A SYSTEMATIC APPROACH TO EVALUATE EROSION POTENTIAL AT ENVIRONMENTAL RESTORATION SITES

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ABSTRACT

The Environmental Restoration (ER) Project at the Los Alamos National Laboratory (LANL) is responsible for investigation and remediation of solid waste management units (SWMUs) under the Resource Conservation and Recovery Act and area of concerns (AOCs) under the direction of the Department of Energy. During the investigation and remediation phases, information may be gathered that indicates that conditions may be present at the site which may affect surface water quality. Depending on the constituent found, its concentration, and erosion/sediment transport potential, it may be necessary to implement temporary or permanent mitigative measures.

I. INTRODUCTION

Los Alamos National Laboratory and the associated residential areas of Los Alamos and White Rock are located in Los Alamos County in north central New Mexico. The km² (27,500 acre) Laboratory and the adjacent communities are situated on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-west oriented canyons cut by ephemeral streams. The mesa tops range in elevation from approximately 2400 m (7800 ft) at the flank of the Jemez Mountains to about 1800 m (6200 ft) at their eastern termination above the Rio Grande Valley.

This paper presents a systematic approach to evaluating surface water concerns at ER sites at LANL. Based on a summary of existing site knowledge, a rapid visual evaluation technique has been developed to rank erosion potential at SWMUs. Since there are more than 2000 SWMUs at LANL, it would be prohibitively expensive to conduct sediment or surface water migration field studies at each site. Instead, the results of a 10-15 minute field assessment process allow operators and regulators to focus their limited resources on sites representing the greatest erosion and/or environmental concern.

II. WORK DESCRIPTION

SWMUs are being investigated at LANL to determine whether they present a threat to human health or the environment. As information becomes available, water quality concerns associated with a SWMU may become evident. If constituents are found to exist at the site above established limits for soil or surface water samples collected at the site, and the topographic and vegetative state of the site suggests that potential migration of those constituents could occur, a corrective action must be proposed, approved and implemented. A three-part approach has been developed to assess any constituents present, to rate the erosion potential of each site and to propose a corrective action, if needed (See Figure 1 - Site Evaluation Flowchart).

A. Part I - Constituent Assessments

The completion of Part I - Constituent Assessments consist of compiling existing SWMU sample data, site maps and knowledge of process information. The following information was requested:

- Soil/sediment sample data that reflect current ambient field conditions which are above detection limits. Information regarding past site conditions was not requested. Information/data are requested only for surface soils and sediments of less than 12 inches in depth.
FIGURE 1: SITE EVALUATION FLOWCHART

NOTE: COPY = CONSTITUENT OF POTENTIAL CONCERN

Knowledge of process

Compile existing analytical data

Part I assessment

Yes

CDPCs on site

Yes

2nd priority team evaluation

Yes

Matrix score > 60

No

CDPCs on site

No

Propose action if appropriate

No

Recommend facility

Address erosion concern

Yes

Recommend implementation

Corrective action

Was corrective action acceptable to regulator?

Yes

Propose "no further action"

No

Implement corrective action

Was corrective action acceptable to regulator?

No

Propose "no further action"

Yes

Propose further evaluation

Site setting

Runoff factors

Run-on factors
Additional information to support site data, including (sample date, sample number, sample location coordinates, media - soil, sediment or tuff, data detection/reporting limits, and supporting background data for the media where data is available).

Surface water sample data where available, regarding sample date, location, whether sample was filtered/non-filtered, and flow information. If surface water samples represent runoff from more than one site, the other SWMUs and their constituents must also be identified.

If samples have been collected but data are not available, the anticipated date when the data could be available. Attach a list of constituents of potential concern (COPCs).

B. Part II - Surface Water Field Assessments

The Surface Water Field Assessments involve evaluating the erosion/sediment transport potential at each SWMU using a pre-developed field assessment form. The information collected from the assessment forms is used to rate the erosion potential of each site using a matrix system. Two-person teams were organized to perform the assessments based on subjective field observations. Erosion potential factors are broken into three categories, 1) Site Setting, 2) Runoff Factors, and 3) Run-On Factors.

1. Site Setting. At LANL, four (4) discrete geographic settings were used to define the location of each SWMU in increasing order of concern; 1) mesa tops, 2) bench or sub-mesa top, 3) floodplains or 4) well defined drainage channels. Where more than one setting is checked, the most conservative setting is used in rating this factor. An example would be where an inactive septic tank was located on a mesa top (a), but the outfall from the septic discharges over the mesa edge onto a defined slope or bench (b), the more conservative setting (b) would be used.

An evaluation of the percentage of ground/canopy cover of the SWMU was made using three pictorial illustrations. These illustrations depicted three percentile ranges; 0%-25%, 25%-75% and 75%-100%. Where more than one percentile range is selected, the most conservative range is used in rating this factor. An example would be where an inactive septic tank was located in a densely vegetated area (c), but the outfall from the septic discharges over the mesa edge onto a less vegetated area (b), the most conservative coverage range (b) would be used.

An evaluation of the percent of slope for the SWMU was made using three pictorial illustrations. These illustrations depicted three percentile ranges; <10%, >10% but <30% and >30%. Where more than one slope factor is selected, the most conservative is used in rating this factor. An example would be where an inactive septic tank was located on a mesa top (a), but the outfall from the septic discharges over the mesa edge onto a very steep slope (c), the most conservative slope factor (c) would be used.

2. Runoff Factors. Runoff factors were assessed by answering one to four (1-4) questions for each SWMU; 1) Is there visible evidence of water and/or sediment discharging from the SWMU? If the answer to question #1 is no, then proceed to Run-on Factor section, if the answer to question #1 is yes, then proceed with answering the following questions, 2) Are the run-off discharges channelized? An explanation box is provided to describe whether observed channelization is naturally occurring or manmade, or if the evidence is related to sheet flow processes, 3) Where does the evidence of run-off terminate? If run-off can be traced to an observable endpoint, three choices are provided to describe the termination point in decreasing order of concern; a) the runoff terminates into a well defined drainage or wetland, b) the runoff terminates within a bench or sub-mesa top, or c) the runoff terminates into other areas such as a meadow or a retention areas (the matrix criteria imposes a heavier weight to runoff termination points in or near watercourses), and 4) Has runoff caused visible erosion at the SWMU? If the answer is yes, then three choices are provided to describe the erosion in increasing order of concern; a) sheet erosion, b) rill erosion or c) gully erosion (the matrix criteria imposes a heavier weight to more severe types of visible erosion).

3. Run-on Factors. Run-on factors were assessed by answering three (3) yes/no related questions for each SWMU; 1) Are structures (e.g., buildings, roof drains, parking lots) creating run-on to this SWMU? 2) Are current operations adversely impacting storm water run-on to the SWMU? 3) Are natural drainage patterns directing storm water onto the SWMU? Typically, either question 1 or 3 would be selected independent of one another. If both are selected, then only one will be rated in the matrix since the weighting is identical.
4. Matrix Scoring. The weight of each factor is intended to reflect its relative importance for erosion potential. Accordingly, Runoff Factors have the greatest weight, 46 percent. In other words, the absence of visible erosion indicates minimal potential for sediment transport and corresponding impact on surface waters. Similarly, if run-off can be traced to a wetland or a well defined drainage, the impact may be of greater potential concern. Site Setting represents a similar weight, 43 percent, reflecting well-defined site characteristics, such as ground cover, slope, and proximity to a watercourse, which has a clear relationship to erosion potential. Run-On factors have a relatively low weight, 11 percent, since run-on is of little concern unless it increases runoff. The range of weighting each site is 0 to 100 (see Figure 2 - Erosion Matrix Score Sheet).

Matrix scores are calculated automatically using Microsoft Access 7.0 during the process of Part II data entry. It should be noted that the matrix score is calculated only when the Part II information is entered into the database, and that the relative weights of the various factors do not appear on the field form. The intent of this is to separate, as much as possible, the process of data collection from the process of data analysis.

To make a manual calculation of the matrix score, transfer the information obtained from the Part II field assessment form onto the Erosion Matrix Score Sheet. Where the selection involves three (3) options, multiply the weighted value by either a low (1), medium (.5) or high (1.0) erosion potential factor. Write the appropriate weighted value selected or calculated in the Calculated Score column. The sum of all criteria from the Calculated Score column equals the Erosion Matrix Score.

III. RESULTS OF EVALUATION

Field teams assembled by the Water Quality & Hydrology Group (ESH-18) completed over 900 surface water field assessments within a seven month period between June and December of 1997. This process included the completion of the field assessment forms, photographic documentation and data entry. The distribution and frequency of the Part II Surface Water Field Assessment scores are shown below.

![Histogram of Erosion Matrix Scores](image)

NOTE: Distribution shows THREE peaks, in the 0-5 range (mostly the minimum score, 3.6); the 20-30 range; and the 55-60 range.

This matrix is not intended to replace or override professional judgment. The erosion matrix score is intended to support the process of comparing and prioritizing sites with various physical characteristics but not to define this process.

Concurrently, personnel from the Environmental Restoration Program compiled data stored in the project’s Facility for Information, Management, Analysis, and Display (FIMAD) database to support the completion of the Part I Constituent Assessments as described in Part II.A.
# Erosion Matrix Score Sheet

## Figure 2

<table>
<thead>
<tr>
<th>CRITERIA EVALUATED</th>
<th>Value</th>
<th>Erosion/Sediment Transport Potential</th>
<th>Calculated Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low 0.1</td>
<td>Medium 0.5</td>
</tr>
<tr>
<td><strong>Site Setting (43)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On mesa top</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within bench of canyon</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within the canyon floodplain but not watercourse</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within bottom of canyon channel in watercourse</td>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated % ground and canopy cover</td>
<td>13</td>
<td>&gt;75%</td>
<td>25-75%</td>
</tr>
<tr>
<td>Slope</td>
<td>13</td>
<td>0-10%</td>
<td>10-30%</td>
</tr>
<tr>
<td><strong>Surface Water Factors-Run-off (46)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visible evidence of runoff discharging? (Yes/No)</td>
<td>5</td>
<td>If no, score of 0 for runoff section.</td>
<td></td>
</tr>
<tr>
<td>Where does runoff terminate?</td>
<td>19</td>
<td>Other</td>
<td>Bench Setting</td>
</tr>
<tr>
<td>Has runoff caused visible erosion? (Yes/No)</td>
<td>22</td>
<td>Sheet</td>
<td>Rill</td>
</tr>
<tr>
<td><strong>Surface Water Factors-Run-on (11)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structures adversely affecting run-on (Yes/No)</td>
<td>7*</td>
<td>If yes, score as 7. If no, score as 0.</td>
<td></td>
</tr>
<tr>
<td>Current operations adversely impacting (Yes/No)</td>
<td>4</td>
<td>If yes, score as 4. If no, score as 0.</td>
<td></td>
</tr>
<tr>
<td>Natural drainages onto site (Yes/No)</td>
<td>7*</td>
<td>If yes, score as 7. If no, score as 0.</td>
<td></td>
</tr>
</tbody>
</table>

*Select either structures or natural drainages.

**MAX. POSSIBLE EROSION MATRIX SCORE:** 100

**Total Score**
A. Part III - Recommended Actions

Parts I and II provide a basis for prioritizing and scheduling corrective actions needed to control undesirable surface water runoff and constituent laden sediments eroding from SWMUs. A team of stakeholders was formed to evaluate the completed assessments. The team uses only existing information for the SWMU of interest, as reported in Parts I and II. The ability of the team to efficiently evaluate a site is directly dependent upon the SWMU documentation to date.

The erosion matrix scores were separated into three ranges to address the potential for migration of constituents in surface water and/or sediment; sites scoring <40, sites scoring > 40 but <60 and sites scoring > 60, which reflected a low, moderate and high priority range respectively. Although a surface water concern could be identified at any SWMU, within any range, the high-priority sites were addressed first.

For sites where Surface Water Field Assessment score is higher than 40, team evaluations are completed to prioritize corrective actions for the site. Sites identified as having pre-defined bioaccumulator constituents or highly concentrated COPCs present, are prioritized to ensure the worst sites are evaluated first. The following table shows the frequency of Part II matrix scores within the selected ranges.

<table>
<thead>
<tr>
<th>Frequency of Part II Matrix Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% scored &gt; 60 on Part II</td>
</tr>
<tr>
<td>16% scored &gt; 40 but &lt; 60 on Part II</td>
</tr>
<tr>
<td>74% scored &lt; 40 on Part II</td>
</tr>
</tbody>
</table>

For sites where the Surface Water Field Assessment score is less than 40, no action is required at over 95% of the sites. This score reflects a site where there is an extremely low potential for migration of constituents. These sites are not included in a committee evaluation, but may be evaluated for other possible unacceptable environmental risks, such as human health and ecological risks.

IV. CONCLUSIONS

Sites with COPCs present, which have a moderate to high erosion potential, require a written summary from the team, to recommend what corrective action will be taken at the site. These corrective actions can be minimal activities such as Best Management Practices (BMPs), which temporarily stabilize the site until a final remedy can be applied. BMPs require routine inspection and maintenance to ensure their effectiveness. Final remedies will likely be constituent removal or the application of an engineered solution, inhibiting migration potential while protecting water resources. Upon completion of a corrective action at a SWMU, a No Further Action report will be generated and submitted to the New Mexico Environment Department describing the results of the actions.

A Watershed Management Program is currently being implemented at the Los Alamos National Laboratory using a "top down" and "bottom up" strategy. In support of the "top down" approach of this strategy, these systematic evaluations have been found to be an effective screening and prioritization tool for determining which sites have the most potential to adversely impact surface waters at LANL. Although the approach is based on subjective observations, it is a rapid and consistent way to characterize erosion and constituent transport potential at a large number of sites. Since it would be prohibitively expensive and time consuming to evaluate pollutant migration at over 2000 sites using modeling techniques, we feel that the limitations of this approach are acceptable. Furthermore, it is hoped that environmental professionals may be able to adapt this approach in future characterization activities, beyond this application for erosion/constituent transport.
ACKNOWLEDGMENTS

Merrick & Company's development of the tracking database and matrix programming work is supported by the University of California, which operates LANL for the U.S. Department of Energy. The approach was created with input from Merrick & Company, Neptune & Company, LANL's Water Quality & Hydrology Group (ESH-18), LANL's Environmental Restoration Project (EM/ER) and New Mexico Environment Department personnel.

REFERENCES