the thickness of each layer, the slope at the base of each drainage layer, the spacing between drainage collectors in each drain system, a description of leakage potential of each geomembrane liner, and a description of the leachate recirculation, if used. As evident by the data requirements, the model permits an evaluation of detailed designs and a sensitivity analysis of design components and climatological variables.

Landfill systems including various combinations of vegetation, cover soils, waste cells, lateral drain layers, low permeability barrier soils, and synthetic geomembrane liners may be modeled. The program facilitates rapid estimation of the daily, monthly, annual, and average annual amounts of runoff, evapotranspiration, drainage, leachate collection, and liner leakage that may result from the operation of a wide variety of landfill designs. The model applies to open, partially closed, and fully closed sites and serves designers and permit writers.

The primary purpose of the model is to assist in the comparison of design alternatives as judged by their water balances. The model is sufficiently sophisticated to consider all of the principal design parameters including vegetation, soil types, geosynthetic materials, initial moisture conditions, thicknesses, slopes, and drain spacing as well as climate effects.

The HELP model was developed at the U.S. Army Engineer Waterways Experiment Station under a cooperative agreement with EPA to support RCRA and Superfund programs. Use of the HELP model is recommended by the EPA and required by most states for evaluating closure designs of hazardous and nonhazardous waste management facilities. More than 2,000 private engineering offices in more than a dozen countries, and greater than 200 offices of federal, state, and municipal governmental agencies, use the model for design evaluation and regulatory permitting actions. The model is also used for training and continuing research at more than 50 universities.

To date, development of the HELP Model has followed an internal QAPP prepared by EPA, dated November 2016, and filed under QAPP Tracking ID # G-LRPCD-0030107-QP-1-1. This external QAPP follows the general outline and content of that QAPP, with revisions to the project roles and schedule to reflect the external support for completing the development of the Visual Basic for Applications (VBA)-based version of the HELP Model that was commenced under the EPA developed QAPP, and to the approach for certain changes in the scope of the model preparation activities.

## Project Description

The primary purpose of work for Task 8 is to update the HELP version 3 model. EPA has migrated the model from Fortran 77 to VBA code. Under this task, the CSRA team will:

* Develop an enhanced user interface for the Excel-VBA based HELP model
* Assist the Agency in deploying and debugging the beta version of the software
* Develop the final references needed to publish the model
* Address enhancements to the VBA version of the model based on beta test suggestions that EPA elects to perform, including specific weather simulation enhancements to the Version 3 model

# Organization and Responsibilities

The organizational structure for this project is provided in Figure 1. Individual roles are described in sections 2.1 through 2.7.

**IWCS Quality Assurance Officer**

**IWCS Subcontract Manager/Project Lead**

**EPA LMMD**

**Work Assignment Contracting Officer’s Representative (WACOR)**

**EPA LMMD Quality Assurance Manager**

**EPA LMMD**

**Task Lead**

**CSRA Work Assignment Lead (WAL) and Deputy WAL**

**CSRA**

**Contract Quality Assurance Officer**

**CSRA Document Reviewers**

**Key**

**Reporting Authority**

**Communication**

Figure 1. Project Team Organization

## EPA Work Assignment Contracting Officer’s Representative (WACOR) and Alternate WACOR

The WACOR and Alternate are responsible for the oversight of the work assignment, and provide technical direction and assigns tasking, including specific technical communication projects, to CSRA.

## EPA Task Lead

The Task Lead will provide project oversight and will oversee review of CSRA-generated project documents and products. If necessary, the Task Lead will coordinate any communication between CSRA and EPA subject matter experts.

## EPA Quality Assurance Manager

The EPA Quality Assurance Manager is responsible for Project and Project QA Activities for entry and processing into the “ORD QA TRACK” tracking database. She will provide independent quality assurance oversight to ensure planning, plan implementation, and resulting products are in accordance with the approved QAPP. She will provide technical direction from a QA/QC perspective to EPA Task Lead Personnel, WACOR, Alternate WACOR and Program QA Manager as needed.

## CSRA Work Assignment Lead (WAL) and Deputy WAL

CSRA’s Work Assignment Lead (WAL) and Deputy WAL implement the QAPP; coordinate staff to ensure that all deliverables meet contractual, functional, and due date requirements; participate in development and implementation of response actions and follow-up activities as required; and review work products to ensure that QA goals are met.

## CSRA Quality Assurance Officer

Independent of the project work, CSRA’s Quality Assurance Officer is responsible for reviewing and approving the QAPP; serves as the focal point of QA operations and oversight; ensures appropriateness of corrective actions and follow-up activities and confirms that performance problems are corrected; and receives copies of all QA and QC information and corrective action reports.

## CSRA Task Lead

The CSRA Task Lead coordinates staff to ensure that all deliverables meet technical and functional requirements; reviews documents for accuracy, completeness, and clarity; and provides editorial and technical review of products and deliverables.

## CSRA Document Reviewers

CSRA Document Reviewers internally review CSRA work products and documents to ensure they are free of typographical errors, formatting errors, and inconsistencies.

## IWCS Subcontract Manager/Project Lead

The IWCS Subcontract Manager/Project Lead coordinates IWCS staff to ensure all deliverables for which the subcontractor has responsibility meet technical and functional requirements; reviews documents for accuracy, completeness, and clarity; and provides editorial and technical review of products and deliverables. For this task, IWCS involvement is limited to certain testing support activities, and not in development of HELP Model components.

## IWCS Quality Assurance Officer

Independent of the project work, IWCS’s Quality Assurance Officer is responsible for reviewing the QAPP; serves as the focal point of subcontractor QA operations and oversight; ensures appropriateness of corrective actions and follow-up activities and confirms performance problems are corrected; and receives copies of all subcontractor QA and quality control (QC) information and corrective action reports.

Table 1 lists the main project personnel and key responsibilities of each role.

Table 1. Project Personnel and Key Responsibilities

| Participant | Role | Responsibilities |
| --- | --- | --- |
| Thabet Tolaymat  (NRMRL/ LMMD) | EPA WA Contracting Officer’s Representative (WACOR) | *Formal communications, technical direction, project management review.* EPA point of contact for technical guidance, co-leads project meetings, synthesizes input from EPA Technical Team, receives updates from the CSRA Technical Team, reviews products, contributes to and comments on written products. |
| David Carson (NRMRL/LMMD) | EPA Alternate WA WACOR | *Temporary substitute for EPA WACOR*, should the EPA WACOR be unavailable. |
| Thabet Tolaymat  (NRMRL/ LMMD) | EPA Task Lead | *Daily task management*. EPA point of contact for day-to-day task management and oversight. Identifies and designates technical collaborators and reviewers as required for a specific product. Will serve as the final approver of all data received. Examines all project data that are received by NRMRL, or delegates the data’s review to qualified individuals. |
| Jill Hoelle | EPA QA Manager | *Quality assurance* *reviews*. Manages QA documentation, conducts QA reviews and audits and works with Technical Team to resolve findings. |
| William Balcke | CSRA WAL | *Formal communication, project management*. CSRA point of contact for program control, deliverables, schedules, goals, milestones, risk mitigation, and contingency planning. |
| William Michaud | CSRA Task Lead | *Daily task management.* CSRA point of contact for day-to-day task management and oversight. |
| William Zobel | CSRA Deputy WAL | *Technical task management and support for CSRA WAL.* Oversees technical activities, compiles monthly progress reports, and supports project management. |
| Maggie Jones | CSRA QA Officer | *QA operations*. Oversees contract activities, evaluates QA program plans, project plans, or other WA materials. |
| Pradeep Jain | IWCS Subcontract Manager/Project Lead | *Formal communication, project management.* IWCS point of contact for program control, deliverables, schedules, goals, milestones, risk mitigation, and contingency planning.  *Daily task management.* IWCS point of contact for day-to-day task management and oversight.  *IWCS Technical Lead.* Manages technical tasks, leads subcontracted technical work, and compiles monthly/bimonthly/quarterly/annual progress reports. |
| Shrawan Singh | IWCS QA Officer | *QA operations*. Oversees subcontract activities, evaluates subcontractor QA program plans, project plans, or other WA materials. |

# Model Selection (Model Application Only)

Because use of the HELP model is recommended by the EPA and required by most states for evaluating closure designs of hazardous and nonhazardous waste management facilities, an updated version of this model is valuable. The existing model published for use by the stakeholder community has a user interface or input facility written in the Quick Basic environment of Microsoft Basic Professional Development System Version 7.1 and runs under DOS 2.1 or higher on ffiM-PC and compatible computers. The updated VBA model interface is designed for use on a standard desktop or laptop personal computer by a user who is computer literate. The tool has been developed using Visual Basic (VB) programming language. Specifically, EPA, prior to engaging CSRA, used the VBA functionality within Microsoft Excel to build an operating system-independent tool. Prior to engaging CSRA, EPA staff used Notepad++, a free text editing software, to migrate the programming code from FORTRAN to VBA. The user’s computer must be connected to the Internet using a current standard Internet browser (e.g., Firefox, Google Chrome, etc.) to access the VBA-based tool.

The original HELP program was developed to provide landfill designers and regulators with a tool for rapid, economical screening of alternative designs. The functionality required of the updated HELP model must include the ability to estimate the magnitudes of various components of the water budget, including the volume of leachate produced and the thickness of water-saturated soil (head) above liners. The results may be used to compare the leachate production potential of alternative designs, to select and size appropriate drainage and collection systems, and to size leachate treatment facilities.

The HELP model utilizes a static set of input data that is supplied with the model. The planned migration effort will use that same data set and it will include the following:

1. Units
2. Location
3. Weather data file names
4. Evapotranspiration information
5. Precipitation data
6. Temperature data
7. Solar radiation data
8. Soil and design data file name
9. General landfill and site information
10. Landfill profile and soil/waste/geomembrane data
11. SCS runoff curve number information

# Model Design (Model Development Only)

The hydrologic processes modeled by the program can be divided into two categories: surface processes and subsurface processes. The surface processes modeled are snowmelt, interception of rainfall by vegetation, surface runoff, and surface evaporation. The subsurface processes modeled are evaporation from soil profile, plant transpiration, unsaturated vertical drainage, barrier soil liner percolation, geomembrane leakage and saturated lateral drainage.

# Model Coding (Model Development Only)

The updated version of HELP should be designed for use on a standard desktop or laptop personal computer by a user who is computer savvy. The version of HELP including the modifications implemented here is planned to be fully compatible with the following operation systems: Mac OS 32 bit, Mac OS 64 bit, Win 32 bit, Win 64 bit (Win XP – 32 bit, Vista, Windows 7 and later), Linux 32 bit, Linux 64 bit.

The pre-existing HELP FORTRAN code was available as a text file. The FORTRAN code was migrated by manually copying from the text file and pasting it into the VBA developer module in Microsoft Excel. The code editing was originally conducted by Dr. Max Krause, an ORISE post-doctoral fellow with EPA ORD. Because of this, the EPA research team determined that there was no need for change control to be implemented. CSRA staff will carry forward Dr. Krause’s work, including the following general activities:

* Development of an enhanced user interface for the Excel VBA model, including a single data entry screen, ability to import HELP v3.07 data files, data entry validation, and user feedback
* Development of new functionality enabling users to import precipitation, temperature and solar radiation data from the National Oceanic and Atmospheric Administration (NOAA) and National Renewable Energy Laboratory (NREL) websites
* Development of capacity to incorporate an expanded list of default soil textures, waste layers, geomembrane liners, and geosynthetic drainage nets

The current version (v3.07) of the HELP model allows users to synthetically generate weather data using the Weather Generation Model (WGEN) developed by the U.S. Department of Agriculture, Agricultural Research Service (Richardson and Wright, 1984). As part of the update to the HELP model, the WGEN FORTRAN code will be translated to VBA and incorporated in the Excel VBA-based HELP model. The code will be designed to allow users to generate synthetic weather data using the parameter values required by WGEN calculated based on daily gridded weather data developed by EPA’s Office of Pesticide Programs (Fry et al., 2016).

Some features of the software may have additional system requirements. For example, importing data from, and exporting results to Microsoft Excel requires Excel to be installed. In the case of interoperability issues with new export functionality added in this work, the inclusion of a standard cross-platform comma separated value (.csv) file type to facilitate cross platform functionality will be considered in the course of the execution of this project.

A portfolio of measures for ensuring software quality will be used in this work including a repository and versioning system, clear and transparent names used for elements in the code, utilization of best practices for providing comments together with code, unit tests for testing functionality especially after the software system has been changed, and agile programming that implements early versions of the software and refines them iteratively.

CSRA will maintain intermediate versions of the software during the modification process and will update versions intermittently, which will be archived and backed up on CSRA’s internal network.

# Model Calibration (Model Development and Model Application)

The existing versions of HELP have been checked and vetted and will be assumed to be without error. Since the migration of the HELP model does not involve modification of the original functionality of the code, there will be no calibration necessary since the original model has already been calibrated.

**Alpha testing**: The EPA WACOR or his designee will review periodic tool releases during ongoing enhancements performed by CSRA to ensure each unit performs as expected. EPA will provide feedback on modifications to the user interface regarding functionality, user experience, intuitiveness, ease of use, speed of execution, etc., and on the results generated regarding their validity and representation of desired quantities.

**Beta testing**: Release of intermediate versions of the modified tool to elicit user feedback has been conducted during the execution of this work. The primary activity will be to address any bugs identified during beta testing, compile a list of beta comments and how they were each addressed, and then perform any agreed upon enhancements suggested in the beta test comments. Consideration for conducting enhancements will be the time and effort required to compile and post intermediate releases and the availability of resources.

**Final testing**: It is the intention that continuous testing throughout the course of this work will minimize the time required for final testing. Nonetheless, additional testing will occur in the final phases of this work to ensure all of the implemented changes function as intended.

**Final beta testing or peer review**: Final testing/review will occur in the final phases of this work to ensure all of the implemented changes function as intended.

The basic project schedule has the following key dates:

1) Beta Testing Fall 2018

2) Revised code with WGEN components: August 2019

3) Peer Review of updated model: August-September 2019

4) Final revisions and release of VBA-based HELP Model: October 2019

# Model Verification (Model Development and Model Application)

The CSRA team will test all aspects of the HELP model, including quality assurance testing for functionality, Section 508 compliance, color contrast, WCAG 2.0 standards, spelling and grammatical errors, and other technical specifications.

Testing for correctness of functionality, and therefore the acceptance criterion, is based on both versions (i.e. DOS and VBA) generating outputs within ± 5% of each other for the same set of input data. It is noted that the HELP model is used mainly to calculate static head on the liner (<30 cm). Thus, 5% variation would translate to 1.5 cm difference in the calculation, which is within the accuracy of the methods used by the model. The following steps describe the process by which the product is validated that it meets the acceptance criterion:

1. The developer will deploy modified files onto the testing environment at the end of each development cycle.

2. Tester(s) will test the functionality that has been completed within the cycle, per the agreed upon requirements.

3. The technical lead and developer will report as bugs any acceptance criteria that are not met and will post them to the product queue.

4. The technical lead and developer will prioritize bugs to be fixed ahead of new features.

5. The developer fixes all reported issues that are blockers.

# Model Evaluation (Model Development and Model Application)

Prior to the product being released into production, EPA will conduct a user acceptance testing period where a product review is conducted and the features of the product are outlined along with a list of features and requirements that have been satisfied. The EPA WACOR (or his designee) will be given a window of time in which to conduct an acceptance testing of the product after which a formal acceptance of the product is requested. This process is repeated for each release of software.

# Model Documentation (Model Development and Model Application)

**User’s Guide and Operations Manual**. A basic user’s guide will be created for the HELP Tool. This guide will be updated as the tool development progresses.

**Software Method Documentation**. Program documentation including program options, system and operating requirements, file structures, program structure and variable descriptions will be provided in a separate report.

The HELP model contains default values of soil characteristics based on soil texture class. The documentation for Version 3 describes the origin of these default values (Schroeder et al., 1994). The User’s Guide will list additional soil texture classes defined by EPA since the publication of HELP Version 3 documentation and will refer to technical documentation developed by EPA to describe the bases for new soil texture classes. Recommended default values for leaf area index (LAI) and evaporative depth based on thick loamy top soils are given in the program.

The HELP model computes values for the three Brooks-Corey parameters as described in the documentation for Version 3 (Schroeder et al., 1994) based on the values for porosity, field capacity and wilting point.

The synthetic weather generation methodology is documented in Richardson and Wright (1984). The basis for the daily gridded weather data parameter values for use in WGEN for the HELP model is documented in Fry et al. (2016). The process for calculation of WGEN parameter values for use in the HELP model will be documented in the User’s Guide or supplemental technical documentation to accompany the User’s Guide and model.

# Reporting (Model Development and Model Application)

## Deliverables

CSRA will produce the following deliverables:

* Updated VBA-based HELP model tool and interface
* Response Summary to Beta Test Comments
* Updated HELP Model User Guide
* Supplemental technical documentation (if needed)

## Final Product

An updated HELP model compatible with current computer software and hardware will be produced as a result of this work.

# 11 References

* EPA (2008). NRMRL QAPP Requirements for Research Model Development Projects, revision 0, 10/2008.
* Fry, M.M., G. Rothman, D.F. Young, and N. Thurman (2016). Daily gridded weather for pesticide exposure modeling. Environmental Modelling & Software (82) 167-173.
* Richardson, C.W., and D.A. Wright (1984). WGEN: A Model for Generating Daily Weather Variables. U. S. Department of Agriculture, Agricultural Research Service, ARS-8.
* Schroeder, P. R., Aziz, N. M., Lloyd, C. M. and Zappi, P. A. (1994). “The Hydrologic Evaluation of Landfill Performance (HELP) Model: User’s Guide for Version 3,” EPA/600/R-94/168a, September 1994, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.

# 12 Revision History

Table 2 serves as documentation of changes made in revisions and subsequent versions of this subject QAPP.

Table 2. Revision History for the Subject QAPP

| **Revision #** | **Description** | **Effective Date** |
| --- | --- | --- |
| 1 | Initial Version | July 15, 2019 |
| 2 | Add the weather simulator and introducing data from OCSPP for the weather simulator |  |