Idaho National Engineering and Environmental Laboratory

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Development of the FY - 02 Supplement of the INEEL Site-Wide Vadose Zone/Groundwater Roadmap

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ABSTRACT

The purpose of this document is to present the results of the preparation of the FY - 02 Supplement of the INEEL Vadose Zone/Groundwater Roadmap. This document is a supplement to the document, "*Uncertain Predictions of Contaminant Behavior at INEEL: A Roadmap for Addressing Current Limitations through Vadose Zone Studies, INEEL/EXT-2001-552, Draft, September 2001.*" This supplement of the roadmap has been developed to determine gaps in knowledge and capabilities for the vadose zone and groundwater at the INEEL and to ensure that ongoing and planned S&T activities will meet INEEL Operations and S&T needs in the coming years. As part of determining these gaps in knowledge and capabilities, a listing of uncertainties was developed by scientists and engineers knowledgeable in the areas of geosciences, flow and transport modeling, source term issues, and surface and groundwater issues. The primary objective of the Roadmap is to develop science strategies that will facilitate monitoring, characterization, prediction, and assessment activities necessary to support the reduction of uncertainties in long term risk predictions, assist in risk management decisions, and ensure that long-term stewardship of contaminantd sites at the INEEL is achieved. The mission of the Roadmap is to insure that the long-term S&T strategy is aligned with site programs, that it takes advantage of progress made to date, and that it can assist in meeting Operations milestones and budgets.

The document also presents Environmental Restoration (ER), Spent Nuclear Fuel (SNF), High Level Waste (HLW), Transuranic Waste (TRU), Low-Level Waste (LLW), Environmental Management (EM), Resource Recovery and Conservation Act (RCRA), and Deactivation/Decontamination/ Decommissioning (D&D&D) milestones tied to accelerated dates and uncertainties. Uncertainties are also matched to S&T being developed by the National Vadose Zone Roadmapping Program. A summary of Operational R&D needs and issues are also presented. These needs were developed through interviews with Operations staff.

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DEVELOPMENT OF THE FY – 02 SUPPLEMENT OF THE INEEL SITE-WIDE VADOSE ZONE/GROUNDWATER ROADMAP

1 INTRODUCTION

The FY – 02 supplement of the INEEL Vadose Zone/Groundwater Roadmap (the Roadmap) has been developed to determine gaps in knowledge and capabilities for the vadose zone and groundwater at the INEEL and to ensure that ongoing and planned S&T activities will meet INEEL Operations and S&T needs in the coming years. The primary objective of the Roadmap is to develop science strategies that will facilitate monitoring, characterization, prediction, and assessment activities necessary to support the reduction of uncertainties in long term risk predictions, assist in risk management decisions, and ensure that long-term stewardship of contaminantd sites at the INEEL is achieved. The mission of the Roadmap is to insure that the long-term S&T strategy is aligned with site programs, that it takes advantage of progress made to date, and that it can assist in meeting Operations milestones and budgets.

In order to determine gaps in knowledge, a listing of uncertainties was developed as part of the INEEL Water Integration Project's Vadose Zone/Groundwater Roadmapping task. The uncertainties were developed by scientists and engineers knowledgeable in the areas of geosciences, flow and transport modeling, source term issues, and surface and groundwater issues. These uncertainties represent gaps in knowledge and capabilities for the vadose zone and groundwater at the INEEL. There were 25 uncertainties developed by utilizing the uncertainties from the document,*"Uncertain Predictions of Contaminant Behavior at INEEL: A Roadmap for Addressing Current Limitations through Vadose Zone Studies, INEEL/EXT-2001-552, Draft, September 2001,"* and from an uncertainties validation meeting held in March 2002.

Twenty-five people participated in a facilitated Value Engineering Session to prioritize the uncertainties. These twenty-five represented public stakeholders, federal and state regulators, State of Idaho INEEL Oversight Program, the United States Geological Survey, DOE Headquarters, DOE-ID, and BBWI. They had a wide range of backgrounds including concerned public, INEEL Operations, geoscience research, flow and transport modeling, geochemistry, contaminant experts, applied geosciences, agriculture, academia, and project management. These 25 people spent two days discussing the uncertainties, developing criteria to be used in the prioritization, and prioritizing the uncertainties. All data from the two days are presented in the document *"Raw Data Report and Meeting Record from the Vadose Zone/Groundwater Uncertainties Prioritization Meeting, April 2 & 3, 2002, INEEL/EXT-02-00529."* The results of this ranking will be used to develop recommendations and science strategies for research and technology development and long term monitoring projects at the INEEL to more effectively achieve programmatic goals.

2 BACKGROUND

Managing contaminantd sites involves characterization of the affected areas, determination of contaminant release history and assessment of current and future risk. Each of these steps introduces a measure of uncertainty that is not fully quantifiable. The process knowledge and data obtained during the assessment stage is used to develop a Record of Decision (ROD) that documents the remedial actions required in the CERCLA process to achieve acceptable risk. Possible remedial actions include removing or destroying selected contaminants, stabilizing contaminants in place, onsite disposal at the INEEL's ICDF, or relocating contaminantd material to locations off of the INEEL. Following the development of the ROD, the Remedial Design/Remedial Action (RD/RA) phase implements the mitigating action(s). The final management stage involves monitoring the INEEL to ensure that the remedial goals have been met and to allow early detection of hazards. After proven successful remediation, the maintenance of acceptable risk is integrated with other site management functions as a component of DOE's long-term stewardship program.

At the INEEL, contaminantd sites include those affected by historical releases (managed through the CERCLA process), sites corresponding to currently operational facilities (managed through the RCRA program), and buildings that are under the Decontamination and Decommissioning (D&D) programs. At the INEEL, CERCLA sites are grouped by waste area (Waste Area Groups, or WAGs), and typically correspond to facility boundaries.

Table 2-1: INEEL Facility Name and Corresponding Waste Area Group (WAG) Designation

INEEL Facility Name	Waste Area Group (WAG) Designation
Test Area North (TAN)	WAG – 1
Teat Reactor Area (TRA)	WAG – 2
Idaho Nuclear Technology and Engineering Center (INTEC)	WAG – 3
Central Facilities Area	WAG – 4
Power Burst Facility and Auxiliary Reactor Area	WAG – 5
Experimental Breeder Reactor No. 1	WAG - 6
Radioactive Waste Management Complex	WAG – 7
Naval Reactor Facility	WAG – 8
Argonne National Laboratory - West	WAG – 9
Miscellaneous Sites and Sitewide Area	WAG - 10

Facilitating scientific advances that result in a reduction of uncertainty in risk calculations for public health risk is one of the goals of this Roadmap. Prioritized uncertainties can assist in regulatory decisions that affect ongoing and proposed remedial actions. Developing science strategies to provide answers to these uncertainties can assist with future regulatory documents and milestones and can be incorporated into ongoing remedial actions by exercising the ROD amendment option or Explanation of Significant Differences (ESD) provided by the CERCLA (42 USC § 9601 et seq.) guidance. Under the ROD amendment option, new technology can be used at anytime to improve the schedule or cost during the remediation of a contaminated area in addition to allowing its use following the 5-year review of each ROD. For sites currently in the RI/FS or post-ROD stage, information garnered through S&T advances will be utilized to answer uncertainties and can be used to support the decision and remedial action selection processes.

3 DECISION BASIS AND SOURCES OF UNCERTAINTY

At the INEEL, environmental management decisions are based on current and potential public health impact. There are essentially two measures of health impact: the first is a measure of risk, and the second is a maximum concentration level (MCL). Risk via ingestion, as defined by the EPA, is expressed by:

Risk = Exposure Factor*Toxicity* Contaminant Concentration

and is composed of several elements including exposure factors and scenarios, contaminant toxicity, and contaminant concentration. The first two of these are dictated by the regulatory agencies and long term use of the land, while the third term provides the focus of the proposed research. The exposure factor is determined by land use scenarios, which includes residential, agricultural, and industrial use scenarios for land and water, and are determined by the EPA. Chemical and radiological toxicity is contaminant specific and is also set by the EPA. The contaminant concentrations of interest to the roadmapping study are the concentrations of contaminants in subsurface waters that can be used for domestic, agricultural, and industrial purposes. The waters of interest are those that occur in harvestable quantities, and are found in the Snake River Aquifer (SRPA), and water occurring in the vadose zone.

To evaluate risk stemming from the use of subsurface water, contaminant concentrations in saturated regions are used as opposed to soil pore-water concentrations. These concentrations are spatially and temporally variable, and depend on the release history of contaminants and on the travel path through the vadose zone. To evaluate current risk, contaminant concentrations are measured at a limited number of locations, and assumptions are made about their spatial continuity and distribution. To evaluate future risk, contaminant concentrations must be predicted over time frames of interest to regulators and to the public. The prediction interval depends on specific contaminants and on the management decision. Time frames can span several months for interim actions or more than 10,000 years for permanent storage of long-lived radionuclides. Environmental management decisions made at INEEL have traditionally relied on predicting future contaminant concentrations with models starting with release history and matching current measurements. Because of our limited understanding of subsurface phenomena and an inability to translate point measurements over spatial scales, there are large uncertainties associated with these predictions of future contaminant behavior.

Information about hydrogeochemical properties or state variables (i.e., pressure, moisture content, and concentration) in highly heterogeneous porous media, such as the fractured basalt-sediment materials underlying the INEEL, are always uncertain to some degree. There is a limited ability to quantify heterogeneous physical, biogeochemical, and hydraulic properties and their nonlinear relationships to state variables. The data are used in computer models, generally employing simplified conceptual models, to describe transport and transformations to predict future contaminant behavior. Uncertainty imbedded in the conceptual models used to represent the systems being simulated, estimates of parameters and processes necessary to implement those conceptual models such as infiltration rates and contaminant inventories and release mechanisms are then propagated and compounded in the modeling process, resulting in a large degree of uncertainty in predictions of contaminant concentrations.

The EPA typically sets drinking water contamination goals to fall within the 1E-6 to 1E-4 risk range. The range also suggests a need to quantify the uncertainty of all components used in modeling contaminant fate and transport, and to understand how to manage the distribution of uncertainty between data sets and functional relationships. To minimize erroneous environmental management decisions, uncertainties in predictions of future contaminant behavior need to be understood and quantified.

The relative importance of parameters and processes in determining the uncertainty is currently unknown. Additionally, parameters and state variables are not typically measured with methodology allowing assessment of uncertainty. The Roadmap places these sources into four primary categories:

- **Conceptual Model uncertainty** addresses our ability to approximate the real world with a conceptual model. Models used as the basis for decision-making need to capture relevant processes (e.g., flow, transport, and transformation) at the level of detail necessary to describe the governing phenomena at relevant temporal and spatial scales. The individual processes included in the models determine which parameters and state variables must be quantified. In addition, each process model determines the required characterization methods and data density.

- **Parameter uncertainty** is introduced in heterogeneous environments and must be quantified in context of the process model used to analyze the information. Interpretation of measured parameters over varying distances (i.e., spatial scales) is one of the key challenges facing sub-surface environmental predictions, and the issue is probably best known as the scaling phenomena. An additional source of parameter uncertainty is introduced through the interpretation of measurements of different parameters made over disparate volumes. An example is provided by measurements of water potential obtained using a limited volume sampling device (e.g., an advanced tensiometer) and measurements of water content obtained using volume averaged geophysical techniques: the result doesn't necessarily describe accurately the relationships between water potential and water content, which is needed to predict unsaturated water flow.

  Important issues relevant to spatial scaling encountered during predicting transport and transformation at the INEEL include determining how to a) incorporate microscale biogeochemical processes into field scale prediction, b) how to extend observations of flow through single fractures to predict field scale transport, and c) how to interpret measurements of water content and water potential over volumes representative of field scale transport. At the INEEL, the parameter space includes biologic, geologic, geochemical, and hydrologic variables for the fractured basalt and the interlayered sediments comprising the Snake River Plain system.

- **Interpretation uncertainty** is introduced through use of indirect estimates of state variables, and by analyzing data in the context of incorrect process models. An example of the first includes using electrical geophysical signals to infer moisture content in heterogeneous media. An example of the second includes inferring hydraulic conductivity in layered sediment and fractured basalt media using a Theis curve approximation developed for radially symmetric flow in confined homogeneous aquifers. In each of these examples, it is not clear what is being measured or how to interpret the obtained values, increasing the overall model uncertainty.

- **Source estimate uncertainty** is introduced when reconstructing historical release inventory and duration when the discharges are poorly (if at all) documented. The problem is compounded when the end state of the facility is yet to be determined and when sampling facility contents is impossible. The potential for exposing personnel to hazardous conditions often precludes our ability to investigate contaminantd sites, operational facilities, or facilities with unknown dangers.

Development of the science strategies will be designed to address the top 10 prioritized uncertainties, which fall into these four areas of uncertainty.

4 OBJECTIVES AND PRIORITIES OF SCIENCE AND TECHNOLOGY RESEARCH

The objective of the science strategy development will be to develop S&T to increase acceptable levels of confidence in environmental management decisions. This requires quantification and reduction in risk prediction uncertainty. Priorities for science and technology research to support the science will be determined on the potential to quantify and reduce the uncertainty in risk predictions. Across the INEEL, the contaminant release history, contaminant inventory, subsurface environment, and surface driving forces vary.

The development of science strategies needs to be coordinated with major decision milestones across the INEEL. Among the individual Programs the decision time frames for accelerated cleanup have been determined and are discussed in the document, *"Environmental Management Performance Management for Accelerating Cleanup of the Idaho National Engineering and Environmental Laboratory, DOE/ID – 11006, Predecisional Draft Revision 0, June 2002*." Appendix A provides a listing of regulatory milestones utilized in the roadmap along with the prioritized uncertainties tied to each milestone.

In addition to the matching of the prioritized uncertainties to the regulatory milestones, S&T from other programs across the complex were reviewed for their applicability to the INEEL needs. The top 10 uncertainties from the uncertainties prioritization workshop were matched to S&T activities presented in the National Roadmap for Vadose Zone Science & Technology (DOE/ID - 10871). This crosswalk is presented in Appendix B. S&T activities from the National program may assist in reducing the VZ/GW uncertainties developed for the INEEL. The National program captured 61 activities, most of which have associated tasks and status points with either a near-term, mid-term, or long-term time frame for achievement. The long-term tasks and status points have results over two to three decades (roughly a 25-year horizon). As the INEEL regulatory milestones are concentrating on an accelerated schedule (2012), the table presented in Appendix B only shows the near-term (approximately 4 years) and the mid-term (approximately 10 years) activities. Other longer term (25 year tasks) identified in the National Roadmap may be useful for Long Term Stewardship of the site. The needs of individual remedial actions across the sites of ER, EM, SNF, HLW, LLW, D&D, and stewardship projects are quite diverse. Each of these factors will impact the relative priority given to individual scientific and technological advances.

5 ROADMAP DEVELOPMENT

The INEEL Vadose Zone/Groundwater Roadmap was developed following the guidance set forth in:

- Introduction to Technology Roadmapping: The Semiconductor Industry Association's Technology Roadmapping Process, 1997, Sandia National Laboratory (SNL) Report SAND97-0666.

- Fundamentals of Technology Roadmapping, 1998, SNL Business Development Department.

- Technology Roadmapping: an Overview. Presentation by McNeil Technologies for the Complex-Wide Vadose Zone Roadmapping Project, 1999.

- Applying Technology Roadmapping in Environmental Management (draft), 2000, DOE EM-50.

Similarities were found between INEEL and Hanford S&T requirements. Because of the technical and regulatory similarities and the National Academy of Sciences review of the Hanford roadmap, the Hanford roadmap was adapted as the template for this Roadmap.

Steps involved in the roadmapping process included:

- A survey was conducted to define specific capabilities and needs in the area of vadose zone activities and the INEEL (November, 1998).
- A Vadose Zone Workshop was held in October 1999 to: validate deficiencies, reduce the number of deficiencies (100 to 26), and to group deficiencies.
- Meetings were held with Hanford GW/VZ Roadmapping Staff to discuss areas of research needs (April 2000).
- Determining the level of knowledge concerning contaminant inventories, subsurface properties and processes, and predictive capabilities required to address contaminant issues at the INEEL. The state of knowledge, acknowledged deficiencies, and recommendations for addressing the deficiencies are captured in the "Deficiencies in Vadose Zone Understanding at the Idaho National Engineering and Environmental Laboratory" (INEEL/EXT-99-00984) report. The deficiencies document was developed primarily from the perspective of improving estimates of concentrations resulting from transport and transformation of contaminants beneath the INEEL. To affect operational decisions, aspects of risk and uncertainty must also be assessed. (August 2000)
- Development of the document, "Uncertain Predictions of Contaminant Behavior at INEEL: A Roadmap for Addressing Current Limitations Through Vadose Zone Studies" INEEL/EXT- 2001-00552. This document was developed to illustrate where uncertainties arise in predictions of contaminant behavior in the unsaturated zone between the land surface and the underlying Snake River Plain Aquifer (SRPA) at the INEEL, and to underscore the scientific advances required to quantify and reduce that uncertainty. Although much has been accomplished and learned through the analysis of contaminantd sites at the INEEL, significant gaps remain. In an effort to close the gaps, the report details limitations in analysis conducted thus far, and recommends specific actions to address the limitations. Currently, the vadose zone experts at the INEEL cannot with confidence predict the movement of water and contaminants through the heterogeneous fractured basalts and sediments comprising the vadose zone, and this results in uncertain environmental management decisions.
- ASME Review of the Vadose Zone Roadmapping project (August 2001). This review of the roadmapping process provided the following recommendations for improvement: Need to develop a Project Management Plan; Need to document how the roadmap fits into current/future Operations, ER, and LTS; Identify uncertainty reduction targets that would have the most impact on project objectives; Hold regular meetings with stakeholders; Link SSI and SGL to uncertainty reduction targets.
- An uncertainties verification meeting was held to verify that the uncertainties identified were still correct and to evaluate if the uncertainties identified apply to both the vadose zone and the aquifer (March 2002).
- An Uncertainties Prioritization Value Engineering Session was held in Idaho Falls, Idaho on April 2 & 3, 2002 to prioritize the vadose zone and groundwater uncertainties. The uncertainties were developed over a two-year period by scientists and engineers knowledgeable in the areas of geosciences, flow and transport modeling, source term issues, and surface and groundwater issues. These uncertainties represent gaps in knowledge and capabilities for the vadose zone and groundwater at the INEEL. There were 25 uncertainties developed by utilizing the uncertainties

from the document,*"Uncertain Predictions of Contaminant Behavior at INEEL: A Roadmap for Addressing Current Limitations through Vadose Zone Studies, INEEL/EXT-2001-552, Draft, September 2001"*, and from the uncertainties verification meeting held in March 2002.

Twenty-five people, representing public stakeholders, federal and state regulators, INEEL State Oversight, the United States Geological Survey, DOE Headquarters, DOE-ID, and BBWI, participated in the Value Engineer Session to prioritize the uncertainties. They had a wide range of backgrounds including concerned public, INEEL Operations, geoscience research, flow and transport modeling, geochemistry, contaminant experts, applied geosciences, agriculture, academia, and project management. The results of this ranking will be used to develop science strategies for integrating research and technology development and long term monitoring projects at the INEEL to more effectively achieve programmatic goals.

- Insertion of the prioritized uncertainties into the major programmatic milestones associated with the site programs. (July 2002)

6 IDENTIFICATION OF SPECIFIC OPERATIONAL NEEDS

As part of the roadmapping activity, personnel with Operations expertise and knowledge of both the needs to meet regulatory milestones and the needs for long term monitoring of the site were asked to identify R&D needs. Approximately 30 people from DOE-ID, BBWI, Northwind, and Argonne were interviewed during this process. There were 118 Operational R&D needs identified from the interviews. The detailed results of the interviews are presented in Attachment C. The detailed list matches specific needs with technical needs, Waste Area Group need, and what uncertainty the R&D would help to solve. The major Operational needs and the WAGs that would benefit from R&D are summarized as follows:

Plutonium Geochemistry/Transport **WAGs 3 & 7**

- Need to develop better understanding of Pu partitioning and Kd values for Pu compounds in to order to understand the geochemistry of Pu transport.
- Need to perform research on how Pu colloids form and move through both the VZ and aquifer.
- Facilitated transport models need to be developed to predict movement of Pu in the subsurface.

Carbon-14 Research **WAG 7**

- Research is needed on C^{14} source, movement, isotope mobility, transport, and two-phase transport in the subsurface at WAG 7.

Actinide Geochemistry Research **WAG 7**

- Research on actinide solubility, oxidation states, and mobility is needed to understand release from waste forms.
- Research to determine source of elevated U in the VZ at Pit 5 and at the west end of the SDA.

Kd Value Research **WAGs 3 & 7**

- Developing appropriate Kd values is necessary in order to determine how geochemistry is influencing flow and transport.

Development of Better Monitoring Methods **WAGs 3, 7, & 10**

- Develop 3-D tomography and other cross-hole geophysical techniques to better define spatial monitoring conditions in both the VZ and aquifer.
- Develop better tracer studies and tracer monitoring methods to study transport through the VZ.

Source Term Research **WAG 3 & 7**

- R&D is necessary to develop source term release rates, effects of near field conditions, waste form information, and fate and transport of contaminants from buried wastes and contaminants that may be left after remediation.

Flow Characterization Methods **WAGs 3, 7, & 10**

- Methods need to be developed to improve characterization of fracturing and to detect preferred "fast" flow pathways in the basalt for the VZ and the SRPA.
- Develop methods using the solute content, temperature differences, natural isotopes, and isotope ratios to define flow, preferential pathways and origins of groundwater in the SRPA.
- Perform vertical profiling of contaminant plume geometry to determine layering effects of flow on transport through the subsurface.

Development of Models and Codes **WAG 7**

- Develop better scientific modeling of moisture movement in the type B probes at WAG 7 to achieve a greater understanding of flow and transport.

Research on Caps/Barriers/Grouting/Remediation Methods **WAG 7**

- Studies of long-term degradation of landfill covers in arid environments are needed.

In order to prioritize the 118 needs identified during the interview process, a second Value Engineering session was held in Idaho Falls, Idaho on September 10 and 11, 2002 to review and prioritize the needs. The objective of the Value Engineering session was to prioritize the programmatic needs for development of science strategies in FY- 03.

Twenty-three people, representing federal and state regulators, INEEL State Oversight, the United States Geological Survey, DOE Headquarters, DOE-ID, and BBWI, participated in the Value Engineer Session to prioritize the Operational R&D needs. This group was made up primarily of the same group that participated in the Uncertainties Prioritization Value Engineering Session that was held in Idaho Falls, Idaho on April 2 & 3, 2002 to prioritize the vadose zone and groundwater uncertainties. They had a wide range of backgrounds including INEEL Operations, geoscience research, flow and transport modeling, geochemistry, contaminant experts, applied geosciences, agriculture, academia, and project management. The results of this prioritized ranking of R&D needs will be used to develop science strategies in FY – 03 for integrating research and technology development and long term monitoring projects at the INEEL to more effectively achieve programmatic goals. The Raw Data Report and Meeting Record of the Value Engineering Session is included as Appendix D to this document.

7 MILESTONES FOR THE INEEL WATER INTEGRATION PROJECT VZ/GW ROADMAP

The following scope and milestones have been developed as a long-term INEEL strategy for management of ecological, economic, social, and health risks associated with contaminant transport in the vadose zone. This scope has been developed to move the INEEL VZ/GW Roadmapping effort forward.

Scope to Be Performed (FY 2002):

- Identify Specific Operational Needs (8/15/02)

Scope to Be Performed (FY 2003):

- Develop science strategies (10/01 – 12/31/02)
- Develop test plans (10/01 – 12/31/02)
- Review science strategies and test plans (1/1 – 2/28/03)
- Write calls for proposals (3/1 – 3/31/03)
- Distribute calls to stakeholders (4/1 – 5/31/03)
- Provide proposals to research proposal development entities (4/1 – 5/31/03)
- Assist proposal development entities in screening of calls (4/15 – 5/31/03)

Scope to Be Performed (FY 2004):

- Implementation of Test Plans and Science Strategies

Attachment A

VZ/GW Roadmap Milestone Dates with Associated Uncertainties

Program	Milestone	Proposed Date	Proposed 2012 Plan Date	New/Actual Date (x if actual is same as proposed)	Uncertainties from the VZ/GW Uncertainties Prioritization Meeting[(2)]
ER	OU 1-07B Draft FDR Phase I Sent by DOE-ID to EPA/IDHW	01/03/00		10/28/99	
ER	OU 1-07B Draft ROD Amendment Submitted to Agencies for Review	02/28/01		X	
ER	OU 1-10 Institutional Control Status Monitoring Report to EPA/IDHW	06/02/00		05/17/00	
ER	OU 1-10 Draft RD/RA Work Plan Sent by DOE-ID to EPA/IDHW for Review and Comment (soils)	07/03/00		04/20/00	
ER	OU 1-10 Group 2 Draft RD/RA Work Plan Sent by DOE-ID to EPA/IDHW for Review and Comment	08/06/01		07/17/01	
ER	OU 1-10 Begin Post-ROD Sampling to Start Continuous Remedial Activities	10/31/00		02/28/00	
ER	OU 1-07B In Situ Bioremediation Draft RD/RA Work Plan Sent by DOE to EPA/IDHW	09/30/02			1, 2, 3, 4, 6, 8, 10, 12, 17, 18
ER	OU 1-07B New Pump and Treat Facility Draft RA Report Sent by DOE to EPA/IDHW	11/30/02			1, 2, 3, 6, 8, 9, 10, 12, 15, 17, 19
ER	OU 1-07B Natural Attenuation Draft RD/RA Work Plan Sent by DOE to EPA/IDHW	03/31/03			1, 2, 3, 4, 6, 9, 10, 12, 17, 18

ER	OU 1-07B New Pump and Treat Facility Phase C Draft O&M Plan Revision Sent by DOE to EPA/IDHW	06/30/03			1, 2, 3, 6 , 8, 9, 12, 15, 17, 19
ER	OU 1-07B In Situ Bioremediation Draft Pre-final Inspection Report Sent by DOE to EPA/IDHW	03/31/04			1, 2, 3, 4, 6, 8, 10, 12, 17, 18, 21
ER	OU 1-10 Group 3 Draft RD/RA Work Plan Sent by DOE to EPA/IDHW	09/30/04			1, 5, 9, 15
ER	***Complete Remediation of WAG 1***		***2005***		2, 3, 4, 8, 9, 10, 12, 17
ER	OU 3-13 Group 1 Phase I Draft RD/RA Work Plan Sent by DOE-ID to EPA/IDHW	05/04/00		04/27/00	
ER	OU 3-13 Group 1 Phase II Draft RD/RA Work Plan Sent by DOE-ID to EPA/IDHW	12/21/00		04/27/00	
ER	OU 3-13 Group 2 Closure Evaluation Criteria and Checklist Sent by DOE-ID to EPA/IDHW	06/13/00		06/06/00	
ER	OU 3-13 Group 4 Draft Monitoring System and Installation Plan Sent by DOE-ID to EPA/IDHW	05/04/00		04/27/00	
ER	OU 3-13 Group 5 Draft Monitoring System and Installation Plan Sent by DOE-ID to EPA/IDHW	07/27/00		07/25/00	
ER	OU 3-13 Group 6 Draft RA Work Plan Sent by DOE-ID to EPA/IDHW	01/18/01		01/03/01	
ER	OU 3-13 Group 7 Title II (90%) Design/RA Work Plan Sent by DOE-ID to EPA/IDHW	02/26/03			1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 14, 16, 17, 21, 22
ER	OU 3-14 Draft Tank Farm Work Plan Sent by DOE to	06/30/00		06/26/00	1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 14, 16, 17, 21, 22

	EPA/IDHW				
ER	OU 3-13 Group 5 Draft Monitoring Report/Decision Summary Sent by DOE to EPA/IDHW	09/18/03			1, 2, 3, 4, 5, 8, 9, 11, 12, 15, 16, 17, 19, 21, 22
ER	OU 3-14 Draft Phase II Characterization Work Plan Sent by DOE to EPA/IDHW	01/31/05			1, 2, 3, 4, 5, 8, 9, 11, 12, 15, 16, 17, 19, 21, 22
ER	OU 3-13 Group 4 Draft Monitoring Report/Decision Summary Sent by DOE to EPA/IDHW	06/13/07			1, 2, 3, 4, 5, 8, 9, 11, 12, 15, 16, 17, 19, 21, 22
ER	OU 3-14 Draft RI/FS Report Sent by DOE to EPA/IDHW	10/31/08			1, 2, 3, 4, 5, 8, 9, 11, 12, 13, 16, 17, 21, 22
ER	OU 3-14 Draft ROD Sent by DOE to EPA/IDHW	05/31/10			1, 2, 3, 4, 5, 8, 9, 11, 12, 15, 16, 17, 19, 21,
ER	OU 3-14 Soil RD/RA Workplan	2013	2010		1, 5, 9, 13, 15, 16, 19, 22
ER	***Remediation of tank farm soils integrated with tank farm RCRA closure activities***		***Prior to 2020***		1, 5, 9, 11, 15, 16, 19, 22
ER	OU 4-13A Draft IA ROD Sent by DOE-ID to EPA/IDHW	11/30/99		11/29/99	
ER	OU 4-13 CFA-08 Draft RD/RA Work Plan Sent by DOE to EPA/IDHW	05/08/02		04/29/02	1, 2, 5, 6, 8, 9, 10, 11, 12, 15, 16, 18
ER	OU 4-13 CFA-04 Draft RD/RA Work Plan Sent by DOE to EPA/IDHW	03/10/03			1, 3, 5, 9, 10, 15, 17, 18
ER	***Complete Remediation of WAG 4***		***2004***		1, 2, 5, 6, 8, 9, 10, 11, 12, 15, 16, 18
ER	OU 5-12 Draft Phase I RD/RA Work Plan Sent by DOE-ID to EPA/IDHW	08/11/00		05/09/00	
ER	OU 5-12 Draft Phase II RD/RA Work Plan Sent by DOE-ID to EPA/IDHW	10/11/00		09/15/00	
ER	OU 5-12 Draft Remedial Action Report Sent by DOE-ID to EPA/IDHW	01/31/06	Prior to 2004		1, 2, 6, 8, 9, 10, 15, 16, 19
ER	OU 5-12 Draft Operations and Maintenance Report	02/23/06	Prior to 2004		1, 2, 6, 8, 9, 10, 15, 16, 19

	Sent by DOE-ID to EPA/IDHW				
ER	***Complete Remediation of WAG 5***		***2004***		5, 6, 9, 10
ER	OU 7-13/14 Pre-Draft RI/BRA Sent by DOE-ID to EPA/IDHW	04/30/02			1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 16, 17, 18, 19, 22, 23
ER	OU 7-13/14 Draft ROD Sent by DOE-ID to EPA/IDHW	12/31/06			1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 16, 17, 18, 19, 22, 23
ER	OU 7-13/14 Draft RI/BRA Sent by DOE-ID to EPA/IDHW	08/31/05			1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 16, 17, 18, 19, 22, 23
ER	OU 7-13/14 Draft FS Sent by DOE-ID to EPA/IDHW	12/31/05			1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 16, 17, 18, 19, 22, 23
ER	OU 7-13/14 Draft Proposed Plan Sent by DOE-ID to EPA/IDHW	03/31/06			1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 16, 17, 18, 19, 22, 23
ER	OU 7-13/14 RD/RA Workplan	2008			1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 16, 17, 18, 19, 22, 23
ER	***WAG 7 Actions Complete***		***2020***		
ER	OU 10-04 Draft RI/FS Report Sent by DOE-ID to EPA/IDHW	06/30/01		03/20/01	
ER	OU 10-04 Draft Comprehensive ROD Sent by DOE-ID to EPA/IDHW	05/01/02			1, 5, 9, 10, 13, 16, 18
ER	***Final OU 10-04 ROD***		***Prior to 2008***		1, 5, 9, 10, 13, 16, 18
ER	OU 10-08 INEEL Site Wide Groundwater Draft RI/FS Work Plan Sent by DOE to EPA/IDHW	04/30/02		03/28/02	
ER	OU 10-08 INEEL Site Wide Groundwater Draft RI/FS ROD Sent by DOE to EPA/IDHW	10/29/04			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 24,25
ER	***WAG 10 Remediation Activities Complete***		***2020***		1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 24,25
SNF	Initiate SNF Transfers into Dry Storage	07/01/03	***2004***		No INEEL VZ/GW Uncertainties associated with activity
SNF	Complete removal of all SNF from	09/30/00		Completed	9, 13

	underwater storage at CPP 603 South Basin				
SNF	Complete transfer of TMI SNF from TAN to the TMI Dry Storage Facility	06/01/01		04/20/01	9, 13
SNF	Consolidate SNF from TAN to INTEC	2017	***2005***		9, 13
SNF	Complete removal of all DOE-owned SNF from wet storage (E119)	12/31/23	***2012***		9, 13
SNF	Remove all SNF at the INEEL out of state to repository	01/01/35	***01/01/35***		No INEEL VZ/GW Uncertainties associated with activity
HLW	Submit closure plan for at least one pillar & panel vaulted	12/31/00		12/31/00	
HLW	Cease Use of Pillar and Panel Tanks	06/30/03		03/02	
HLW	Cease use of the six remaining 300,000 gallon waste tanks	12/31/12			9, 13
HLW	Treat all HLW to be ready to be moved out of Idaho	12/31/35	***2012***		9, 13
HLW	Tank Farm D&D/Closure	~2013	***12/31/2012***		9, 13
HLW	Commence negotiating a plan and schedule for calcined waste treatment	12/31/99		09/97	
HLW	Calciner put into standby mode; decision on Calciner operation or closure	06/01/00		05/29/00	
HLW	Issue ROD for calcined waste treatment	12/31/09			9, 13
HLW	***Complete characterization of calcine to support repository waste form acceptance criteria***	2012	***2012***		9, 13
HLW	***Complete construction of calcine retrieval and packaging facility***	2035	***2020***		9, 13
HLW	***Retrieve, stabilize, package, and ship calcine to a repository***	2070	***2035***		9, 13
HLW	Issue INEEL HLW & FD EIS ROD	10/31/02			9, 13

TRU	3100 m^3 out of ID	12/31/02	***12/31/02***		No INEEL VZ/GW Uncertainties associated with activity
TRU	All Stored TRU Waste out of ID	12/31/18	***2012***		No INEEL VZ/GW Uncertainties associated with activity
TRU	AMWTF D&D/Closure	~2021	***2012***		9, 13
LLW	Consolidate mixed waste storage to one facility	--	***2004***		
LLW	Eliminate mixed waste backlog	2006	***2004***		
LLW	Cease Waste Receipts	2020	***2009***		9, 13
LLW	ICDF Closure	~2013	***2019***		1, 2, 3, 5, 9, 10, 12, 14, 15, 16, 18, 22
EM	***Package and ship all EM-managed special nuclear material to offsite locations***	***2044***	***2012***		NA
EM	***Cease EM management services for Special Nuclear Material***	---	***2009***		NA
EM	***Consolidate EM activities to INTEC***	---	***2012***		9, 13
EM	***Reduce EM footprint by 51%***	---	***2012***		9, 13
RCRA	***Complete all voluntary consent order characterization work***	***2016***	***2006***		1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 21, 22
RCRA	***Complete all voluntary consent order actions***	***2019***	***2012***		1, 5, 9, 11, 15, 16, 19, 22
D&D&D	***Reduce active INEEL footprint by 51%***		***2012***		9, 13
D&D&D	***Surveillance and monitoring***		***2050***		9, 13
WIP	Conceptual Model Development	2003			1, 2, 3, 4, 5, 6, 7, 8,9, 10,11,12,13,14,15, 16, 17, 18, 20, 23, 24, 25

Notes: 1) Milestones and dates shown in ***italics*** are from "*Environmental Management Performance Management Plan for Accelerating Cleanup of the Idaho National engineering and Environmental Laboratory, , DOE/ID-11006, Predecisional Draft Revision 0, June 2002.*"
2) Numbers for the uncertainties are keyed to the following list of prioritized uncertainties. These uncertainties are from the document, *"Raw Data Report and Meeting Record from the Vadose Zone/Groundwater Uncertainties Prioritization Meeting, April 2 & 3, 2002, INEEL/EXT – 02 –00529."*

1. Mechanisms and parameters describing adsorption of contaminants onto INEEL materials have not been adequately developed or measured. (score 15.85)
2. Knowledge of stratigraphic and structural controls on flow patterns in the vadose zone and the aquifer is limited. (New uncertainty) (score 15.49)
3. Available field data are of insufficient quality and quantity for use in predictive simulation. (score 15.25)
4. Conceptual Models are often inadequate for prediction because they do not incorporated necessary physical and biogeochemical processes. (score 14.88)
5. Chemistry of the near-field environment (e.g. the oxidation-reduction potential and solubility effects) may significantly affect the release and the rate of migration. (Original 7 & 11 combined) (score 14.77)
6. Flow direction and temporal behavior in the aquifer is limited. (New uncertainty) (score 14.43)
7. Conditions leading to facilitated transport are unknown. (score 14.19)
8. Preferred pathways are not detected or monitored, and there is relatively little information available. (score 14.12)
9. Contaminant Inventory Uncertainties (replaces original #14) (score 14.02)
10. Various sources of uncertainty and their relative impact on the predictability of transport is unknown and currently unqualified. (score 13.90)
11. Temporally varying fluid saturation and pressures, precipitation, evapotranspiration, temperature, barometric pressure, etc., are collected sporadically. (score 13.74)
12. Limited information is available on possible vertical transport in the aquifer. (score 13.57)
13. Temporal behavior of the containers and waste forms relative to contaminant release is unknown. (score 13.48)
14. Laboratory-determined properties have not been related to field-scale values and conditions. (score 13.14)
15. Near-field hydraulic conditions and their influence on contaminant release and migration are unknown. (score 12.72)
16. Relationships between extracted concentrations, small volume measurements of vadose zone parameters, biologic indicators, and state variables to those of the larger subsurface environment are unknown. (Combination of original #s 16,22, & 23) (score 12.37)
17. The extent to which interactions between phases (vapor, liquid, organic interactions, etc.) affects transport is unknown. (New uncertainty) (score 12.21)
18. Microbial effects on contaminant degradation transport rates, and mechanisms in both the vadose zone and the aquifer have not been addressed. (score 12.10)
19. Spatially variable parameters have been measured for a very small percentage of the total volume of the geomedia existing in the INEEL subsurface. (score 12.07)
20. Geophysical logs and the tools for analyzing basalt logs are inadequate for conceptual model development. (New uncertainty) (score 11.69)
21. The extent of well construction affects on vadose zone and aquifer monitoring results is unknown. (New Uncertainty) (score 11.47)
22. Instrument bias and accuracy are often unknown. (score 10.97)
23. Quantifying the relative contributions to non-ideal behavior will require advances in detection and discriminatory analysis capabilities. (score 9.45)
24. Little is known about the effects of hydrothermal variations on flow and transport in the aquifer. (New uncertainty) (score 9.03)
25. Nonlinear governing equations for multiphase flow requires iterative solution schemes. (technical limitation) (score 7.29)

Attachment B

Top Ten INEEL VZ/GW Uncertainties[1] with Interfaces to the National Vadose Zone S&T Activities/Tasks[2] That May Assist in Reducing the Uncertainty (DRAFT 6/7/2002)

1. Mechanisms and parameters describing adsorption of contaminants onto INEEL materials have not been adequately developed or measured. (score 15.85)

- ***Activity CH1:*** *Extend solution chemistry models to higher temperature and ionic strengths (e.g. Pitzer equations) relevant to VZ contamination problems. (Near Term Completion)*[3]
- ***Activity CH2:*** *Improve the understanding of kinetic rate mechanisms and effective surface areas in order to develop improved rate laws.*
  - ***Status****: Reaction in kinetics and rate laws have been formulated that are appropriate for use in numerical continuum models of reactive flow and transport for many VZ contamination problems, including DOE sites. (Near Term Completion)*
- ***Activity CH3:*** *Investigate cation exchange capacity and surface site densitycomplexation reactions on mineral surfaces and colloids for systems typical of VZ environments and contamination problems. Resolve the importance of lack of charge conservation in surface complexation models when combined with transport, possibly including streaming potentials in the formulation.*
  - ***Task****: Determine if significant differences exist for measurement of cation exchange capacity and surface site density between in situ field measurements of undisturbed samples and lab batch measurements involving disturbed media. Validate conditions under which batch K_d measurements can be used to estimate retardation in variably saturated flowing systems. (Near Term Completion)*
  - ***Status:*** *The kinetics (including reversibility) of ion exchange and surface complexation reactions on mineral surfaces and colloids has been determined for most solution-solid systems relevant to VZ contamination problems. (Mid Term Completion)*
- ***Activity CH4:*** *Investigate the effects of dissolution and precipitation on porosity, pore structure, and permeability. Study nucleation controls that may bias dissolution and/or precipitation to particular pore environments.*
  - ***Task:*** *Develop a functional description for porosity/permeability evolution reflecting chemical effects. (Mid Term Completion)*
- ***Activity CH5:*** *Investigate phase boundary conditions occurring in VZ environments that may significantly influence liquid flow and contaminant transport.*
  - ***Task:*** *Develop accurate models for mineral reactions in contact with a thin liquid film that may have different properties compared to bulk fluid (e.g. for extreme evaporation conditions that may favor formation of evaporite mineral phases). (Mid Term Completion)*
  - ***Task:*** *Develop accurate models for mineral reactions in unsaturated systems having variable gas phase chemistries (e.g. low high CO_2 or O_2). (Mid Term Completion)*

2. **Knowledge of stratigraphic and structural controls on flow patterns in the vadose zone and the aquifer is limited. (New uncertainty) (score 15.49)**

   This is a site-specific uncertainty. Some of the necessary S&T inputs to the stratigraphic and structural control uncertainties will be covered in the National VZ activities shown for uncertainty 4.

3. Available field data are of insufficient quality and quantity for use in predictive simulation. (score 15.25)

- ***Activity PH6:*** *Develop, improve, and confirmation of methods for measuring basic hydrologic properties.*
  - ***Status:*** *Moisture content, matric potential, and temperature measurements are no longer a major source of uncertainty for site-wide monitoring and modeling. Monitoring approaches for these properties are robust enough to cover long-term stewardship responsibilities. (Near Term Completion)*
- ***Activity PH9:*** *Develop capability to detect the presence and movement of fluid in fractures and fracture networks.*
  - ***Task:*** *Quantify the relationships among the most likely geophysical methods or combination of methods that will provide fracture diagnostics. (Near Term Completion)*
  - ***Task:*** *Discover and quantify new relationships between surface geophysical measurements and fractures a few centimeters across at depths of 10 meters can be routinely mapped. (Mid Term Completion)*
- ***Activity PH10:*** *Characterize the petrophysical relationships for translating geophysical attributes in near-surface strata into estimates of hydrologic parameters relevant to vadose zone contamination (e.g. porosity and water content).*
  - ***Task:*** *Investigate how multiple types of geophysical and other data reduce uncertainty in applying petrophysical relationships between geophysical and hydrologic parameters. (Near Term Completion)*
  - ***Task:*** *Develop a quick and reliable way to assess the scale of a vadose zone contamination problem relative to the scale of the hydrologic heterogeneity so that the most appropriate techniques and acquisition parameters can be selected for characterizing the key parameters that control flow and transport at that site. (Mid Term Completion).*
- ***Activity PH11:*** *Improve and apply geophysical methods for characterizing near-surface environments typical of sites with vadose zone contamination.*
  - ***Task:*** *Develop automatic data picking and quality control approaches for crosshole tomographic methods. (Near Term Completion)*
  - ***Task:*** *Investigate the utility of constrained and joint inversion for improved estimation of hydrologic parameters. Develop stochastic inversion procedures that yield distributions of possible geophysical attributes at each location. (Near Term Completion)*

4. **Conceptual Models are often inadequate for prediction because they do not incorporated necessary physical and biogeochemical processes. (score 14.88)**

- ***Activity MON1:*** *Build, catalogue, and update conceptual models for fate and transport of VZ contaminants, using field data on specific contaminant plumes to select and improve models for the catalogue.*
  - ***Status:*** *At least 2 or 3 conceptual models for fate and transport of particular contaminants, including contaminants of particular interest to DOE, have been built, catalogued, and updated using field data on specific contaminant plumes from DOE sites or other VZ contamination sites. (Near Term Completion)*
  - ***Status:*** *Field measurements from within and outside the DOE complex have been compiled to provide broad-based technical support for the catalogue of fate and transport models. Characteristic transport distances, chemical controls on attenuation, and hydrologic factors have been determined on a site-specific basis, but these features have been used collectively to update the conceptual models in the catalogue. (Mid Term Completion)*
  - ***Status:*** *Contaminant-specific monitoring needs have been catalogued. Current "standard" monitoring approaches that cannot conceivably update or refine the catalogue of conceptual models for attenuation of a specific contaminant have been identified. (Mid Term Completion)*

5. **Chemistry of the near-field environment (e.g. the oxidation-reduction potential and solubility effects) may significantly affect the release and the rate of migration. (Original 7 & 11 combined) (score 14.77)**

   This is a site-specific uncertainty. Some of the necessary S&T inputs to the near field chemical uncertainties will be covered in the National VZ activities shown for uncertainty 1.

6. **Flow direction and temporal behavior in the aquifer is limited. (New uncertainty) (score 14.43)**

- ***Activity PH1:*** *Assess the importance of fluid flow and chemical transport processes and subsurface properties relevant to site characterization, remediation and long-term stewardship.*
  - ***Status:*** *Subsurface properties (e.g., gravitational, pressure, temperature and chemical gradients) of importance to fluid flow and chemical transport at contaminantd vadose zone sites have been identified and assessed. (Near Term Completion)*
- ***Activity PH3:*** *Improve process-based understanding and models for flow and transport in macroporous soils and unsaturated fractured rocks.*
  - ***Task:*** *Develop realistic representations of pore-space geometry of, and fluid flow in, fractured media using geological, pedologic, and topological characterization techniques. (Mid Term Completion)*
  - ***Task:*** *Develop and implement improved descriptions of matrix-fracture interactions. (Mid Term Completion)*
  - ***Task:*** *Develop general constitutive relationships for both granular and structured media. (Mid Term Completion)*

- ***Task:*** *Develop pore network and other models based upon appropriate equations (e.g. Navier-Stokes), and devise methods for upscaling processes and/or properties to sample and formation scales. (Mid Term Completion)*

- ***Activity PH5:*** *Improve the state of practice in flow and transport models used by government agencies for VZ contamination simulations, beginning with DOE.*
  - ***Status:*** *DOE flow and transport prediction models and solutions have been updated by incorporating known models/modules with a more sound physical-chemical basis. (Near Term Completion)*
  - ***Task:*** *Integrate critical elements of chemistry and microbial activity in models for liquid flow and solute transport. (Mid Term Completion)*
- ***Activity PH6:*** *Develop, improve, and confirm of methods for measuring basic hydrologic properties.*
  - ***Status:*** *Moisture content, matric potential, and temperature measurements are no longer a major source of uncertainty for site-wide monitoring and modeling. Monitoring approaches for these properties are robust enough to cover long-term stewardship responsibilities. (Near Term Completion)*
- ***Activity PH9:*** *Develop capability to detect the presence and movement of fluid in fractures and fracture networks.*
  - ***Status:*** *The presence of fluid in individual fractures can be detected in some cases. (Near Term Completion)*
  - ***Task:*** *Quantify the relationships among the most likely geophysical methods or combinations of methods that will provide fracture diagnostics. (Near Term Completion)*
  - ***Status:*** *Contaminant fluid in fractures can be detected in most cases. (Mid Term Completion)*
  - ***Task:*** *Discover and quantify new relationships between surface geophysical measurements and fractures, so that fractures a few centimeters across at depths of 10 meters can be routinely mapped. (Mid Term Completion)*
- ***Activity PH10:*** *Characterize the petrophysical relationships for translating geophysical attributes in near-surface strata into estimates of hydrologic parameters relevant to vadose zone contamination (e.g., porosity and water content).*
  - ***Task:*** *Investigate how multiple types of geophysical and other data reduce uncertainty in applying petrophysical relationships and can aid in resolving issues of non-uniqueness in relationships between geophysical and hydrologic parameters. (Near Term Completion)*
  - ***Status:*** *The mechanisms of geophysical energy propagation at the field tomographic scale within unconsolidated or loosely consolidated, low pressure, granular porous material are understood. (Mid Term Completion)*
  - ***Status:*** *Joint and constrained inversions that honor all data can be performed. How additional data improve the estimate and decrease the estimation error is understood. Data with different measurement scales can be incorporated in the inversion process correctly. (Mid Term Completion)*
  - ***Task:*** *Develop a quick and reliable way to assess the scale of a vadose zone contamination problem relative to the scale of the hydrologic heterogeneity so that the most appropriate techniques and acquisition parameters can be selected for characterizing the key parameters that control flow and transport at that site. (Mid Term Completion)*
- ***Activity PH11:*** *Improve and apply geophysical methods for characterizing near- surface environments typical of sites with vadose zone contamination.*
  - ***Task:*** *Develop automatic data picking and quality control approaches for crosshole tomographic methods. (Near Term Completion)*

- ***Task:*** *Investigate the utility of constrained and joint inversion for improved estimation of hydrologic parameters. Develop stochastic inversion procedures that yield distributions of possible geophysical attributes at each location. (Near Term Completion)*
- ***Status:*** *Stochastic estimation techniques that provide an estimate of the property of interest, as well as information about its uncertainty, have been tested and applied to contaminantd vadose zone sites. (Near Term Completion)*
- ***Status:*** *Incorporate measurement support scale, and other means of recognizing the importance of scale, when applying geophysical methods to estimate hydrologic properties and correlation lengths. (Near Term Completion)*
- ***Status:*** *Hydrologic properties (e.g. water content, permeability and porosity) and their associated uncertainties and spatial correlation functions are being estimated from different types of geophysical data such as crosshole tomographic imagery. These estimates are conditioned to direct measurements, with attention to scale, using hierarchical spatial scale estimation procedures with multi-scale data. (Mid Term Completion)*

7. Conditions leading to facilitated transport are unknown. (score 14.19)

- ***Activity COL1:*** *Improve sampling and analysis for colloids and colloidal transport.*
  - ***Task:*** *Develop a scientifically based protocol for field based sampling and analysis for colloids and colloidally transported contaminants. (Near Term Completion).*
  - ***Task:*** *Develop new sampling techniques for in situ measurements of colloidal particles in pore water. (Near Term Completion).*
- ***Activity COL2:*** *Studies of colloidal transport.*
  - ***Task:*** *Understand relevance of colloid-facilitated transport to contaminant movement under transient flow conditions, including wetting, drying, and infiltration processes. (Mid Term Completion)*
  - ***Task:*** *Quantify the potential for in situ colloid formation and mobilization under conditions relevant for major VZ contamination sites, particularly in the presence of extreme chemical conditions that can lead to dissolution and precipitation of soil minerals. (Mid Term Completion)*
  - ***Task:*** *Evaluate the effects on production and behavior of microbial colloids of (1) changing contaminant flux, (2) nutrient injection during engineered bioremediation, and (3) cell to cell communication (quorum sensing) in biofilms and other cell assemblages. (Mid Term Completion).*
  - ***Task:*** *Characterize colloid-contaminant interactions as a function of solution chemistry and water saturation, at both the microscopic and macroscopic levels. (Mid Term Completion)*

8. Preferred pathways are not detected or monitored, and there is relatively little information available. (score 14.12)

This is a site-specific uncertainty. Some of the necessary S&T inputs to the near field chemical uncertainties will be covered in the National VZ activities shown for uncertainty 1.

9. **Contaminant Inventory Uncertainties (replaces original #14) (score 14.02)**

- ***Activity B2:*** *Understand how mixtures of contaminants in DOE wastes affect microbial activity with respect to flow and transport of specific contaminants.*
  - ***Status:*** *The rates of biodegradation of particular contaminants can be predicted as a function of the type and concentration of other contaminants present. (Mid Term Completion)*
- ***Activity MP2:*** *Studies of key contaminant mixtures (for DOE and other contaminantd VZ sites) as multiphase systems.*
  - ***Task:*** *Measure flow and transport properties of key contaminant mixtures. Refine theory and numerical models to describe their flow and transport in relevant subsurface environments. (Mid Term Completion)*
  - ***Task:*** *Design, implement, and analyze controlled tests of complex contaminant mixtures in highly heterogeneous systems. (Mid Term Completion)*

10. **Various sources of uncertainty and their relative impact on the predictability of transport is unknown and currently unqualified. (score 13.90)**

- ***Activity UC1:*** *Catalogue, assess, and prioritize R&D needs for addressing the different sources of uncertainty in models of VZ flow and transport.*
  - ***Status:*** *State-of-the-art methods of uncertainty estimation and reduction, especially for risk analyses, have been catalogued and assessed. (Near Term Completion)*
  - ***Status:*** *Sources of uncertainty in VZ modeling, including choice of conceptual model, geological heterogeneity; parameter values; and initial and dynamic boundary conditions, have been quantified and R&D needs to address them have been prioritized. (Near Term Completion)*
  - **Task:** Develop and test new theories and methodological approaches for *describing and understanding the spatial and temporal structures of naturally occurring heterogeneities and fluctuations. Use advanced geological modeling to capture both flow-sensitive and chemical spatial heterogeneity. (Mid Term Completion)*
- ***Activity UC2:*** *Research to decrease uncertainties in VZ modeling.*
  - ***Task:*** *Analyze existing long-term geological, hydrologic, chemical, and biological records to improve conceptual models, reduce their uncertainties, and reduce or quantify the uncertainties in estimates of parameters and boundary conditions used in VZ models. (Near Term Completion)*
  - ***Task:*** *Test candidate methods for uncertainty estimation and reduction, and applications of these methods, on synthetic test problems, s mall-scale and meso-scale lab experiments, and field-scale research sites. (Mid Term Completion)*
  - ***Task:*** *Evaluate effects of uncertainties for invasive and noninvasive field characterization and monitoring methods with different scales and degrees of resolution. (Mid Term Completion)*
  - ***Status:*** *New, more sophisticated and efficient probabilistic approaches to uncertainty estimation and reduction have been developed and tested. (Mid Term Completion)*
  - ***Status:*** *Uncertainty estimation and reduction methods are in use to predict the value of new data, to optimize the design and operation of characterization and monitoring activities, and to automatically update a model when new data becomes available. (Near Term Completion)*

<u>Notes:</u>

1). These uncertainties are from the document, *"Raw Data Report and Meeting Record from the Vadose Zone/Groundwater Uncertainties Prioritization Meeting, April 2 & 3, 2002, INEEL/EXT – 02 –00529"*.

2). The activities/tasks shown in italics are from the document, *"A National Roadmap for Vadose Zone Science & Technology, Understanding Monitoring, and Predicting Contaminant Fate and Transport in the Unsaturated Zone, August 2001, DOE/ID-10871"*.

3). Completions have been divided into Near Term (those tasks/status that will occur in the next 4 to 5 years) and Mid Term (those tasks/status that will occur in the next 10 years.

4). Status points are milestones where the status of the activity is evaluated to determine if the activity is on track to meet it's objective.

Attachment C

Summary of Operational R&D Needs/Issues

Need/Issue	WAG Application	Assists in Solving Uncertainty: (1)
Plutonium Needs		
Better Kd value/Better understanding other than Kd	3,7	1, 5, 7, 16, 17, 19
Migration and Transport	3	1, 5, 7, 12, 14, 15, 16, 17, 18, 19, 21, 22
Take background samples across the site	Sitewide	1, 2, 3, 4, 7, 8
Development of facilitated transport models	3, 7	7, 10, 15, 16, 17, 18, 23
Pu Mobility and formation of colloids	7	5, 7, 15, 17, 18, 22, 23
Develop better monitoring methods	7	1, 3, 5, 7, 16, 21, 22
Evaluate how installation of monitoring equipment affects how Pu is detected	7	3, 7, 9, 21
Develop a partitioning model for Pu	3, 7	5, 7, 17, 22, 25
C^{14}		
vapor transport of rad	7	5, 12, 15, 17, 18
isotope mobility	7	5, 11, 12, 15, 17, 18, 19, 22
movement in the subsurface	7	5, 11, 12, 15, 17, 18, 19, 22
studies of C^{14} trends	7	3, 5, 12, 16, 17, 18, 19, 21, 22
Joint sampling for C^{14} between WAGS 3,2,&7	2, 3, 7	2, 3, 5, 6, 8, 12, 15, 16, 17, 18, 19, 21, 22, 23
Actinide Geochemistry Studies		
Solubility Studies	3,7	5, 7, 13, 14, 16, 17, 18, 22
Oxidation States	3,7	5, 7, 13, 14, 16, 17, 18, 22
Mobility	3,7	5, 7, 13, 14, 16, 17, 18, 22
Better monitoring of Clemson Studies	3,7	10, 14, 16
Utilization of larger column studies than Clemson	3,7	10, 14, 16
Studies of solubility and	3,7	5, 13, 14, 15, 18, 22

release of U from waste forms		
Studies to better define source of elevated U in the vadose zone at Pit 5 and west end of SDA	7	3, 5, 7, 9, 13, 15, 17, 18, 22
Kd Values		
Develop appropriate Kd values	3, 7, Sitewide	1, 14, 18
Evaluate other methods besides the use of Kd Values	3, 7, Sitewide	1, 14
Develop more "site specific" Kd values for calculating risk	9	1, 3, 7, 19
Determine what from the standpoint of geochemistry is influencing flow and retardation	3, Sitewide	1, 4, 10, 14, 16, 18, 22
Development of better and integrated databases	7, Sitewide	3
Development of Better Monitoring Methods		
Demonstrate the use of 3D Tomography/other cross-hole geophysics	3, Sitewide	3, 19, 20, 22
Long term improvements in downhole (VZ & GW) monitoring	7	3, 19, 20, 22
Demonstration of the geochemical probe	7	3, 5, 14, 16, 22
Development of tools and methods for gross quantification of organics	7	3, 5, 14, 16, 18
Development of tensiometer type porous sampling cup	7	3, 5, 15,
Investigate the correlation of between well construction and sampling results	7, Sitewide	3, 10, 21
Investigate the correlation of between sampling method (such as ceramic lysimeter cup) and sampling results	7, Sitewide	3, 10, 16, 21, 22
Develop tools for	Sitewide	3, 16, 21, 22

micropurge sampling for depths of the SRPA		
Better designed tracer studies to study transport through the vadose zone	3	3, 6, 8, 12, 15, 19
Develop innovative methods for RCRA monitoring	3, 4	3, 5, 15, 16, 17, 18, 19
Develop bettor sensors for the distal portion of the TAN TCE plume	1	3, 9, 17, 18, 19, 22
Coordinate sitewide GW monitoring and USGS monitoring such that GW monitoring to obtain water level measurements for all wells at the same relative time	Sitewide	3, 4, 11, 19, 22
Develop better methods for measurement of water levels in a flat gradient environment	1	3, 4, 6, 19, 24
Source Term Studies		
Develop appropriate source term release rates for contaminant in buried waste	7	9, 13, 14, 15, 18
Studies of source release/waste form/fate and transport of contaminants	7	9, 13, 14, 15, 18
Research on contaminant release from grout, treated waste forms, and vitrified waste	7	9, 13, 18
Studies of infiltration through waste – quantity and geochemistry	7	5, 9, 13, 14, 15, 18
Develop a better understanding of source term chemistry	3, 7	5, 9, 13, 15, 18
Perform corrosion rate studies	7	5, 9, 13
Development of reactive transport code – need better data in the near field	7	3, 5, 13, 15, 16, 17, 18
Modeling/Codes		
Develop a 3D model	3	4, 12, 19, 24

that can be performed quickly		
Enhance speed of running TETRAD	3	4
Integration of parameter estimation codes	3	4, 23
Develop statistical methods for applying point data over large areas	Sitewide	4, 16, 19
Develop better scientific modeling of moisture movement in the Type B probes	7	3, 4, 8, 15, 19
Optimize sequential codes to parallel processing to speed run times	Sitewide	4, 10
Develop 3-D data presentation methodologies	3	4, 12, 19
Develop better reactive transport codes	7	1, 5, 15, 17, 23
Resolve model/observational issues in WAG 7 RI/FS	7	4
Develop codes for integrating multiple data sets	3, 7, Sitewide	4, 5, 16, 17, 19, 25
Determine relationship of moisture content and matrix flow in unsaturated flow models	Sitewide	4, 10, 14, 16, 19
Perform an evaluation of continuous flow models	Sitewide	4, 6
Characterization		
Develop nonintrusive detection tools for fast flow zones in the aquifer	7, Sitewide	2, 3, 4, 6, 8, 12, 19, 20, 24
Develop/Demonstrate better suites of quantitative geophysics methods	Sitewide	2, 3, 4, 6, 8, 20
Develop better tracer methods to track flow through the interbeds	3	2, 3, 4, 6, 8, 12, 19
Determine amount of diffusion of contaminants moving from perched zones to the basalt	3	1, 2, 3, 6, 8, 10, 14, 15, 18, 19
Characterize relationship of flow in Big Lost River to VZ &	3	2, 3, 4, 8, 15, 19

GW flow in Tank Farm		
Develop meso-scale experiments with instrumentation built into the large block to test the effects on readings & data before and after drilling	3, Sitewide	3, 10, 14, 16, 21
Develop methods for broad area characterization	Sitewide	2, 3, 4, 16, 19, 24
Develop better methods for isotope characterization	Sitewide	3, 5, 10, 17, 20, 22
Forensic contaminant source detection for perched water contaminants	2, 3	3, 4, 5, 9, 16
Investigate perched water zones for cause, connectivity, and water volume in zones	3	2, 3, 4, 5, 9, 16, 19
Development of methods to better characterize fracturing and detect preferred pathways in the basalt for the vadose zone and the aquifer	7, 9, Sitewide	2, 3, 4, 8, 12, 15, 19
Temperature studies of aquifer to relation to GW flow	Sitewide	2, 3, 4, 6, 8, 12, 19, 24
Evaluate other parameters, similar to temperature, that can be utilized to narrow the field of data	Sitewide	2, 3, 4, 6, 8, 12, 19
Flow R&D for WAG 7	7	1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22, 24
Methods for detecting horizontal movement of transient water, especially how water in the spreading areas effects changes to gradients and flow in the interbeds	7	2, 3, 4, 6, 8, 19
Methods for delineation of flow direction in aquifer	7, Sitewide	2, 3, 4, 6, 8, 12, 19, 24
Develop methods for using solute content, natural isotopes, and isotope ratios to define flow, preferential pathways, & origin of groundwater	Sitewide	3, 6, 8, 12, 16, 19, 24

Utilize numerical models during the experiment design phase to predict experiment outcome	Sitewide	10
Perform vertical profiling of contaminant plume geometry to determine layering effects	3	2, 3, 4, 6, 8, 12, 19
More information needed on vertical controls of Cr^6 from TRA and lateral extent of plume	2	2, 3, 4, 6, 8, 9, 12, 19
Need additional definition of GW flow direction at WAG 4	4	2, 3, 4, 6, 8, 12, 19
Sources of nitrates and other contaminants at CFA	4	3, 5, 9, 13, 15, 16, 18, 19
Studies on coupled processes (driving forces, microbial actions, etc.)	3, 7, Sitewide	1, 3, 5, 7, 10, 13, 14, 15, 16, 17, 18, 19, 24
Expand basic geologic knowledge of: level of understanding of stratigraphy & structure; effects of being at caldera margins	Sitewide	2, 3, 4, 6, 8, 12, 19, 24
Need deep coreholes to verify geophysical studies	Sitewide	2, 3, 4, 6, 8, 12, 19, 20, 24
Study deep cold flow channels that may be influencing differences in the regional flow directions	Sitewide	2, 3, 4, 6, 8, 12, 19, 24
Measurement of travel time through VZ to SRPA	Sitewide	2, 3, 4, 8, 19
Flow velocity in the SRPA	Sitewide	2, 3, 4, 6, 19, 24
Evaluate dispersivity	Sitewide	1, 2, 3, 4, 6, 7, 11, 12, 14, 15, 16, 17, 18, 19, 24
Caps/Barriers/ Grouting/Remediation		
Evaluation of the thrust block grouting technique for retrieval and production grouting	7	
Studies of grout formulation: grout for retrieval vs. grout to be left in place; grout performance in high	7	3, 5, 15

radiation environments; methods for simulation of long term testing; research on how to get boron to stay in solution		
Non-intrusive methods for in-situ testing of grout placement	7	3, 10, 13, 20
Demonstration of the SMART barrier system	7, 3	9
Development of methods for measuring hydraulic conductivity in a grouted mass	7	13
Development of point measurement approaches for measuring infiltration through the CFA landfill cover	2	3, 13
Studies of long term degradation of landfill covers including plant uptake, ability to simulate the effects of freeze/thaw cycles on soil covers over long periods of time, effects of evapotranspiration	3	10
Development of long lasting, mobile, easily detected tracers that could be buried with the waste at landfills	3	5, 10, 13
Development of reliable long-lasting sensors with low failure rate that could be either placed below the liners at landfills or be placed in the liner itself for long term leak detection	3	10
Investigate effects of the development of condensation beneath impermeable barriers	3	10, 15
Develop alternatives for sodium lactate for ISB. Alternate electron donor	1	5, 10
Investigate mechanism for aerobic degradation of TAN TCE plume far downgradient	1	5, 10, 17, 18, 19
Develop in-site remediation techniques such as subsurface barriers and	Sitewide	10, 13, 15, 18

bioremediation		
Develop better engineered barriers, caps, and covers	Sitewide	10, 13
Develop methods for better optimization of TAN degradation	1	5, 10, 13, 15, 18
Continued development of criticality sensor	7	3, 9, 10
Review of VOC destruction units	7	9
Develop technically defensible zoning concept to support management of TOSCA (PCBs) requirements during Pit 9 retrieval	7	1, 3, 5, 9, 10, 13, 15, 17, 18, 19
Leak Detection		
Development of sensors to detect & identify source of leakage into vaults at INTEC tank farm	3	3, 5, 9, 10, 15
Development of methods to determine source of high concentrations of contaminants around 603 basin	3	3, 5, 8, 9, 10, 15, 17
Development of forensic methods to detect any leakage from waste calcine facility monolith	3	1, 3, 5, 9, 10, 13, 15
Development of early warning leak detection systems	Sitewide	3, 5, 9, 10, 15, 19

Notes:

1) Numbers for the uncertainties are keyed to the following list of prioritized uncertainties. These uncertainties are from the document, *"Raw Data Report and Meeting Record from the Vadose Zone/Groundwater Uncertainties Prioritization Meeting, April 2 & 3, 2002, INEEL/EXT – 02 –00529."*

1. Mechanisms and parameters describing adsorption of contaminants onto INEEL materials have not been adequately developed or measured. (score 15.85)
2. Knowledge of stratigraphic and structural controls on flow patterns in the vadose zone and the aquifer is limited. (New uncertainty) (score 15.49)
3. Available field data are of insufficient quality and quantity for use in predictive simulation. (score 15.25)
4. Conceptual Models are often inadequate for prediction because they do not incorporated necessary physical and biogeochemical processes. (score 14.88)
5. Chemistry of the near-field environment (e.g. the oxidation-reduction potential and solubility effects) may significantly affect the release and the rate of migration. (Original 7 & 11 combined) (score 14.77)
6. Flow direction and temporal behavior in the aquifer is limited. (New uncertainty) (score 14.43)

7. Conditions leading to facilitated transport are unknown. (score 14.19)
8. Preferred pathways are not detected or monitored, and there is relatively little information available. (score 14.12)
9. Contaminant Inventory Uncertainties (replaces original #14) (score 14.02)
10. Various sources of uncertainty and their relative impact on the predictability of transport is unknown and currently unqualified. (score 13.90)
11. Temporally varying fluid saturation and pressures, precipitation, evapotranspiration, temperature, barometric pressure, etc., are collected sporadically. (score 13.74)
12. Limited information is available on possible vertical transport in the aquifer. (score 13.57)
13. Temporal behavior of the containers and waste forms relative to contaminant release is unknown. (score 13.48)
14. Laboratory-determined properties have not been related to field-scale values and conditions. (score 13.14)
15. Near-field hydraulic conditions and their influence on contaminant release and migration are unknown. (score 12.72)
16. Relationships between extracted concentrations, small volume measurements of vadose zone parameters, biologic indicators, and state variables to those of the larger subsurface environment are unknown. (Combination of original #s 16,22, & 23) (score 12.37)
17. The extent to which interactions between phases (vapor, liquid, organic interactions, etc.) affects transport is unknown. (New uncertainty) (score 12.21)
18. Microbial effects on contaminant degradation transport rates, and mechanisms in both the vadose zone and the aquifer have not been addressed. (score 12.10)
19. Spatially variable parameters have been measured for a very small percentage of the total volume of the geomedia existing in the INEEL subsurface. (score 12.07)
20. Geophysical logs and the tools for analyzing basalt logs are inadequate for conceptual model development. (New uncertainty) (score 11.69)
21. The extent of well construction affects on vadose zone and aquifer monitoring results is unknown. (New Uncertainty) (score 11.47)
22. Instrument bias and accuracy are often unknown. (score 10.97)
23. Quantifying the relative contributions to non-ideal behavior will require advances in detection and discriminatory analysis capabilities. (score 9.45)
24. Little is known about the effects of hydrothermal variations on flow and transport in the aquifer. (New uncertainty) (score 9.03)
25. Nonlinear governing equations for multiphase flow requires iterative solution schemes. (technical limitation) (score 7.29)

Appendix D

Raw Data Report and Meeting Record

From the

Vadose Zone/Groundwater Needs Prioritization Meeting

September 10 & 11, 2002

Report Prepared by
William "Buck" West
Meeting Facilitator

Idaho National Engineering and Environmental Laboratory
Idaho Falls, Idaho 83415

Executive Summary

Dates and Times

September 10 & 11, 2002, from 0800 hours to 1700 hours each day.

Location

West Coast Hotel, Bannock Conference room, Idaho Falls, ID.

Objective

Prioritize the programmatic needs for development of science strategies during FY 2003.

Meeting Facilitated by:

William "Buck" West, BBWI

Attendees

9/10	9/11	NAME	REPRESENTING	PHONE	E-MAIL
X	X	Burns, Doug	INEEL	526-4324	Deb4@inel.gov
X	X	Frederick, Dave	INEEL Oversight	528-2614	Dfrederi@deq.state.id.us
X		Gibson, Patrick	INEEL	526-1379	Gibspl@inel.gov
X		Hall,Rachel Collins	DOE-ID	526-1661	hallrc@id.doe.gov
X	X	Kauffman, Richard M.	DOE-ID	526-7177	Kauffmrm@id.doe.gov
X	X	Knobel, LeRoy	USGS	526-2158	Llknobel@usgs.gov
X	X	Kowall, Steve	INEEL	526-4287	kowasj@inel.gov
X	X	Mattson, Earl	INEEL	526-4084	Matted@inel.gov
X	X	Magnuson, Swen	INEEL	526-8618	Smm@inel.gov
X	X	McCarthy, James	INEEL	526-8319	Ja7@inel.gov
X	X	McLing, Travis	INEEL	526-7269	Tm1@inel.gov
X		Natoni, Patty	DOE-ID	526-0977	Natonipm@id.doe.gov
X	X	Nimmo, John	USGS	650-329-4537	Jrnimmo@usgs.gov
X	X	Nuckols, E. B.	DOE Head Quarters	301-903-2805	Ernest.nuckols@em.doe.gov
X	X	Nygard, Dean	Idaho DEQ	373-0285	Dnygard@deq.stste.id.gov
X	X	Orr, Brennon	North Wind Environmental	557-7871	Borr@nwindenv.com
X	X	Perry, Jeffrey N.	DOE-ID	526-4570	Perryjn@id.doe.gov
X	X	Pierre, Wayne	EPA	206-553-7261	Pierre.wayne@epa.gov
X	X	Powell, Amy	ANL-W	533-7259	Amy.powell@anlw.anl.gov
X	X	Shaw, Mark	DOE-ID	526-6442	Shawrm@id.doe.gov
X	X	Smith, Dick	INEEL	526-9896	RPS3@inel.gov
X		Smith, Robert W.	UI/INRA	282-7954	Smithbob@uidaho.edu
X	X	Winter, Gerry	Idaho DEQ	373-0402	Gwinter@deq.state.id.us
X	X	Yonk, Alan	INEEL	526-5828	Yonkak@inel.gov

Meeting Results

The group identified six criteria to use in the prioritization of the Vadose Zone/Groundwater needs. The criteria were weighted for importance. The six criteria and weights are:

Criterion 1: The need addresses a highly ranked uncertainty. (Weight 0.40)
Criterion 2: The returns (reduced social cost, cleanup costs, monitoring costs, and reduced or eliminated fines) exceed the costs of addressing or meeting the need. (Weight 1.42)
Criterion 3: Results of the need are transferable to multiple programs, other sites and locations. (Weight 0.18)
Criterion 4: It is practical to address the need. (Weight 1.30)
Criterion 5: Positive impact of the need on enabling and demonstrating the cleanup of waste. (Weight 2.27)
Criterion 6: Addressing the need will have a positive impact on the planned schedules. (Weight 0.43)

The needs to be evaluated were placed into ten major headings or groups prior to the meeting. At the start of the meeting, the participants placed the ten groups into priority order from the most important to least important. This rank order was done to establish a sequence for addressing the needs during the meeting. This was done to ensure that if it were not possible to discuss all the needs during the meeting the most important needs would be sure to be evaluated. The group priorities (see page 52 of this record for details of the ranking) were:

1. Characterization
2. Development of Better Monitoring Methods
3. Source Term Studies
4. Caps/Barriers/Grouting/Remediation
5. Actinide Geochemistry Studies
6. Plutonium R&D
7. C^{14} R&D
8. Modeling/Codes
9. Kd Values
10. Leak Detection

Review of the priority list of needs in the characterization group indicated little or no consensus among the meeting participants. After some discussion, it is believed that the participants were not approaching the analysis from a common perspective or goal. Participants were evaluating the needs from their own perspective and the evaluations were widely dispersed in a generally normal distribution. As a result of this distribution of individual scores, the combined scores generally tend toward a medium rating reflecting the normal distribution of the participants. The prioritized needs also demonstrated a fairly uniform stair-step pattern in the scores and there was no clear or obvious break in the scores to delineate priority grouping of the needs.

Meeting Process

Jeff Perry opened the meeting with welcoming remarks and an expression of the importance of the subject. Alan Yonk explained that the needs were identified through interviews with selected program people. Interviews were no more than 15 minutes in length and were held at a very high level of detail. The interview information was then summarized by Alan in Attachment C of *Development of the FY-0 2 Supplement of the INEEL Site-Wide Vadose Zone/Groundwater Roadmap* (INEEL/EXT-02-01038-Draft, August, 2002). That summarization included a preliminary linking by Alan of the needs to the uncertainties from the April 2002 meeting (*Raw data Report and Meeting Record from the Vadose Zone/Groundwater Uncertainties Prioritization Meeting*, INEEL/EXT-02-00529, April 2002).

The group then discussed the criteria to use in evaluating the needs. The criteria from the April uncertainties meeting (slightly revised for the subject of this meeting) were presented as strawman criteria along with four additional criteria proposed by the Vadose roadmap team. Those strawman criteria were:

- The need addresses a significant uncertainty in the concentration of the contaminant(s) of concern.
- Return on investment.
- Results of the need are transferable to multiple programs, other sites and locations, and are crosscutting.
- It is practical to address the need.
- Positive impact of addressing the need on enabling cleanup of waste.
- Positive impact of addressing the need on proving cleanup of waste.
- Positive impact of addressing the need in the short-term (<2007).
- Positive impact of addressing the need in the mid- and long-term (>2007).

After discussion the criteria were revised and the number reduced to six (see page 48 of this record for the final criteria). The group then applied weights to the criteria through a pair-wise comparison of the criteria. All the criteria were compared in pairs, the group was asked which of the two criteria was more important. They were then asked on a scale of 1 to 9 (1 means the criteria are of equal importance and 9 means the selected criteria is absolutely more important) how much more the important the selected criteria was than the other criteria in the pair (see page 53 of this report for the results of the pair-wise comparison).

In some cases, the pair-wise comparison did not result in a clear choice between the criterion in the pair (e.g. the group was equally or almost equally split between the criteria in the pair). During the lunch break, the facilitator made a judgement call about how the pair should be scored. The following table shows the group results for each pair and the facilitator judgement on the final score.

Criteria Pair	First Criterion		Second Criterion		Equal	Facilitator Judgement	
	Votes	**Mean Score**	**Votes**	**Mean Score**	**Votes**	**Criterion**	**Score**
1 & 2	8	6	12	6	1	2	5
1 & 3	13	6	5	6	3	1	5
1 & 4	4	6	13	6	4	4	5
1 & 5	4	6	15	7	2	5	6
1 & 6	9	6	11	7	1	6	1
2 & 3	16	7	3	4	2	2	6
2 & 4	8	6	9	6	4	4	1
2 & 5	6	5	9	6	6	5	1
2 & 6	11	6	6	6	4	2	3
3 & 4	3	6	17	7	1	4	6
3 & 5	2	6	18	7	1	5	4
3 & 6	5	5	13	7	3	6	5
4 & 5	8	5	12	6	1	5	4
4 & 6	12	6	8	7	1	4	5
5 & 6	17	7	3	4	1	5	6

The results were transferred into the *Criterion DecisionPlus®* software package for calculation of the weights for each criterion. The calculated weights were used by the group throughout the rest of the meeting. *Criterion DecisionPlus®* software package calculated a consistency ratio of 0.094 and the software recommends a ration below 0.10. The ratio of .094 indicates the group was reasonably consistent in their ranking of the criteria. The calculated weights for each of the criteria were:

Criterion 1: The need addresses a highly ranked uncertainty. (Weight 0.40)
Criterion 2: The returns (reduced social cost, cleanup costs, monitoring costs, and reduced or eliminated fines) exceed the costs of addressing or meeting the need. (Weight 1.42)
Criterion 3: Results of the need are transferable to multiple programs, other sites and locations. (Weight 0.18)
Criterion 4: It is practical to address the need. (Weight 1.30)
Criterion 5: Positive impact of the need on enabling and demonstrating the cleanup of waste. (Weight 2.27)
Criterion 6: Addressing the need will have a positive impact on the planned schedules. (Weight 0.43)

After the meeting was finished, the facilitator reviewed his judgements regarding the weights and recalculated the scores by converting the responses to the pair-wise questions (see page 53) to a scale of –9 to +9. On this scale, all the participants assigning a score to the first criterion were converted to negative numbers and all the scores assigned to the second criterion were left at the original value (e.g. a participant score of 4 for the first criterion in a pair was converted to –4 and a participants score of 7 for the second criterion was left at 7). Participants indicating the criteria were equal were scored as a

1. All the scores were then averaged and rounded to the nearest integer. A negative integer indicated the first criterion was preferred over the second and a positive integer indicated the second criterion was preferred. The following table shows the recalculated scores.

	Criteria Pairs														
	1 & 2	1 & 3	1 & 4	1 & 5	1 & 6	2 & 3	2 & 4	2 & 5	2 & 6	3 & 4	3 & 5	3 & 6	4 & 5	4 & 6	5 & 6
Total points for criterion 1	-46	-78	-25	-22	-57	-110	-47	-30	-64	-17	-11	-25	-37	-76	-116
Total points for criterion 2	74	28	73	101	72	7	55	58	37	112	124	96	72	52	4
Total points for equal	1	3	4	2	1	2	4	6	4	1	1	3	1	1	1
Total Points	29	-47	52	81	16	-101	12	34	-23	96	114	74	36	-23	-111
Average score	1.38	-2.24	2.48	3.86	0.76	-4.81	0.57	1.62	-1.10	4.57	5.43	3.52	1.71	-1.10	-5.29
Rounded score	1	-2	2	4	1	-5	1	2	-1	5	5	4	2	-1	-5

The recalculated scores were transferred into the *Criterion DecisionPlus®* software package for calculation of the weights for each criterion. *Criterion DecisionPlus®* software package calculated a consistency ratio of 0.035 and the software recommends a ration below 0.10. The ratio of .035 indicates the group was very consistent in their ranking of the criteria. The calculated weights for each of the criteria were:

Criterion 1: The need addresses a highly ranked uncertainty. (Weight 0.65)
Criterion 2: The returns (reduced social cost, cleanup costs, monitoring costs, and reduced or eliminated fines) exceed the costs of addressing or meeting the need. (Weight 0.95)
Criterion 3: Results of the need are transferable to multiple programs, other sites and locations. (Weight 0.26)
Criterion 4: It is practical to address the need. (Weight 1.06)
Criterion 5: Positive impact of the need on enabling and demonstrating the cleanup of waste. (Weight 2.29)
Criterion 6: Addressing the need will have a positive impact on the planned schedules. (Weight 0.80)

Because of the better consistency exhibited by calculating the weights in this manner, these weights will be used throughout the rest of this report. It is believed that the group discussion of the results of scoring the needs against the criteria would have been the same regardless if the original weights or the revised weights were used. The original results have been retained in the record and can be recreated at any time.

The group then prioritized the ten groups of needs from the most important to the least important. This rank order was done to establish a sequence for addressing the needs during the meeting. This was done to ensure that if it were not possible to discuss all the needs during the meeting the most important needs would be sure to be evaluated (see page 52 of this record for the prioritization results).

After lunch, the group reviewed the weights assigned to the criteria. Participants were asked if the weights looked reasonable and all agreed that they were. There was some discussion about deleting the low weighted criteria as they would have little or no impact on the results. It was pointed out that sometime a group of low weight criteria can combine to overcome a more heavily weighted criterion. It was also pointed out that criterion can always be eliminated at a future date but that it would be impossible to add that information in the future if they were not scored in this meeting. The group agreed to leave all six criteria in the rating process. Participants were then invited to comment on the criteria (see page 68 of this record for those comments).

The group then discussed the needs as provided in Attachment C of *Development of revision 2 of the INEEL Site-Wide Vadose Zone/Groundwater Roadmap* (INEEL/EXT-02-01038-Draft, August, 2002). Each need was reviewed and questioned for: “Was it clear and understandable?” and “Was it a duplicate with another need and should be combined?” Based on the discussions the need may have been reworded, combined with other need(s), tabled until more information could be gathered about the need, or moved to another need group for evaluation with that group. The group also added new needs at this time. After discussion of the needs, participants were allowed to comment on the needs to provide background and other supporting information.

During preparation of Attachment C, the vadose roadmap team made a preliminary association between the April uncertainties and the needs. This association was the roadmap team's best opinion of which of the uncertainties the need addressed. The participants discussed and agreed that the evaluation of criterion 1 could be done by the vadose roadmap team outside of the meeting based on the original associations made by the roadmap team as modified by comments from this group. The participants were asked to provide their comments regarding which of the uncertainties from the April meeting that the need addressed during the comment time on the needs. The vadose team was instructed to rate criterion 1 in the following manner:

High = The need addresses uncertainties prioritized 1-10 in the April meeting;
Medium = The need addresses uncertainties prioritized 11-19 in the April meeting;
Low = The need addresses uncertainties prioritized 20-25 in the April meeting.

See page 5 of *Raw data Report and Meeting Record from the Vadose Zone/Groundwater Uncertainties Prioritization Meeting* (INEEL/EXT-02-00529, April 2002) for the prioritized list of uncertainties.

After commenting, the participants then evaluated the needs against the criteria using a High (H), Medium (M), or Low (L) rating about how well the need responded to the criteria. The group would then review the prioritized needs (minus the rating of criterion 1 to be done outside the meeting) for a quick reality check of the ranking. Review of the priority list of needs in the characterization group indicated little or no consensus among the meeting participants. After some discussion, it is believed that the participants were not approaching the analysis from a common perspective or goal. Participants were evaluating the needs from their own perspective and the evaluations were widely dispersed in a generally normal distribution. As a result of this distribution of individual scores, the combined scores generally tend toward a medium rating reflecting the normal distribution of the participants. The prioritized needs also demonstrated a fairly uniform stair-step pattern in the scores and with no clear or obvious break in the scores to delineate priority grouping of the needs.

During discussion of the results, the question was raised about participants scoring a need relative to other needs in the group of if they were scoring the need relative to all 118 needs. The consensus of the participants was that they were scoring relative to the group not relative to all the needs. This position makes comparison the priority needs between groups difficult and the participants recommended to the vadose roadmap team not to make such a comparison without carefully examining the detailed scoring data.

This process of discussion/commenting/rating/review was repeated for each of the ten needs groups. The review of results of other needs groups was more cursory than that of the characterization group and was mainly limited to seeing which of the needs were rated highest and if there were any natural breaks in the prioritization. The comments and rating results for all ten groups can be found beginning on page 72of this record.

As a final activity, the group was asked to complete a meeting evaluation. The results of that evaluation are included in a separate report provided to the Vadose Zone Roadmap leadership.

Prioritization of Need Groups

The following table shows the results of the ranking from most important (1) to least important (10) of the ten needs groups. The number in each cell of the matrix indicates the number of participants who placed the criteria at that position on the list.

Need Group		Priority order												
	Rank Sum	1	2	3	4	5	6	7	8	9	10	Mean	STD	n
Characterization	168	10	2	3	2	0	1	0	1	2	0	3.00	2.74	21
Development of Better Monitoring Methods	150	2	5	3	5	2	2	0	0	2	0	3.86	2.24	21
Source Term Studies	147	4	2	4	2	4	2	1	1	1	0	4.00	2.35	21
Caps/Barriers/Grouting /Remediation	125	1	5	2	1	3	1	4	1	2	1	5.05	2.77	21
Actinide Geochemistry Studies	112	0	1	2	3	4	5	2	2	1	1	5.67	2.03	21
Plutonium R&D	106	1	0	2	4	2	2	5	2	1	2	5.95	2.40	21
C14 R&D	104	2	1	2	1	3	2	2	2	4	2	6.05	2.91	21
Modeling/Codes	89	0	2	2	1	3	1	1	4	2	5	6.76	2.83	21
Kd Values	79	1	1	0	1	0	2	3	7	4	2	7.24	2.36	21
Leak Detection	75	0	2	1	1	0	3	3	1	2	8	7.43	2.79	21
Group consensus (1.00 = most consensus): 0.25														

Group Survey for Weighting Criteria

1. Of the two criteria below, select the one you think is more important.

Choices	Total
The need addresses a highly ranked uncertainty.	8
The returns (reduced social cost, cleanup costs, monitoring costs, reduced or eliminated fines) exceed the costs of addressing or meeting the need.	12
Equal (neither is more important than the other).	1

2. How much more important is the first criterion than the second criterion?

Choices	Count
1(2)	0
2(3)	0
3(4)	3
4(5)	1
5(6)	1
6(7)	2
7(8)	0
8(9)	1

Statistics

Total	46
Mean	5(5.75)
Mode	3
High	8
Low	3
STD	1.83
N	21
n	8

3. How much more important is the second criterion than the first criterion?

Choices	Count
1(2)	0
2(3)	1
3(4)	1
4(5)	2
5(6)	3
6(7)	3
7(8)	0
8(9)	2

Statistics

Total	74
Mean	5(6.17)
Mode	??
High	8
Low	2
STD	1.80
N	21
n	12

4. **Of the two criteria below, select the one you think is more important.**

Choices	Total
The need addresses a highly ranked uncertainty.	13
Results of the need are transferable to multiple programs, other sites and locations.	5
Equal (neither is more important than the other).	3

5. **How much more important is the first criterion than the second criterion?**

Choices	Count
1(2)	0
2(3)	1
3(4)	4
4(5)	1
5(6)	1
6(7)	3
7(8)	0
8(9)	3

Statistics

Total	78
Mean	5(6.00)
Mode	3
High	8
Low	2
STD	2.16
N	21
n	13

6. **How much more important is the second criterion than the first criterion?**

Choices	Count
1(2)	0
2(3)	1
3(4)	2
4(5)	0
5(6)	0
6(7)	0
7(8)	1
8(9)	1

Statistics

Total	28
Mean	5(5.60)
Mode	3
High	8
Low	2
STD	2.70
N	21
n	5

7. **Of the two criteria below, select the one you think is more important.**

Choices	Total
The need addresses a highly ranked uncertainty.	4
It is practical to address the need.	13
Equal (neither is more important than the other).	4

8. **How much more important is the first criterion than the second criterion?**

Choices	Count
1(2)	0
2(3)	0
3(4)	1
4(5)	1
5(6)	0
6(7)	1
7(8)	0
8(9)	1

Statistics

Total	25
Mean	5(6.25)
Mode	??
High	8
Low	3
STD	2.22
N	21
n	4

9. **How much more important is the second criterion than the first criterion?**

Choices	Count
1(2)	1
2(3)	1
3(4)	2
4(5)	3
5(6)	2
6(7)	1
7(8)	1
8(9)	2

Statistics

Total	73
Mean	5(5.62)
Mode	4
High	8
Low	1
STD	2.18
N	21
n	13

10. Of the two criteria below, select the one you think is more important.

Choices	Total
The need addresses a highly ranked uncertainty.	4
Positive impact of the need on enabling and demonstrating the cleanup of waste.	15
Equal (neither is more important than the other).	2

11. How much more important is the first criterion than the second criterion?

Choices	Count
1(2)	0
2(3)	0
3(4)	2
4(5)	1
5(6)	0
6(7)	0
7(8)	0
8(9)	1

Statistics

Total	22
Mean	5(5.50)
Mode	3
High	8
Low	3
STD	2.38
N	21
n	4

12. How much more important is the second criterion than the first criterion?

Choices	Count
1(2)	0
2(3)	0
3(4)	3
4(5)	2
5(6)	1
6(7)	2
7(8)	4
8(9)	3

Statistics

Total	101
Mean	6(6.73)
Mode	7
High	8
Low	3
STD	1.91
N	21
n	15

13. Of the two criteria below, select the one you think is more important.

Choices	Total
The need addresses a highly ranked uncertainty.	9
Addressing the need will have a positive impact on the planned schedules.	11
Equal (neither is more important than the other).	1

14. How much more important is the first criterion than the second criterion?

Choices	Count
1(2)	0
2(3)	2
3(4)	1
4(5)	0
5(6)	1
6(7)	1
7(8)	2
8(9)	2

Statistics

Total	57
Mean	5(6.33)
Mode	??
High	8
Low	2
STD	2.45
N	21
n	9

15. How much more important is the second criterion than the first criterion?

Choices	Count
1(2)	1
2(3)	0
3(4)	1
4(5)	1
5(6)	3
6(7)	0
7(8)	2
8(9)	3

Statistics

Total	72
Mean	6(6.55)
Mode	??
High	8
Low	1
STD	2.30
N	21
n	11

16. Of the two criteria below, select the one you think is more important.

Choices	Total
The returns (reduced social cost, cleanup costs, monitoring costs, reduced or eliminated fines) exceed the costs of addressing or meeting the need.	16
Equal (neither is more important than the other).	3
Results of the need are transferable to multiple programs, other sites and locations.	2

17. How much more important is the first criterion than the second criterion?

Choices	Count
1(2)	0
2(3)	1
3(4)	1
4(5)	4
5(6)	0
6(7)	2
7(8)	3
8(9)	5

Statistics

Total	110
Mean	6(6.88)
Mode	8
High	8
Low	2
STD	2.06
N	21
n	16

18. How much more important is the second criterion than the first criterion?

Choices	Count
1(2)	0
2(3)	1
3(4)	1
4(5)	0
5(6)	0
6(7)	0
7(8)	0
8(9)	0

Statistics

Total	7
Mean	3(3.50)
Mode	??
High	3
Low	2
STD	0.71
N	21
n	2

19. Of the two criteria below, select the one you think is more important.

Choices	Total
The returns (reduced social cost, cleanup costs, monitoring costs, reduced or eliminated fines) exceed the costs of addressing or meeting the need.	8
It is practical to address the need.	9
Equal (neither is more important than the other).	4

20. How much more important is the first criterion than the second criterion?

Choices	Count
1(2)	0
2(3)	1
3(4)	1
4(5)	2
5(6)	0
6(7)	2
7(8)	2
8(9)	0

Statistics

Total	47
Mean	5(5.88)
Mode	??
High	7
Low	2
STD	1.89
N	21
n	8

21. How much more important is the second criterion than the first criterion?

Choices	Count
1(2)	0
2(3)	0
3(4)	2
4(5)	1
5(6)	2
6(7)	3
7(8)	0
8(9)	1

Statistics

Total	55
Mean	5(6.11)
Mode	6
High	8
Low	3
STD	1.62
N	21
n	9

22. Of the two criteria below, select the one you think is more important.

Choices	Total
The returns (reduced social cost, cleanup costs, monitoring costs, reduced or eliminated fines) exceed the costs of addressing or meeting the need.	6
Positive impact of the need on enabling and demonstrating the cleanup of waste.	9
Equal (neither is more important than the other).	6

23. How much more important is the first criterion than the second criterion?

Choices	Count
1(2)	0
2(3)	2
3(4)	0
4(5)	3
5(6)	0
6(7)	0
7(8)	0
8(9)	1

Statistics

Total	30
Mean	4(5.00)
Mode	4
High	8
Low	2
STD	2.19
N	21
n	6

24. How much more important is the second criterion than the first criterion?

Choices	Count
1(2)	0
2(3)	0
3(4)	2
4(5)	1
5(6)	1
6(7)	2
7(8)	2
8(9)	1

Statistics

Total	58
Mean	5(6.44)
Mode	??
High	8
Low	3
STD	1.81
N	21
n	9

25. Of the two criteria below, select the one you think is more important.

Choices	Total
The returns (reduced social cost, cleanup costs, monitoring costs, reduced or eliminated fines) exceed the costs of addressing or meeting the need.	11
Addressing the need will have a positive impact on the planned schedules.	6
Equal (neither is more important than the other).	4

26. How much more important is the first criterion than the second criterion?

Choices	Count
1(2)	0
2(3)	2
3(4)	0
4(5)	5
5(6)	0
6(7)	1
7(8)	1
8(9)	2

Statistics

Total	64
Mean	5(5.82)
Mode	4
High	8
Low	2
STD	2.14
N	21
n	11

27. How much more important is the second criterion than the first criterion?

Choices	Count
1(2)	0
2(3)	1
3(4)	2
4(5)	0
5(6)	0
6(7)	0
7(8)	1
8(9)	2

Statistics

Total	37
Mean	5(6.17)
Mode	??
High	8
Low	2
STD	2.79
N	21
n	6

28. Of the two criteria below, select the one you think is more important.

Choices	Total
Results of the need are transferable to multiple programs, other sites and locations.	3
It is practical to address the need.	17
Equal (neither is more important than the other).	1

29. How much more important is the first criterion than the second criterion?

Choices	Count
1(2)	0
2(3)	1
3(4)	0
4(5)	0
5(6)	0
6(7)	2
7(8)	0
8(9)	0

Statistics

Total	17
Mean	5(5.67)
Mode	6
High	6
Low	2
STD	2.31
N	21
n	3

30. How much more important is the second criterion than the first criterion?

Choices	Count
1(2)	1
2(3)	1
3(4)	1
4(5)	1
5(6)	3
6(7)	4
7(8)	2
8(9)	4

Statistics

Total	112
Mean	6(6.59)
Mode	??
High	8
Low	1
STD	2.12
N	21
n	17

31. Of the two criteria below, select the one you think is more important.

Choices	Total
Results of the need are transferable to multiple programs, other sites and locations.	2
Positive impact of the need on enabling and demonstrating the cleanup of waste.	18
Equal (neither is more important than the other).	1

32. How much more important is the first criterion than the second criterion?

Choices	Count
1(2)	1
2(3)	0
3(4)	0
4(5)	0
5(6)	0
6(7)	0
7(8)	0
8(9)	1

Statistics

Total	11
Mean	5(5.50)
Mode	??
High	8
Low	1
STD	4.95
N	21
n	2

33. How much more important is the second criterion than the first criterion?

Choices	Count
1(2)	0
2(3)	1
3(4)	3
4(5)	0
5(6)	2
6(7)	4
7(8)	3
8(9)	5

Statistics

Total	124
Mean	6(6.89)
Mode	8
High	8
Low	2
STD	2.00
N	21
n	18

34. Of the two criteria below, select the one you think is more important.

Choices	Total
Results of the need are transferable to multiple programs, other sites and locations.	5
Addressing the need will have a positive impact on the planned schedules.	13
Equal (neither is more important than the other).	3

35. How much more important is the first criterion than the second criterion?

Choices	Count
1(2)	0
2(3)	2
3(4)	1
4(5)	0
5(6)	1
6(7)	0
7(8)	0
8(9)	1

Statistics

Total	25
Mean	4(5.00)
Mode	2
High	8
Low	2
STD	2.55
N	21
n	5

36. How much more important is the second criterion than the first criterion?

Choices	Count
1(2)	0
2(3)	0
3(4)	1
4(5)	1
5(6)	2
6(7)	1
7(8)	4
8(9)	4

Statistics

Total	96
Mean	6(7.38)
Mode	??
High	8
Low	3
STD	1.66
N	21
n	13

37. Of the two criteria below, select the one you think is more important.

Choices	Total
It is practical to address the need.	8
Positive impact of the need on enabling and demonstrating the cleanup of waste.	12
Equal (neither is more important than the other).	1

38. How much more important is the first criterion than the second criterion?

Choices	Count
1(2)	1
2(3)	1
3(4)	1
4(5)	3
5(6)	1
6(7)	1
7(8)	0
8(9)	0

Statistics

Total	37
Mean	4(4.63)
Mode	4
High	6
Low	1
STD	1.60
N	21
n	8

39. How much more important is the second criterion than the first criterion?

Choices	Count
1(2)	0
2(3)	3
3(4)	1
4(5)	0
5(6)	2
6(7)	3
7(8)	1
8(9)	2

Statistics

Total	72
Mean	5(6.00)
Mode	??
High	8
Low	2
STD	2.26
N	21
n	12

40. Of the two criteria below, select the one you think is more important.

Choices	Total
It is practical to address the need.	12
Addressing the need will have a positive impact on the planned schedules.	8
Equal (neither is more important than the other).	1

41. How much more important is the first criterion than the second criterion?

Choices	Count
1(2)	0
2(3)	1
3(4)	2
4(5)	2
5(6)	1
6(7)	2
7(8)	1
8(9)	3

Statistics	
Total	76
Mean	5(6.33)
Mode	8
High	8
Low	2
STD	2.15
N	21
n	12

42. How much more important is the second criterion than the first criterion?

Choices	Count
1(2)	0
2(3)	1
3(4)	1
4(5)	1
5(6)	0
6(7)	2
7(8)	1
8(9)	2

Statistics	
Total	52
Mean	6(6.50)
Mode	??
High	8
Low	2
STD	2.27
N	21
n	8

43. Of the two criteria below, select the one you think is more important.

Choices	Total
Positive impact of the need on enabling and demonstrating the cleanup of waste.	17
Equal (neither is more important than the other).	3
Addressing the need will have a positive impact on the planned schedules.	1

44. How much more important is the first criterion than the second criterion?

Choices	Count
1(2)	0
2(3)	0
3(4)	2
4(5)	1
5(6)	4
6(7)	5
7(8)	1
8(9)	4

Statistics

Total	116
Mean	6(6.82)
Mode	6
High	8
Low	3
STD	1.63
N	21
n	17

45. How much more important is the second criterion than the first criterion?

Choices	Count
1(2)	0
2(3)	0
3(4)	1
4(5)	0
5(6)	0
6(7)	0
7(8)	0
8(9)	0

Statistics

Total	4
Mean	3(4.00)
Mode	3
High	3
Low	3
STD	0.00
N	21
n	1

Comments on Criteria

Criterion 1: The need addresses a highly ranked uncertainty.

- High = uncertainty 1-10; Medium = 11-19; low = 20-25 {#81[1]}
- The number of uncertainties the need addresses and each uncertainties ranking should be taken into account in the weighting. {#29}
- People had needs in mind when they identified and ranked uncertainties. Therefore I don't think this should be used as a criteria. Our ranking of the needs should be independent and serve as a check on the earlier identification and ranking of uncertainties. {#35}
- Comment #29 makes a good point. A method to factor in the number of uncertainties addressed and their respective rankings is needed to make this criteria most effective. {#42}
- I suggest we first combine/clarify the needs. Then we quantify the statement "highly ranked" (e.g. top 10) and take a vote whether each of the needs meet this single criteria. Only those needs for which a majority view as a "highly ranked" uncertainty are ranked against the five remaining criteria. {#59}
- This appears to be the most important criteria. {#70}
- I think that the needs should be ranked separately for #1. Then compared with the rankings using #2 through #6. {#80}

Criterion 2: The returns (reduced social cost, cleanup costs, monitoring costs, reduced or eliminated fines) exceed the costs of addressing or meeting the need.

- A net benefit on total costs and on social costs. {#22}
- The returns (reduced social cost, cleanup costs, monitoring costs, reduced or eliminated fines) exceed the costs of addressing or meeting the need. {#23}
- Sustainability and maintaining the brain trust. {#24}
- Returns means reducing the cost of cleanup, monitoring, minimizing the loss of the land {#25}
- How do we measure "social costs"? It is possible to "reduce social costs" (interpreted to include the meaning "improve public acceptance of a selected remedy") which results in a significant increase in cleanup cost. Are these parenthetical elements of this criterion potentially mutually exclusive? This criterion is not specific enough to provide the discrimination needed. {#43}
- Addressing one need may not provide a return. However, addressing that need together with several other needs could provide a huge return. Short sighted to look at needs separately. {#44}
- Return is a reduction in overall cleanup cost, reduction in O&M cost, and long term monitoring cost. {#45}
- How do we "maintain a brain trust"? Is this measurable? {#46}
- Inherent in this criteria is the assumption that the research may result in creating or building a better "mouse trap" for remediating contaminantd sites. Maintaining the protectiveness of the remedy is paramount and should not be sacrificed for cost or schedule. {#48}
- Agree with #46--This is about current research needs--not about our ability to do research in the future. {#53}
- Needs are very focused and may not provide a return without the also addressing some other need. Maybe reword to say potential return. {#66}
- I agree with #46 and #53. {#64}

[1] Numbers at the end of a comment were added by the software to track comments as they were entered into the data base. These numbers were used by participants to reference, support, or oppose other comments.

- Concerning comment #44, the criteria does not specifically suggest that each return be evaluated separately to determine if the "returns - plural" exceed the costs - plural". {#77}

Criterion 3: Results of the need are transferable to multiple programs, other sites and locations.

- The results may be transferable to multiple programs, but the discussion thus far on the needs has indicated that the 117 needs have been developed by INEEL Operations staff for the INEEL and that there was not a question asked on transferability. {#30}
- Although this is an important criteria, it is difficult to know if the results from addressing a local need will or will not be transferable. {#32}
- I'm not sure that transferability to other sites is an important discriminator for operational research needs since operational needs tend to be site-specific. {#34}
- Agree with #34. {#37}
- We don't have representatives from other sites involved in this meeting so we only have a limited ability to judge whether a given need is truly applicable to other sites. {#39}
- Another agreement with #34, I think given past experience that the transferability criterion can be dropped {#50}
- Results of the need are tied to sites with similar contaminants and subsurface geological environments (large vadose zone, fractured volcanic aquifer, etc.). {#57}
- Delete the need that it meet the needs of other sites. {#61}
- Some highly ranked needs may not be transferable between locations but may be very useful for a location and should not be penalized because of this apparent deficiency. {#62}
- Agree w/ 61 {#63}
- Many problems (e.g. adsorption of contaminants on earth materials) are common at multiple sites, so it makes sense to attack them broadly, with input from and application to work at other sites. {#69}
- Agree with 61. Nothing in DOE's system prevents transferability of results to other sites; I don't think this is a discriminating criterion. {#72}
- Much of the research will be site specific, however, EM will more likely fund research that has a broad application of the research results. {#75}
- Question of whether it is sufficient to be transferable or crosscutting or does it need to make a significant advance in transfer information that reduces a prioritized uncertainty. If this is the case this attribute may not be mutually exclusive and may be part of #2? {#79}

Criterion 4: It is practical to address the need.

- Practical does not address cost and schedule that are addressed in other specific criteria. {#26}
- The definition of practical is rooted in the need statement. {#27}
- Practical in the sense as to our current understanding of the technological impediments. {#36}
- "Practical" is an evaluation that the need is not fundamentally flawed in terms of implementability
- An evaluation that the uncertainty addressed will be applicable to the decision process {#38}
- This is a very subjective criteria. There probably are practical approaches for addressing each need. {#65}
- Practical is tied specifically to ones understanding or comprehension of the technical problem. {#68}
- Does practical have a dollar value associated with it? What may seem practical to one, may not to another (who may not have to implement the recommended action). {#73}

- How about "The need can be reasonably and technically addressed" {#74}
- Suggest that this be re-worded to state that "It has applicability to the program priorities" {#76}

Criterion 5: Positive impact of the need on enabling and demonstrating the cleanup of waste.

- Positive impact of the need on proving cleanup of waste. {#7}
- Defending the cleanup and moving into the monitoring phase. {#18}
- What research is needed to defend the cleanup state. {#17}
- This is more public oriented {#16}
- Proving comes down to analytical data {#15}
- Regarding #15, proving also means that the analytical data is representative of anything and is collected in the correct location, i.e. within a preferential pathway. {#28}
- Reword? Addressing the need will have a positive impact on enabling and demonstrating waste clean up. {#31}
- Reword? Addressing the need will have a positive impact on demonstrating effectiveness and adequacy of a cleanup action {#41}
- Agree with #41 {#47}
- "Cleanup" is defined in the broad sense of investigation, feasibility, construction, operation and monitoring of contaminants and can apply to a specific site or categories of sites. {#49}
- re: #41 -- "adequacy" needs definition; public perception of 'adequate' cleanup is significantly different from regulatory adequacy. {#51}
- "Cleanup" means any action taken to minimize hazards arising from the presence of the waste. {#52}
- With regard to #15 and #28, it is also necessary to identify what analytical data needs to be collected. {#54}

Criterion 6: Addressing the need will have a positive impact on the planned schedules.

- Baseline means current schedule contained in the PMP and DWP. {#20}
- Positive impact is without a reduction in the protectiveness value. {#21}
- I don't believe this criteria is very clear. Would it be better to phrase it "Addressing the need will not have an adverse impact on the planned schedule." i.e. studies can be completed in time for results to be incorporated in the decision. {#33}
- Beyond any specific schedules, addressing the need may have value concerning impacts over any indefinite time span. {#40}
- Schedules apply to existing and planned binding commitments under state & federal laws and DOE policies. {#55}
- In regards to comment #33, the rephrasing would be a different thought entirely from the original criteria - "positive impact" vs. "not an adverse impact" are two different concepts altogether. {#56}
- Using #33, this criterion could be reworded to "Addressing this need can be performed in a timeframe to support initial decisions, or reviews of the decisions." {#58}
- Is the term "positive impact" equivalent to "reducing the time to accomplish the cleanup"? Suggest specifying what is meant by positive impact. {#60}
- In regards to the above comments, perhaps the criterion should be: Addressing the need can expected to have a positive impact within the planned schedules. {#67}

- re: #33. If is it recognized that a planned schedule cannot be met (i.e. a decision made) without unacceptable uncertainty, the SCHEDULE should be changed to provide time for the need to be met (the research to be done). {#71}
- "Planed Schedules" are tied directly into national priorities and thus can substantially change over time. {#78}

Characterization Needs Group

Discussion and comment on the categorization needs

1. Need to determine preferred flow zones in the aquifer for Characterization at the regional and sub-regional scale
    - Define nonintrusive {#254}
    - Seems difficult. There may be fast-flow zones at different depths at the same geographical location. {#255}
    - Wells are expensive. Good to maximize the information obtained without them. {#256}
    - This requires clarification of whether this is practical {#257}
    - Better description of these technologies is needed to understand the role of these technologies with respect to aquifer monitoring. {#258}
    - Noninvasive determination of hydraulic property distribution to identify fast (preferred) flow zones in the aquifer {#261}
    - Need to Develop methods for using solute content, natural isotopes, and isotope ratios to define flow, preferential pathways, & origin of groundwater.{#156}
    - Need Flow velocity in the SRPA.{#178}
    - Temperature, isotope data can be useful in this process. {#273}
2. Need to better define the porosity and permeability in selected areas.
    - Distribution of porosity and permeability at any scale may be nearly impossible because of the complexities of the fracture-dominated system and relation of literally hundreds of basalt flows and interbed units. {#276}
3. Need to develop a better understanding of vapor transport.
    - And ways to determine if vapors follow gradients for Characterization {#266}
4. Need to Develop better tracer tests to track flow through the interbeds in selected areas.
    - Interbed flow is extremely important. Maybe techniques not involving tracers are needed also. {#281}
    - Based on discussion of the monitoring needs this need should include the entire vadose zone as well as the interbeds. {#287}
5. Need to define the accuracy and reliability in field instrumentation measurements.
    - Need to Develop meso-scale test of network of experiments with instrumentation built into
    - The large block to test the effects on readings & data before and after drilling. {#267}
    - We're not certain that the readings taken after a well is drilled would be the same as the readings that would have been produced if a well had never been drilled at all (i.e., did drilling the well change the system?) {#268}
    - If you don't know what the reading is or if the reading is correct why bother? {#274}
    - Needed for confidence building among managers & stakeholders. {#275}
6. Need a fingerprint contaminant source detection for perched water contaminants at INTEC.
7. Need to Investigate perched water zones for source of water and perching mechanisms, source of contaminants, connectivity between perched zones, and water volume.
    - Need to Characterize relationship of flow in Big Lost River to VZ & GW flow beneath the Tank Farm contamination. {#132}
    - Need Methods for detecting horizontal movement of transient water, especially how water in the spreading areas effects changes to gradients and flow in the interbeds.{#152}

- Perched water is strongly characteristic of many locations at INEEL, is of critical importance for contaminant transport, and is poorly understood. {#277}

8. Need development of methods to better characterize fracturing and detect preferred pathways in the basalt for the vadose zone.
    - Top priority. Preferred paths in the basalt are critical to accelerated transport modes and to the issue on adsorption or non-adsorption of contaminants in the vadose zone. {#279}
9. Need analyze existing data and collect temp logs on all aquifer and vadose zone wells to evaluate flow regimes.
    - Flow regimes include active aquifer thickness, preferred pathways {#269}
    - Need to Study deep cold flow channels that may be influencing differences in the regional flow directions.{#174}
    - Addressing this need takes advantage of readily available information and easy-to-collect information to gain much greater insight into aquifer flow and transport mechanics. It has a very high payoff for very minor investment of time and money. It should be rated as one of the highest needs for increasing understanding of aquifer flow. {#278}
10. Need methods for delineation of flow direction in aquifer at a facility scale.
    - Need additional definition of GW flow direction at WAG 4. {#164}
11. Need to perform vertical profiling of contaminant plume geometry to determine layering effects (e.g. Cr6 from TRA).
    - Need More information on vertical controls of Cr6 from TRA and lateral extent of plume.{#162}
    - This is broader than just vertical profiling contaminant plume geometry. It is the effort to understand vertical water movement within the aquifer, and the effects of wells on that movement. Vertical dispersivity and varying behavior of semi-confined layers in the aquifer has the potential to greatly affect model results and aquifer remediation strategies. {#282}
12. Need better understanding of Sources of nitrates and other contaminants in the aquifer at CFA.
    - Nitrates are just not the big issue. {#283}
13. Need deep core holes to verify geo and biophysical studies.
    - Addressing this need is a way to constrain aquifer properties that cannot be determined in other ways. It will provide opportunity to learn about aquifer thickness variations, vertical profiling of aquifer chemistry and physical properties, and ultimately better understanding of the operation of the aquifer leading to increased ability to make valid remediation decisions. {#284}
14. Need measurement technique to monitor ambient water travel time through VZ to SRPA at selected facilities.
    - Many aspects of this travel time are important: spatial variability at various scales, the distinction between first-arrival travel time and average travel time, relative contributions of basalts and interbeds to travel time, etc. {#285}
15. Need to evaluate dispersivity at selected facilities.
16. Need source term Characterization of the SDA Rocky Flats Plant wastes
    - We've got to know what's there and what condition it is in now. Some direct sampling would be of great value. {#286}
17. Need to evaluate timing and duration of leachate flux under current and historic conditions.
    - I believe that the original intent was to determine the percentage of precipitation recharging the aquifer. Restricting this need to the timing and duration of leachate infiltration assumes that all infiltration contacts buried waste. This would not necessarily be the case. {#280}

Unclear need, more information is needed for clarity

1. Need to develop/demonstrate better suites of quantitative geophysics methods for characterization?

- For what purpose, geology or waste zone characterization or both? {#259}
- This is really a means to answering a need, rather than a need. {#260}

2. Need to Determine amount and mechanism of diffusion of contaminants of concern moving from perched zones to the basalts .
3. Need to develop methods for broad area characterization for Characterization
4. Need to develop better field screening methods for isotope characterization.
5. Need to evaluate other parameters, similar to temperature, that can be utilized to narrow the field of data.
6. Need flow R&D for WAG 7 for Characterization
7. Need to utilize numerical models during the experiment design phase to predict experiment outcome.
8. Need studies on coupled processes (driving forces, microbial actions, etc.).
9. Need to expand basic geologic knowledge of: level of understanding of stratigraphy & structure; effects of being at caldera margins.
10. Need to evaluate the possible source of DNAPLs below the 240 ft. interbed.

Need moved to the KD needs group

1. Need to Investigate interbed ion exchange interactions at selected facilities.

Characterization needs rated against the criteria

This table shows the average scores for each of the criteria within a need. The color of the cell indicates the level of consensus of the scores within that cell. A green cell indicates a high level of consensus and a red cell indicates a low level of consensus. The blue cells were not rated by the participants during the meeting.

A consensus threshold value was set to help focus the group on those cells that had the most disagreement in the scores in the limited time available for discussion. It was not intended to imply that the group was in agreement on the score in that cell. The threshold level for consensus was set at 0.50. Typically, the threshold is set at 0.6 for discussion. The lower than normal threshold is indicative of the different perspectives of the participants.

Needs	Criterion									
	1	2	3	4	5	6	Total	Mean	STD	Weighted Total
(Weight)	0.65	0.95	0.26	1.06	2.29	0.80				
1.Need to determine preferred flow zones in the aquifer for Characterization at the regional and sub-regional scale		H(4.10)	M(2.40)	M(3.80)	M(3.60)	M(2.37)	16.27	M(3.25)	0.81	18.69
2.Need to better define the porosity and permeability in selected areas.		M(3.70)	M(2.20)	M(3.70)	M(3.90)	M(2.37)	15.87	M(3.17)	0.82	18.83
3.Need to develop a better understanding of vapor transport.		M(3.20)	M(2.90)	M(3.40)	M(3.70)	M(2.89)	16.09	M(3.22)	0.34	18.19
4.Need to develop better tracer tests to track flow through the interbeds in selected areas.		M(3.63)	M(3.00)	M(3.84)	M(3.95)	M(2.79)	17.21	M(3.44)	0.52	19.57
5.Need to define the accuracy and reliability in field instrumentation measurements.		M(2.89)	M(3.84)	M(3.42)	M(3.21)	M(2.26)	15.63	M(3.13)	0.59	16.54
6.Need a fingerprint contaminant source detection for perched water contaminants at INTEC.		M(2.70)	M(2.00)	M(2.80)	M(3.30)	M(2.79)	13.59	M(2.72)	0.47	15.84
7.Need to investigate perched water zones for source of water and perching mechanisms, source of contaminants, connectivity between perched zones, and water volume.		M(3.80)	L(1.90)	M(3.60)	M(3.70)	M(3.00)	16.00	M(3.20)	0.79	18.79
8.Need development of methods to better characterize fracturing and detect preferred pathways in the basalt for the vadose zone.		M(3.80)	M(3.10)	M(2.50)	M(3.90)	M(2.89)	16.19	M(3.24)	0.60	18.31

Needs	Criterion 1	2	3	4	5	6	Total	Mean	STD	Weighted Total
9.Need analyze existing data and collect temp logs on all aquifer and vadose zone wells to evaluate flow regimes.		M(3.40)	M(2.30)	H(4.00)	M(2.60)	M(2.37)	14.67	M(2.93)	0.74	15.92
10.Need methods for delineation of flow direction in aquifer at a facility scale.		M(3.50)	M(2.50)	M(3.50)	M(3.10)	M(2.68)	15.28	M(3.06)	0.46	16.93
11.Need to perform vertical profiling of contaminant plume geometry to determine layering effects (e.g. Cr6 from TRA).		M(3.40)	L(1.80)	M(3.10)	M(3.10)	M(2.68)	14.08	M(2.82)	0.62	16.23
12.Need better understanding of Sources of nitrates and other contaminants in the aquifer at CFA.		M(2.05)	L(1.42)	M(2.37)	M(2.47)	L(1.42)	9.74	L(1.95)	0.50	11.63
13.Need deep core holes to verify geo and biophysical studies.		M(3.50)	M(2.50)	M(3.30)	M(2.90)	L(1.53)	13.73	M(2.75)	0.78	15.34
14.Need measurement technique to monitor ambient water travel time through VZ to SRPA at selected facilities.		M(3.90)	M(3.40)	M(3.40)	H(4.00)	M(3.00)	17.70	M(3.54)	0.41	19.75
15.Need to evaluate dispersivity at selected facilities.		M(2.60)	M(2.00)	M(2.50)	M(2.90)	M(2.16)	12.16	M(2.43)	0.36	14.01
16.Need source term Characterization of the SDA Rocky Flats Plant wastes		M(3.70)	L(1.60)	M(2.80)	H(4.20)	M(3.32)	15.62	M(3.12)	0.99	19.17
17.Need to evaluate timing and duration of leachate flux under current and historic conditions.		M(3.90)	M(2.50)	M(3.50)	M(3.90)	M(3.53)	17.33	M(3.47)	0.57	19.82

Criteria scores by need

This table shows the distribution of scores (H, M, L) across the six criteria for each of the needs. The number within a criteria/score cell indicates the number of participants that used that score for that criteria. Within a need, the criteria are sorted from the highest to the lowest mean score.

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
1.Need to determine preferred flow zones in the aquifer for Characterization at the regional and sub-regional scale									
Criterion 1 (0.65)									
Criterion 2 (0.95)	13	5	2	82	H(4.10)	H	1.37	20	3.89
Criterion 4 (1.06)	11	6	3	76	M(3.80)	H	1.51	20	4.03

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 5 (2.29)	12	2	6	72	M(3.60)	H	1.85	20	8.24
Criterion 3 (0.26)	4	6	10	48	M(2.40)	L	1.60	20	0.62
Criterion 6 (0.80)	3	7	9	45	M(2.37)	L	1.50	19	1.89
2.Need to better define the porosity and permeability in selected areas.									
Criterion 1 (0.65)									
Criterion 5 (2.29)	12	5	3	78	M(3.90)	H	1.52	20	8.93
Criterion 2 (0.95)	10	7	3	74	M(3.70)	H	1.49	20	3.51
Criterion 4 (1.06)	10	7	3	74	M(3.70)	H	1.49	20	3.92
Criterion 6 (0.80)	3	7	9	45	M(2.37)	L	1.50	19	1.89
Criterion 3 (0.26)	5	2	13	44	M(2.20)	L	1.77	20	0.57
3.Need to develop a better understanding of vapor transport.									
Criterion 1 (0.65)									
Criterion 5 (2.29)	11	5	4	74	M(3.70)	H	1.63	20	8.47
Criterion 4 (1.06)	8	8	4	68	M(3.40)	??	1.54	20	3.60
Criterion 2 (0.95)	8	6	6	64	M(3.20)	H	1.70	20	3.04
Criterion 3 (0.26)	5	9	6	58	M(2.90)	M	1.52	20	0.75
Criterion 6 (0.80)	5	8	6	55	M(2.89)	M	1.56	19	2.32
4.Need to develop better tracer tests to track flow through the interbeds in selected areas.									
Criterion 1 (0.65)									
Criterion 5 (2.29)	10	8	1	75	M(3.95)	H	1.22	19	9.04
Criterion 4 (1.06)	9	9	1	73	M(3.84)	??	1.21	19	4.07
Criterion 2 (0.95)	8	9	2	69	M(3.63)	M	1.34	19	3.45
Criterion 3 (0.26)	5	9	5	57	M(3.00)	M	1.49	19	0.78
Criterion 6 (0.80)	3	11	5	53	M(2.79)	M	1.32	19	2.23
5.Need to define the accuracy and reliability in field instrumentation measurements.									

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 1 (0.65)									
Criterion 3 (0.26)	11	5	3	73	M(3.84)	H	1.54	19	1.00
Criterion 4 (1.06)	8	7	4	65	M(3.42)	H	1.57	19	3.63
Criterion 5 (2.29)	8	5	6	61	M(3.21)	H	1.75	19	7.35
Criterion 2 (0.95)	6	6	7	55	M(2.89)	L	1.70	19	2.75
Criterion 6 (0.80)	3	6	10	43	M(2.26)	L	1.52	19	1.81
6.Need a fingerprint contaminant source detection for perched water contaminants at INTEC.									
Criterion 1 (0.65)									
Criterion 5 (2.29)	7	9	4	66	M(3.30)	M	1.49	20	7.56
Criterion 4 (1.06)	4	10	6	56	M(2.80)	M	1.44	20	2.97
Criterion 6 (0.80)	6	5	8	53	M(2.79)	L	1.75	19	2.23
Criterion 2 (0.95)	4	9	7	54	M(2.70)	M	1.49	20	2.56
Criterion 3 (0.26)	4	2	14	40	M(2.00)	L	1.65	20	0.52
7.Need to investigate perched water zones for source of water and perching mechanisms, source of contaminants, connectivity between perched zones, and water volume.									
Criterion 1 (0.65)									
Criterion 2 (0.95)	10	8	2	76	M(3.80)	H	1.36	20	3.61
Criterion 5 (2.29)	10	7	3	74	M(3.70)	H	1.49	20	8.47
Criterion 4 (1.06)	7	12	1	72	M(3.60)	M	1.14	20	3.82
Criterion 6 (0.80)	5	9	5	57	M(3.00)	M	1.49	19	2.40
Criterion 3 (0.26)	1	7	12	38	L(1.90)	L	1.21	20	0.49
8.Need development of methods to better characterize fracturing and detect preferred pathways in the basalt for the vadose zone.									
Criterion 1 (0.65)									
Criterion 5 (2.29)	14	1	5	78	M(3.90)	H	1.77	20	8.93
Criterion 2 (0.95)	11	6	3	76	M(3.80)	H	1.51	20	3.61
Criterion 3 (0.26)	8	5	7	62	M(3.10)	H	1.77	20	0.81

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 6 (0.80)	3	12	4	55	M(2.89)	M	1.24	19	2.32
Criterion 4 (1.06)	2	11	7	50	M(2.50)	M	1.28	20	2.65
9.Need analyze existing data and collect temp logs on all aquifer and vadose zone wells to evaluate flow regimes.									
Criterion 1 (0.65)									
Criterion 4 (1.06)	14	2	4	80	H(4.00)	H	1.65	20	4.24
Criterion 2 (0.95)	9	6	5	68	M(3.40)	H	1.67	20	3.23
Criterion 5 (2.29)	6	4	10	52	M(2.60)	L	1.79	20	5.95
Criterion 6 (0.80)	3	7	9	45	M(2.37)	L	1.50	19	1.89
Criterion 3 (0.26)	3	7	10	46	M(2.30)	L	1.49	20	0.60
10.Need methods for delineation of flow direction in aquifer at a facility scale.									
Criterion 1 (0.65)									
Criterion 4 (1.06)	7	11	2	70	M(3.50)	M	1.28	20	3.71
Criterion 2 (0.95)	10	5	5	70	M(3.50)	H	1.70	20	3.32
Criterion 5 (2.29)	8	5	7	62	M(3.10)	H	1.77	20	7.10
Criterion 6 (0.80)	5	6	8	51	M(2.68)	L	1.67	19	2.15
Criterion 3 (0.26)	4	7	9	50	M(2.50)	L	1.57	20	0.65
11.Need to perform vertical profiling of contaminant plume geometry to determine layering effects (e.g. Cr6 from TRA).									
Criterion 1 (0.65)									
Criterion 2 (0.95)	9	6	5	68	M(3.40)	H	1.67	20	3.23
Criterion 5 (2.29)	6	9	5	62	M(3.10)	M	1.52	20	7.10
Criterion 4 (1.06)	8	5	7	62	M(3.10)	H	1.77	20	3.29
Criterion 6 (0.80)	6	4	9	51	M(2.68)	L	1.80	19	2.15
Criterion 3 (0.26)	2	4	14	36	L(1.80)	L	1.36	20	0.47
12.Need better understanding of sources of nitrates and other contaminants in the aquifer at CFA.									
Criterion 1 (0.65)									

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 5 (2.29)	5	4	10	47	M(2.47)	L	1.74	19	5.66
Criterion 4 (1.06)	1	11	7	45	M(2.37)	M	1.16	19	2.51
Criterion 2 (0.95)	3	4	12	39	M(2.05)	L	1.54	19	1.95
Criterion 6 (0.80)		4	15	27	L(1.42)	L	0.84	19	1.14
Criterion 3 (0.26)	1	2	16	27	L(1.42)	L	1.07	19	0.37
13.Need deep core holes to verify geo and biophysical studies.									
Criterion 1 (0.65)									
Criterion 2 (0.95)	8	9	3	70	M(3.50)	M	1.43	20	3.32
Criterion 4 (1.06)	9	5	6	66	M(3.30)	H	1.75	20	3.50
Criterion 5 (2.29)	6	7	7	58	M(2.90)	??	1.65	20	6.64
Criterion 3 (0.26)	3	9	8	50	M(2.50)	M	1.43	20	0.65
Criterion 6 (0.80)		5	14	29	L(1.53)	L	0.90	19	1.22
14.Need measurement technique to monitor ambient water travel time through VZ to SRPA at selected facilities.									
Criterion 1 (0.65)									
Criterion 5 (2.29)	12	6	2	80	H(4.00)	H	1.38	20	9.16
Criterion 2 (0.95)	12	5	3	78	M(3.90)	H	1.52	20	3.70
Criterion 4 (1.06)	7	10	3	68	M(3.40)	M	1.39	20	3.60
Criterion 3 (0.26)	10	4	6	68	M(3.40)	H	1.79	20	0.88
Criterion 6 (0.80)	5	9	5	57	M(3.00)	M	1.49	19	2.40
15.Need to evaluate dispersivity at selected facilities.									
Criterion 1 (0.65)									
Criterion 5 (2.29)	6	7	7	58	M(2.90)	??	1.65	20	6.64
Criterion 2 (0.95)	3	10	7	52	M(2.60)	M	1.39	20	2.47
Criterion 4 (1.06)	2	11	7	50	M(2.50)	M	1.28	20	2.65
Criterion 6 (0.80)	3	5	11	41	M(2.16)	L	1.54	19	1.73

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 3 (0.26)	1	8	11	40	M(2.00)	L	1.21	20	0.52
16.Need source term characterization of the SDA Rocky Flats Plant wastes									
Criterion 1 (0.65)									
Criterion 5 (2.29)	15	2	3	84	H(4.20)	H	1.51	20	9.62
Criterion 2 (0.95)	11	5	4	74	M(3.70)	H	1.63	20	3.51
Criterion 6 (0.80)	9	4	6	63	M(3.32)	H	1.80	19	2.65
Criterion 4 (1.06)	4	10	6	56	M(2.80)	M	1.44	20	2.97
Criterion 3 (0.26)	2	2	16	32	L(1.60)	L	1.31	20	0.42
17.Need to evaluate timing and duration of leachate flux under current and historic conditions.									
Criterion 1 (0.65)									
Criterion 5 (2.29)	11	7	2	78	M(3.90)	H	1.37	20	8.93
Criterion 2 (0.95)	12	5	3	78	M(3.90)	H	1.52	20	3.70
Criterion 6 (0.80)	9	6	4	67	M(3.53)	H	1.61	19	2.82
Criterion 4 (1.06)	8	9	3	70	M(3.50)	M	1.43	20	3.71
Criterion 3 (0.26)	3	9	8	50	M(2.50)	M	1.43	20	0.65

Need scores by criteria

This table shows the distribution of scores (H, M, L) across the needs for each of the six criteria. The number in each cell of the matrix indicates the number of participants who placed the criteria at that position on the list.

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	**n**
1.Criterion 2								
Need to determine preferred flow zones in the aquifer for characterization at the regional and sub-regional scale	13	5	2	82	H(4.10)	H	1.37	20
Need measurement technique to monitor ambient water travel time through VZ to SRPA at selected facilities.	12	5	3	78	M(3.90)	H	1.52	20
Need to evaluate timing and duration of leachate flux under current and historic conditions.	12	5	3	78	M(3.90)	H	1.52	20

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need to investigate perched water zones for source of water and perching mechanisms, source of contaminants, connectivity between perched zones, and water volume.	10	8	2	76	M(3.80)	H	1.36	20
Need development of methods to better characterize fracturing and detect preferred pathways in the basalt for the vadose zone.	11	6	3	76	M(3.80)	H	1.51	20
Need to better define the porosity and permeability in selected areas.	10	7	3	74	M(3.70)	H	1.49	20
Need source term characterization of the SDA Rocky Flats Plant wastes	11	5	4	74	M(3.70)	H	1.63	20
Need to develop better tracer tests to track flow through the interbeds in selected areas.	8	9	2	69	M(3.63)	M	1.34	19
Need deep core holes to verify geo and biophysical studies.	8	9	3	70	M(3.50)	M	1.43	20
Need methods for delineation of flow direction in aquifer at a facility scale.	10	5	5	70	M(3.50)	H	1.70	20
Need analyze existing data and collect temp logs on all aquifer and vadose zone wells to evaluate flow regimes.	9	6	5	68	M(3.40)	H	1.67	20
Need to perform vertical profiling of contaminant plume geometry to determine layering effects (e.g. Cr6 from TRA).	9	6	5	68	M(3.40)	H	1.67	20
Need to develop a better understanding of vapor transport.	8	6	6	64	M(3.20)	H	1.70	20
Need to define the accuracy and reliability in field instrumentation measurements.	6	6	7	55	M(2.89)	L	1.70	19
Need a fingerprint contaminant source detection for perched water contaminants at INTEC.	4	9	7	54	M(2.70)	M	1.49	20
Need to evaluate dispersivity at selected facilities.	3	10	7	52	M(2.60)	M	1.39	20
Need better understanding of Sources of nitrates and other contaminants in the aquifer at CFA.	3	4	12	39	M(2.05)	L	1.54	19
2.Criterion 3								
Need to define the accuracy and reliability in field instrumentation measurements.	11	5	3	73	M(3.84)	H	1.54	19
Need measurement technique to monitor ambient water travel time through VZ to SRPA at selected facilities.	10	4	6	68	M(3.40)	H	1.79	20
Need development of methods to better characterize fracturing and detect preferred pathways in the basalt for the vadose zone.	8	5	7	62	M(3.10)	H	1.77	20
Need to develop better tracer tests to track flow through the interbeds in selected areas.	5	9	5	57	M(3.00)	M	1.49	19
Need to develop a better understanding of vapor transport.	5	9	6	58	M(2.90)	M	1.52	20
Need deep core holes to verify geo and biophysical studies.	3	9	8	50	M(2.50)	M	1.43	20
Need to evaluate timing and duration of leachate flux under current and historic conditions.	3	9	8	50	M(2.50)	M	1.43	20
Need methods for delineation of flow direction in aquifer at a facility scale.	4	7	9	50	M(2.50)	L	1.57	20

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need to determine preferred flow zones in the aquifer for characterization at the regional and sub-regional scale	4	6	10	48	M(2.40)	L	1.60	20
Need analyze existing data and collect temp logs on all aquifer and vadose zone wells to evaluate flow regimes.	3	7	10	46	M(2.30)	L	1.49	20
Need to better define the porosity and permeability in selected areas.	5	2	13	44	M(2.20)	L	1.77	20
Need to evaluate dispersivity at selected facilities.	1	8	11	40	M(2.00)	L	1.21	20
Need a fingerprint contaminant source detection for perched water contaminants at INTEC.	4	2	14	40	M(2.00)	L	1.65	20
Need to investigate perched water zones for source of water and perching mechanisms, source of contaminants, connectivity between perched zones, and water volume.	1	7	12	38	L(1.90)	L	1.21	20
Need to perform vertical profiling of contaminant plume geometry to determine layering effects (e.g. Cr6 from TRA).	2	4	14	36	L(1.80)	L	1.36	20
Need source term characterization of the SDA Rocky Flats Plant wastes	2	2	16	32	L(1.60)	L	1.31	20
Need better understanding of sources of nitrates and other contaminants in the aquafer at CFA.	1	2	16	27	L(1.42)	L	1.07	19
3.Criterion 4								
Need analyze existing data and collect temp logs on all aquifer and vadose zone wells to evaluate flow regimes.	14	2	4	80	H(4.00)	H	1.65	20
Need to develop better tracer tests to track flow through the interbeds in selected areas.	9	9	1	73	M(3.84)	??	1.21	19
Need to determine preferred flow zones in the aquifer for characterization at the regional and sub-regional scale	11	6	3	76	M(3.80)	H	1.51	20
Need to better define the porosity and permeability in selected areas.	10	7	3	74	M(3.70)	H	1.49	20
Need to investigate perched water zones for source of water and perching mechanisms, source of contaminants, connectivity between perched zones, and water volume.	7	12	1	72	M(3.60)	M	1.14	20
Need methods for delineation of flow direction in aquifer at a facility scale.	7	11	2	70	M(3.50)	M	1.28	20
Need to evaluate timing and duration of leachate flux under current and historic conditions.	8	9	3	70	M(3.50)	M	1.43	20
Need to define the accuracy and reliability in field instrumentation measurements.	8	7	4	65	M(3.42)	H	1.57	19
Need measurement technique to monitor ambient water travel time through VZ to SRPA at selected facilities.	7	10	3	68	M(3.40)	M	1.39	20
Need to develop a better understanding of vapor transport.	8	8	4	68	M(3.40)	??	1.54	20
Need deep core holes to verify geo and biophysical studies.	9	5	6	66	M(3.30)	H	1.75	20
Need to perform vertical profiling of contaminant plume geometry to determine layering effects (e.g. Cr6 from TRA).	8	5	7	62	M(3.10)	H	1.77	20
Need a fingerprint contaminant source detection for perched water contaminants at INTEC.	4	10	6	56	M(2.80)	M	1.44	20

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need source term characterization of the SDA Rocky Flats Plant wastes	4	10	6	56	M(2.80)	M	1.44	20
Need development of methods to better characterize fracturing and detect preferred pathways in the basalt for the vadose zone.	2	11	7	50	M(2.50)	M	1.28	20
Need to evaluate dispersivity at selected facilities.	2	11	7	50	M(2.50)	M	1.28	20
Need better understanding of Sources of nitrates and other contaminants in the aquifer at CFA.	1	11	7	45	M(2.37)	M	1.16	19
4.Criterion 5								
Need source term characterization of the SDA Rocky Flats Plant wastes	15	2	3	84	H(4.20)	H	1.51	20
Need measurement technique to monitor ambient water travel time through VZ to SRPA at selected facilities.	12	6	2	80	H(4.00)	H	1.38	20
Need to develop better tracer tests to track flow through the interbeds in selected areas.	10	8	1	75	M(3.95)	H	1.22	19
Need to evaluate timing and duration of leachate flux under current and historic conditions.	11	7	2	78	M(3.90)	H	1.37	20
Need to better define the porosity and permeability in selected areas.	12	5	3	78	M(3.90)	H	1.52	20
Need development of methods to better characterize fracturing and detect preferred pathways in the basalt for the vadose zone.	14	1	5	78	M(3.90)	H	1.77	20
Need to investigate perched water zones for source of water and perching mechanisms, source of contaminants, connectivity between perched zones, and water volume.	10	7	3	74	M(3.70)	H	1.49	20
Need to develop a better understanding of vapor transport.	11	5	4	74	M(3.70)	H	1.63	20
Need to determine preferred flow zones in the aquifer for Characterization at the regional and sub-regional scale	12	2	6	72	M(3.60)	H	1.85	20
Need a fingerprint contaminant source detection for perched water contaminants at INTEC.	7	9	4	66	M(3.30)	M	1.49	20
Need to define the accuracy and reliability in field instrumentation measurements.	8	5	6	61	M(3.21)	H	1.75	19
Need to perform vertical profiling of contaminant plume geometry to determine layering effects (e.g. Cr6 from TRA).	6	9	5	62	M(3.10)	M	1.52	20
Need methods for delineation of flow direction in aquifer at a facility scale.	8	5	7	62	M(3.10)	H	1.77	20
Need deep core holes to verify geo and biophysical studies.	6	7	7	58	M(2.90)	??	1.65	20
Need to evaluate dispersivity at selected facilities.	6	7	7	58	M(2.90)	??	1.65	20
Need analyze existing data and collect temp logs on all aquifer and vadose zone wells to evaluate flow regimes.	6	4	10	52	M(2.60)	L	1.79	20
Need better understanding of Sources of nitrates and other contaminants in the aquifer at CFA.	5	4	10	47	M(2.47)	L	1.74	19
5.Criterion 6								

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need to evaluate timing and duration of leachate flux under current and historic conditions.	9	6	4	67	M(3.53)	H	1.61	19
Need source term characterization of the SDA Rocky Flats Plant wastes	9	4	6	63	M(3.32)	H	1.80	19
Need to investigate perched water zones for source of water and perching mechanisms, source of contaminants, connectivity between perched zones, and water volume.	5	9	5	57	M(3.00)	M	1.49	19
Need measurement technique to monitor ambient water travel time through VZ to SRPA at selected facilities.	5	9	5	57	M(3.00)	M	1.49	19
Need development of methods to better characterize fracturing and detect preferred pathways in the basalt for the vadose zone.	3	12	4	55	M(2.89)	M	1.24	19
Need to develop a better understanding of vapor transport.	5	8	6	55	M(2.89)	M	1.56	19
Need to develop better tracer tests to track flow through the interbeds in selected areas.	3	11	5	53	M(2.79)	M	1.32	19
Need a fingerprint contaminant source detection for perched water contaminants at INTEC.	6	5	8	53	M(2.79)	L	1.75	19
Need methods for delineation of flow direction in aquifer at a facility scale.	5	6	8	51	M(2.68)	L	1.67	19
Need to perform vertical profiling of contaminant plume geometry to determine layering effects (e.g. Cr6 from TRA).	6	4	9	51	M(2.68)	L	1.80	19
Need to determine preferred flow zones in the aquifer for characterization at the regional and sub-regional scale	3	7	9	45	M(2.37)	L	1.50	19
Need to better define the porosity and permeability in selected areas.	3	7	9	45	M(2.37)	L	1.50	19
Need analyze existing data and collect temp logs on all aquifer and vadose zone wells to evaluate flow regimes.	3	7	9	45	M(2.37)	L	1.50	19
Need to define the accuracy and reliability in field instrumentation measurements.	3	6	10	43	M(2.26)	L	1.52	19
Need to evaluate dispersivity at selected facilities.	3	5	11	41	M(2.16)	L	1.54	19
Need deep core holes to verify geo and biophysical studies.		5	14	29	L(1.53)	L	0.90	19
Need better understanding of sources of nitrates and other contaminants in the aquifer at CFA.		4	15	27	L(1.42)	L	0.84	19

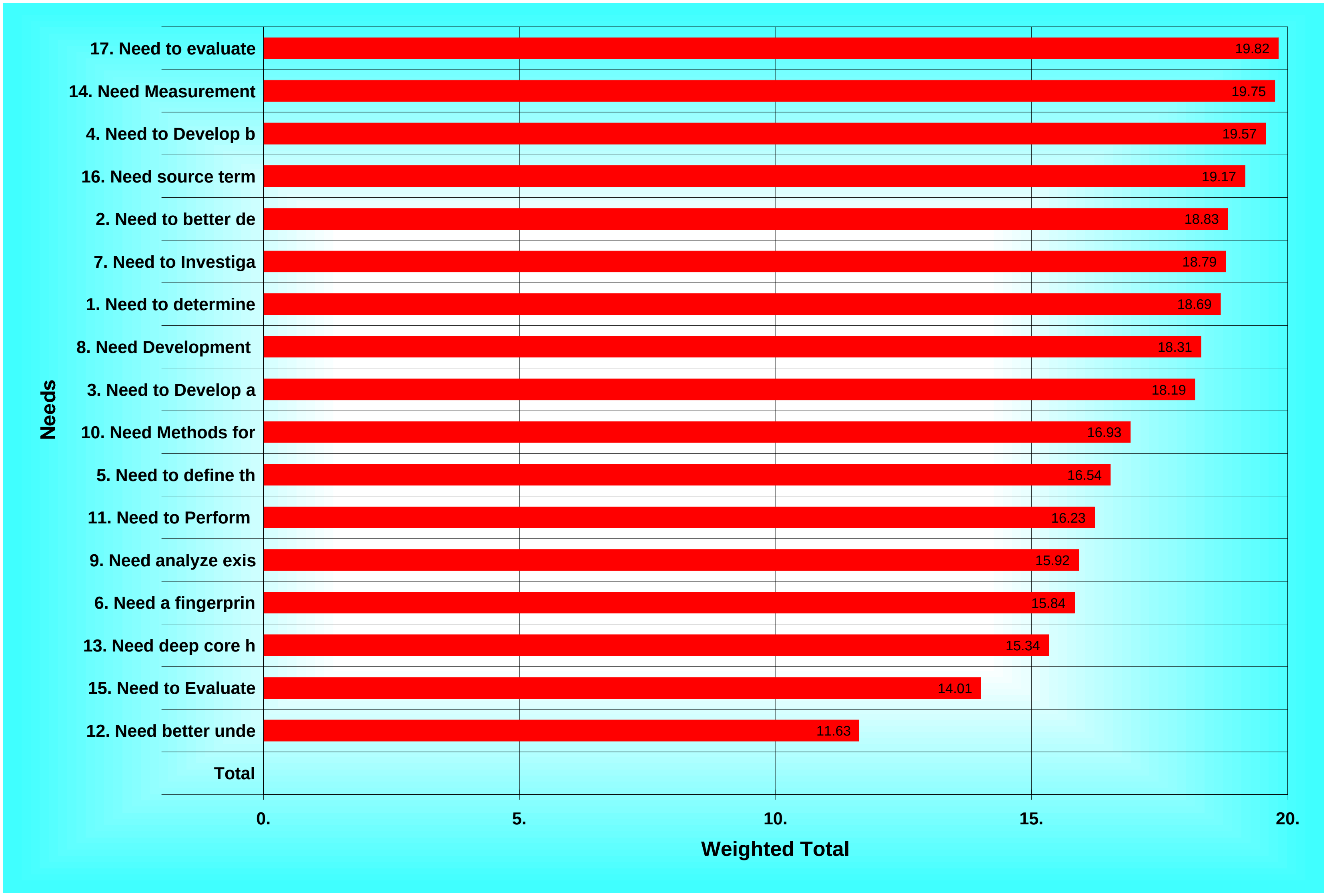

Figure 1. Weighted total scores of characterization needs without criterion 1.

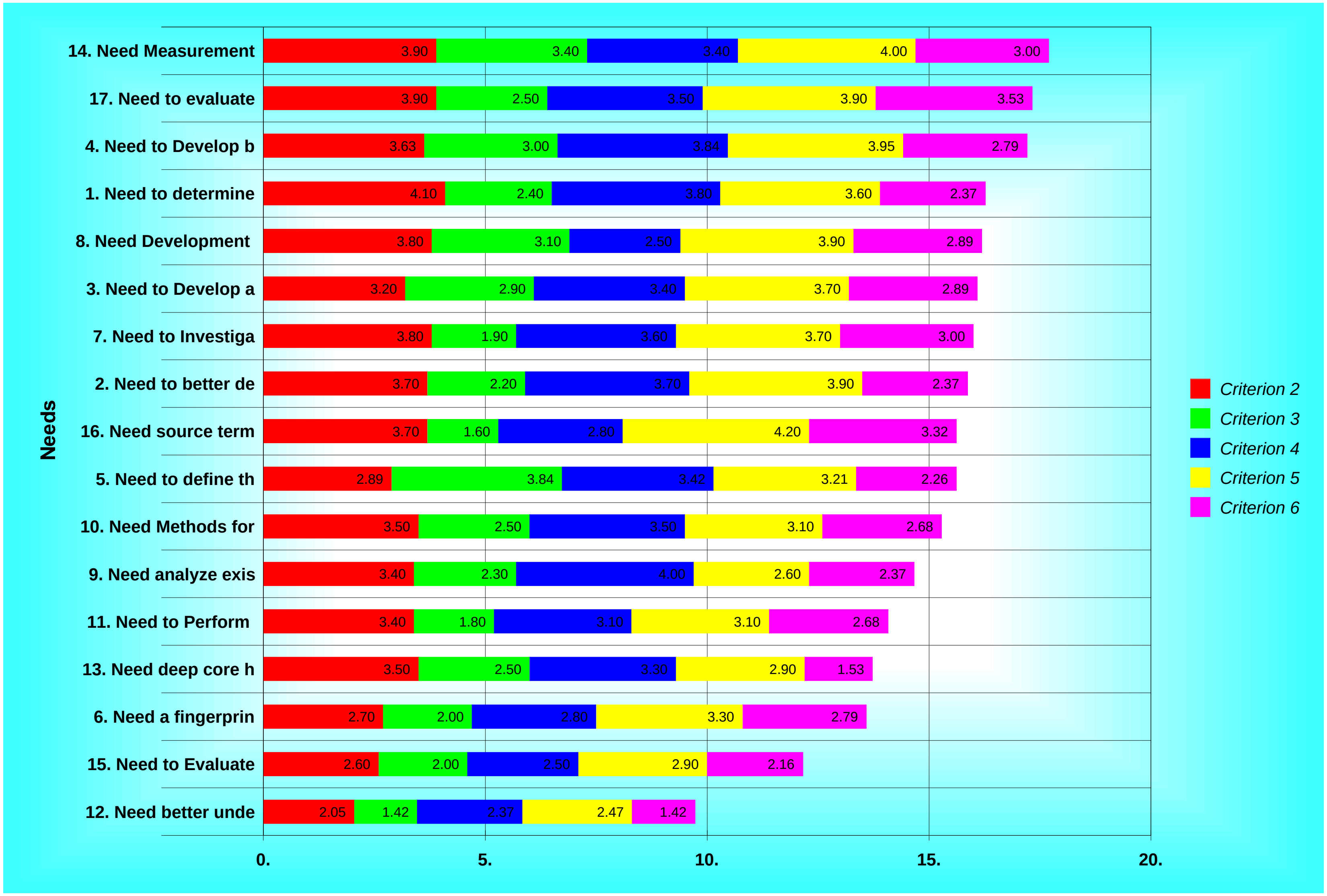

Figure 2. Unweighted criteria scores of characterization needs without criterion 1.

Monitoring Needs Group

Discussion and comments on the monitoring needs

1. Need to improve the use of 3D Tomography/other cross-hole geophysics for selected facilities to show changes in moisture.
   - Much is already being done in this regard. Careful review of ongoing work should be done before developing new research projects that may be duplicative. {#18}
   - In the near field (tens of feet), cross-hole tomographic methods can provide a better understanding of the complexities of vadose-zone flow in the layered basalt stratigraphy. {#19}
   - Potentially this will provide a big payoff in gain of needed information, at low-to-moderate cost. {#37}

2. Need a development and testing of the in situ geochemical probe to measure EH, Ph and ORP, selected ions in vadose zone studies.
   - EH and ORP are redundant. {#20}
   - Selected ions can mean the site specific COC {#45}
   - Need to identify which contaminants would be most suited to this approach and the presence of these contaminants at the site. {#49}

3. Need to investigate the correlation of between well construction and sampling results.

I don't have a clue what this means. {#22}

   - Correlation between accuracy or precision or what? {#31}
   - Echo #22. Suggest that start with a review of studies that have already been done to determine if there are problem areas that require further study. {#60}
   - Well construction can significantly affect sampling results, particularly when those results are near detection limits. Well construction also should include issues related to micropurge, pumping and sampling systems. {#67}
   - Wells at the site do not all have the same construction/completion. Yet we use sample/monitoring results from the wells as if there is no effect of well construction/completion. Is that true? I doubt it. For example, you are getting quite different water levels from an open hole then a well completed as an isobaric well. {#69}
   - Does this mean well construction (filter pack, screen type, casing type), screened interval, or how the well is sampled. Currently we don't understand how well completion impacts the characteristics(i.e. chemistry, productivity etc.) we assign to the water in that well {#72}

4. Need to investigate the correlation of between sampling method (such as ceramic lysimeter cup) and sampling results.
   - Need Development of tensiometer type porous sampling cup.{#12}
   - Correlation as to precision, accuracy - what aspect? {#29}
   - The key concept would seem to be bias of the method, e.g. does sampling through a porous cup reduce the proportion of organics relative to inorganic salts, while other methods might sample both more equally. {#57}

5. Need to develop tools for micropurge sampling for deep depths (>200 ft.).
   - Tools include pump controllers that will allow pumping rates down to 1 L/min. {#23}
   - There is a current ASTM Standard that addresses these issues. Micropurge is not a good representation of the process. Low-flow is better; however, with large flow velocities present in the SRPA, if the withdrawal is significantly lower than aquifer flow velocities, turbulence can actually be created in the borehole. {#25}

- The advantages of micropurge are related to the challenge of obtaining depth-representative samples and to reducing or eliminating the volume of purge water that must be disposed. {#38}
- This is essential for understanding the flow regime of the aquifer. Existing studies suggest that the aquifer is really a layered sequence of confined and semi-confined aquifers and this is a way to further investigate that concept. {#61}

6. Need to develop bettor in situ sensors for chlorinated VOCs of the distal portion of the TAN TCE plume.
   - I assume this is to really monitor the natural attenuation, if so, then surrogate measurements would also be appropriate {#52}
   - Would be helpful to better understand what are the shortfalls of current sensors to better define what needs to be done here. {#68}
   - Agree w/ 68. What's wrong with current technology? {#75}
7. Need to develop better methods for correction factors of measurement of water levels in a flat gradient environment.
   - Define "flat gradient" {#27}
   - I feel that current methods and correction factors are much more precise that the tools that use the data. What is truly needed are better methods of interpreting the data. {#28}
   - Corrections are attributed in part to well construction (completion), hole deviation, barometric pressure, as well as instrument corrections such as tape stretch, temperature, etc. {#30}
   - Regarding comment 27, the errors introduced by factors requiring correction are of similar magnitude to differences in water-level altitude and make resolution of flow direction very difficult. {#34}
   - This is a major problem with current approaches to measuring the elevation of the water table in highly transmissive aquifers and especially when the well depths begin to exceed depths of probably 100 feet. More work is needed on this fundamental problem so that we can better understand the direction ground water is flowing at sites.. {#59}
8. Need to evaluate long term (>100 years) metallurgical problems associated with using carbon and stainless steal casing.
   - VE study for materials of construction selection for future wells. Determination of replacement times for existing wells {#33}
   - Should be "metallurgical" {#36}
   - Should also include investigation and testing of non-metallic casings to increase longevity and for facilitation of periodic geophysical logging to obtain fluid and rock property data. {#41}
   - Need to find out what the oil and gas industry is currently doing in this area. {#63}
   - Should this be a subset of #3? {#65}
   - Structural and chemical compatibility must be considered too. {#71}
   - Echo comment #33 {#76}
9. Need to develop a sensitive real time bore hole sensor analysis for contaminant monitoring of COCs.
   - Need long term inplacement of sensors for monitoring of contaminants of concern. {#39}
   - Sensor emplacement in both the vadose zone and aquifer {#48}
   - Sensors to determine flow should also be included. {#50}
   - Pretty broad - lends to impractical vote {#51}
   - Real-time data that could be transmitted to a web site for analysis {#54}
   - The sensitivity required would need to be at ~1/5 the MCL or risk-based concentration {#55}
   - May be impractical given the large list of COCs {#58}
   - Regarding #55 why would the sensitivity need to be this low? {#78}

10. Need to develop techniques for physical and chemical long-term transient monitoring in the individual fracture .

- "transient"? {#43}
- Should state: long-term monitoring of transient events in an individual fracture {#47}
- For clarity (?), current efforts at characterizing flow in fractures (field in-situ) utilize equivalent porous media concepts. Different instruments and approaches are needed in individual fractures. Assuming water-bearing fractures can be identified (they are at TW1-DL04 in the SDA. For example, the concept of moisture content is likely irrelevant in a fracture. Rather, water film thickness may be more appropriate. {#56}
- "Transient" is not really necessary to specify. The point is obviously to get a record of physical and chemical conditions as a function of time. {#66}
- Important need. Maybe difficult, but necessary because the behavior of a small number of individual fractures dominates the flow system in many circumstances at the INEEL. {#79}

11. Need to develop a real time (or near real time), web based information on monitoring data for the public because of the episodic nature of the vadose zone.

- Impractical - validation considerations {#44}
- The cost of operating such a database may reduce the ability to perform the necessary monitoring {#46}
- Disagree with #44, yes it is a problem to overcome, and could be addressed through the "near" real time. The value of providing the public/researchers with real time data can outweigh the problems with validation. {#62}
- Need to consider data quality (validation) before release to the public. {#64}
- Agree w/ 64 {#70}
- Other agencies, such as USGS, have dealt with the problem of quality before rapid release, and have some solutions. {#73}
- For real-time data available to the public, we simply put a caveat on the database with flags identifying whether data has been quality checked. This will allow for explanation and reduce the amount of unnecessary responses to questions from the public. My experience is that the public just wants to know what is going on - that answer that we still need to validate the data is acceptable to most stakeholders. {#74}
- Although a large number of the public would request this, only a small percentage are likely to access it. {#77}
- #74 easy to say, but the public will still use it improperly! {#80}
- Any data we release to the public will be used against us--regardless of how it's caveated. {#81}
- Will help show honesty to the stakeholders and public. {#82}
- Most of public will say they want the data to be posted this way, but probably only a small percentage will really access it. {#83}

Unclear need, more information is needed for clarity

1. Need long term improvements in down hole (VZ & GW) monitoring.
2. Need development of tools and methods for gross quantification of organics.
3. Need to develop innovative methods for RCRA monitoring.

Needs that were addressed in the characterization group

1. Need a better designed tracer studies to study transport through the vadose zone.
2. Need to develop a better understanding of soil gas monitoring in vicinity of WAG 7.

Based on discussion was included as a note in the vapor transport needs in characterization. {#26}

A coordination issue, but not an R&D need

1. Need to coordinate Site-wide GW monitoring and USGS monitoring such that GW monitoring to obtain water level measurements for all wells at the same relative time.

Monitoring needs rated against the criteria

This table shows the average scores for each of the criteria within a need. The color of the cell indicates the level of consensus of the scores within that cell. A green cell indicates a high level of consensus and a red cell indicates a low level of consensus. The blue cells were not rated by the participants during the meeting.

A consensus threshold value was set to help focus the group on those cells that had the most disagreement in the scores in the limited time available for discussion. It was not intended to imply that the group was in agreement on the score in that cell. The threshold level for consensus was set at 0.50. Typically, the threshold is set at 0.6 for discussion. The lower than normal threshold is indicative of the different perspectives of the participants.

Needs	Criterion						Total	Mean	STD	Weighted Total
	1	2	3	4	5	6				
Weight	0.65	0.95	0.26	1.06	2.29	0.80				
1.Need to Improve the use of 3D tomography/other cross-hole geophysics for selected facilities to show changes in moisture.		M(3.00)	H(4.10)	M(3.10)	M(3.00)	L(1.95)	15.15	M(3.03)	0.76	15.63
2.Need a development and testing of the in situ geochemical probe to measure EH, Ph and ORP, selected ions in vadose zone studies.		M(3.80)	H(4.70)	H(4.30)	M(3.70)	M(2.79)	19.29	M(3.86)	0.72	20.09
3.Need to investigate the correlation of between well construction and sampling results.		M(2.80)	H(4.10)	M(3.90)	M(2.60)	L(1.84)	15.24	M(3.05)	0.94	15.29
4.Need to investigate the correlation of between sampling method (such as ceramic lysimeter cup) and sampling results.		M(3.50)	H(4.00)	H(4.00)	M(3.00)	M(2.47)	16.97	M(3.39)	0.66	17.45
5.Need to develop tools for micropurge sampling for deep depths (>200 ft.).		H(4.20)	H(4.50)	H(4.20)	M(3.30)	M(2.68)	18.88	M(3.78)	0.76	19.32
6.Need to develop bettor in situ sensors for chlorinated VOCs of the distal portion of the TAN TCE plume.		M(3.30)	H(4.00)	M(3.00)	M(3.50)	M(2.47)	16.27	M(3.25)	0.57	17.35
7.Need to develop better methods for correction factors of measurement of water levels in a flat gradient environment.		M(3.40)	M(3.60)	M(3.80)	M(2.50)	M(2.26)	15.56	M(3.11)	0.69	15.73
8.Need to evaluate long term (>100 years) metallurgical problems associated with using carbon and stainless steal casing.		M(2.90)	M(3.80)	M(3.60)	M(2.10)	L(1.84)	14.24	M(2.85)	0.87	13.84
9.Need to develop a sensitive real time bore hole sensor analysis for contaminant monitoring of COCs		M(3.10)	H(4.30)	M(3.20)	M(3.90)	M(3.00)	17.50	M(3.50)	0.57	18.79

Needs	Criterion						Total	Mean	STD	Weighted Total
	1	2	3	4	5	6				
contaminant monitoring of COCs.										
10.Need to develop techniques for physical and chemical long-term transient monitoring in the individual fracture .		M(3.20)	M(3.60)	M(2.50)	M(3.70)	M(2.26)	15.26	M(3.05)	0.65	16.91
11.Need to develop a real time (or near real time), web based information on monitoring data for the public because of the episodic nature of the vadose zone.		M(2.30)	M(3.40)	M(3.20)	M(2.40)	L(1.95)	13.25	M(2.65)	0.62	13.51

Criteria scores by need

This table shows the distribution of scores (H, M, L) across the six criteria for each of the needs. The number within a criteria/score cell indicates the number of participants that used that score for that criteria. Within a need, the criteria are sorted from the highest to the lowest mean score.

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
1.Need to Improve the use of 3D tomography/other cross-hole geophysics for selected facilities to show changes in moisture.									
Criterion 3 (0.26)	14	3	3	82	H(4.10)	H	1.52	20	1.07
Criterion 4 (1.06)	8	5	7	62	M(3.10)	H	1.77	20	3.29
Criterion 5 (2.29)	7	6	7	60	M(3.00)	??	1.72	20	6.87
Criterion 2 (0.95)	8	4	8	60	M(3.00)	??	1.84	20	2.85
Criterion 6 (0.80)	2	5	12	37	L(1.95)	L	1.39	19	1.56
Criterion 1 (0.65)								0	
2.Need a development and testing of the in situ geochemical probe to measure EH, Ph and ORP, selected ions in vadose zone studies.									
Criterion 3 (0.26)	17	3		94	H(4.70)	H	0.73	20	1.22
Criterion 4 (1.06)	13	7		86	H(4.30)	H	0.98	20	4.56
Criterion 2 (0.95)	10	8	2	76	M(3.80)	H	1.36	20	3.61
Criterion 5 (2.29)	11	5	4	74	M(3.70)	H	1.63	20	8.47
Criterion 6 (0.80)	6	5	8	53	M(2.79)	L	1.75	19	2.23

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 1 (0.65)								0	
3.Need to investigate the correlation of between well construction and sampling results.									
Criterion 3 (0.26)	14	3	3	82	H(4.10)	H	1.52	20	1.07
Criterion 4 (1.06)	12	5	3	78	M(3.90)	H	1.52	20	4.13
Criterion 2 (0.95)	5	8	7	56	M(2.80)	M	1.58	20	2.66
Criterion 5 (2.29)	5	6	9	52	M(2.60)	L	1.67	20	5.95
Criterion 6 (0.80)	2	4	13	35	L(1.84)	L	1.38	19	1.47
Criterion 1 (0.65)								0	
4.Need to investigate the correlation of between sampling method (such as ceramic lysimeter cup) and sampling results.									
Criterion 4 (1.06)	11	8	1	80	H(4.00)	H	1.21	20	4.24
Criterion 3 (0.26)	12	6	2	80	H(4.00)	H	1.38	20	1.04
Criterion 2 (0.95)	10	5	5	70	M(3.50)	H	1.70	20	3.32
Criterion 5 (2.29)	8	4	8	60	M(3.00)	??	1.84	20	6.87
Criterion 6 (0.80)	4	6	9	47	M(2.47)	L	1.61	19	1.98
Criterion 1 (0.65)								0	
5.Need to develop tools for micropurge sampling for deep depths (>200 ft.).									
Criterion 3 (0.26)	16	3	1	90	H(4.50)	H	1.10	20	1.17
Criterion 4 (1.06)	12	8		84	H(4.20)	H	1.01	20	4.45
Criterion 2 (0.95)	13	6	1	84	H(4.20)	H	1.20	20	3.99
Criterion 5 (2.29)	9	5	6	66	M(3.30)	H	1.75	20	7.56
Criterion 6 (0.80)	5	6	8	51	M(2.68)	L	1.67	19	2.15
Criterion 1 (0.65)								0	
6.Need to develop bettor in situ sensors for chlorinated VOCs of the distal portion of the TAN TCE plume.									
Criterion 3 (0.26)	13	4	3	80	H(4.00)	H	1.52	20	1.04
Criterion 5 (2.29)	10	5	5	70	M(3.50)	H	1.70	20	8.01

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 2 (0.95)	10	3	7	66	M(3.30)	H	1.87	20	3.13
Criterion 4 (1.06)	5	10	5	60	M(3.00)	M	1.45	20	3.18
Criterion 6 (0.80)	3	8	8	47	M(2.47)	??	1.47	19	1.98
Criterion 1 (0.65)								0	
7.Need to develop better methods for correction factors of measurement of water levels in a flat gradient environment.									
Criterion 4 (1.06)	12	4	4	76	M(3.80)	H	1.64	20	4.03
Criterion 3 (0.26)	12	2	6	72	M(3.60)	H	1.85	20	0.94
Criterion 2 (0.95)	10	4	6	68	M(3.40)	H	1.79	20	3.23
Criterion 5 (2.29)	4	7	9	50	M(2.50)	L	1.57	20	5.72
Criterion 6 (0.80)	2	8	9	43	M(2.26)	L	1.37	19	1.81
Criterion 1 (0.65)								0	
8.Need to evaluate long term (>100 years) metalological problems associated with using carbon and stainless steal casing.									
Criterion 3 (0.26)	12	4	4	76	M(3.80)	H	1.64	20	0.99
Criterion 4 (1.06)	10	6	4	72	M(3.60)	H	1.60	20	3.82
Criterion 2 (0.95)	5	9	6	58	M(2.90)	M	1.52	20	2.75
Criterion 5 (2.29)	4	3	13	42	M(2.10)	L	1.65	20	4.81
Criterion 6 (0.80)	3	2	14	35	L(1.84)	L	1.54	19	1.47
Criterion 1 (0.65)								0	
9.Need to develop a sensitive real time bore hole sensor analysis for contaminant monitoring of COCs.									
Criterion 3 (0.26)	13	7		86	H(4.30)	H	0.98	20	1.12
Criterion 5 (2.29)	11	7	2	78	M(3.90)	H	1.37	20	8.93
Criterion 4 (1.06)	8	6	6	64	M(3.20)	H	1.70	20	3.39
Criterion 2 (0.95)	7	7	6	62	M(3.10)	??	1.65	20	2.94
Criterion 6 (0.80)	7	5	7	57	M(3.00)	??	1.76	19	2.40
Criterion 1 (0.65)								0	

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
10.Need to develop techniques for physical and chemical long-term transient monitoring in the individual fracture .									
Criterion 5 (2.29)	12	3	5	74	M(3.70)	H	1.75	20	8.47
Criterion 3 (0.26)	11	4	5	72	M(3.60)	H	1.73	20	0.94
Criterion 2 (0.95)	8	6	6	64	M(3.20)	H	1.70	20	3.04
Criterion 4 (1.06)	3	9	8	50	M(2.50)	M	1.43	20	2.65
Criterion 6 (0.80)	4	4	11	43	M(2.26)	L	1.66	19	1.81
Criterion 1 (0.65)								0	
11.Need to develop a real time (or near real time), web based information on monitoring data for the public because of the episodic nature of the vadose zone.									
Criterion 3 (0.26)	9	6	5	68	M(3.40)	H	1.67	20	0.88
Criterion 4 (1.06)	8	6	6	64	M(3.20)	H	1.70	20	3.39
Criterion 5 (2.29)	3	8	9	48	M(2.40)	L	1.47	20	5.50
Criterion 2 (0.95)	5	3	12	46	M(2.30)	L	1.75	20	2.18
Criterion 6 (0.80)	3	3	13	37	L(1.95)	L	1.54	19	1.56
Criterion 1 (0.65)								0	

Need scores by criteria

This table shows the distribution of scores (H, M, L) across the needs for each of the six criteria. The number in each cell of the matrix indicates the number of participants who placed the criteria at that position on the list.

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
2.Criterion 2								
Need to develop tools for micropurge sampling for deep depths (>200 ft.).	13	6	1	84	H(4.20)	H	1.20	20
Need a development and testing of the in situ geochemical probe to measure EH, Ph and ORP, selected ions in vadose zone studies.	10	8	2	76	M(3.80)	H	1.36	20
Need to Investigate the correlation of between sampling method (such as ceramic lysimeter cup) and sampling results.	10	5	5	70	M(3.50)	H	1.70	20

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need to develop better methods for correction factors of measurement of water levels in a flat gradient environment.	10	4	6	68	M(3.40)	H	1.79	20
Need to develop bettor in situ sensors for chlorinated VOCs of the distal portion of the TAN TCE plume.	10	3	7	66	M(3.30)	H	1.87	20
Need to develop techniques for physical and chemical long-term transient monitoring in the individual fracture .	8	6	6	64	M(3.20)	H	1.70	20
Need to develop a sensitive real time bore hole sensor analysis for contaminant monitoring of COCs.	7	7	6	62	M(3.10)	??	1.65	20
Need to Improve the use of 3D Tomography/other cross-hole geophysics for selected facilities to show changes in moisture.	8	4	8	60	M(3.00)	??	1.84	20
Need to evaluate long term (>100 years) metallurgical problems associated with using carbon and stainless steal casing.	5	9	6	58	M(2.90)	M	1.52	20
Need to Investigate the correlation of between well construction and sampling results.	5	8	7	56	M(2.80)	M	1.58	20
Need to develop a real time (or near real time), web based information on monitoring data for the public because of the episodic nature of the vadose zone.	5	3	12	46	M(2.30)	L	1.75	20
3.Criterion 3								
Need a development and testing of the in situ geochemical probe to measure EH, Ph and ORP, selected ions in vadose zone studies.	17	3		94	H(4.70)	H	0.73	20
Need to develop tools for micropurge sampling for deep depths (>200 ft.).	16	3	1	90	H(4.50)	H	1.10	20
Need to develop a sensitive real time bore hole sensor analysis for contaminant monitoring of COCs.	13	7		86	H(4.30)	H	0.98	20
Need to Improve the use of 3D Tomography/other cross-hole geophysics for selected facilities to show changes in moisture.	14	3	3	82	H(4.10)	H	1.52	20
Need to investigate the correlation of between well construction and sampling results.	14	3	3	82	H(4.10)	H	1.52	20
Need to investigate the correlation of between sampling method (such as ceramic lysimeter cup) and sampling results.	12	6	2	80	H(4.00)	H	1.38	20
Need to develop bettor in situ sensors for chlorinated VOCs of the distal portion of the TAN TCE plume.	13	4	3	80	H(4.00)	H	1.52	20
Need to evaluate long term (>100 years) metallurgical problems associated with using carbon and stainless steal casing.	12	4	4	76	M(3.80)	H	1.64	20
Need to develop techniques for physical and chemical long-term transient monitoring in the individual fracture .	11	4	5	72	M(3.60)	H	1.73	20
Need to develop better methods for correction factors of measurement of water levels in a flat gradient environment.	12	2	6	72	M(3.60)	H	1.85	20
Need to develop a real time (or near real time), web based information on monitoring data for the public because of the episodic nature of the vadose zone.	9	6	5	68	M(3.40)	H	1.67	20

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
4.Criterion 4								
Need a development and testing of the in situ geochemical probe to measure EH, Ph and ORP, selected ions in vadose zone studies.	13	7		86	H(4.30)	H	0.98	20
Need to develop tools for micropurge sampling for deep depths (>200 ft.).	12	8		84	H(4.20)	H	1.01	20
Need to investigate the correlation of between sampling method (such as ceramic lysimeter cup) and sampling results.	11	8	1	80	H(4.00)	H	1.21	20
Need to Investigate the correlation of between well construction and sampling results.	12	5	3	78	M(3.90)	H	1.52	20
Need to develop better methods for correction factors of measurement of water levels in a flat gradient environment.	12	4	4	76	M(3.80)	H	1.64	20
Need to evaluate long term (>100 years) metallurgical problems associated with using carbon and stainless steal casing.	10	6	4	72	M(3.60)	H	1.60	20
Need to develop a sensitive real time bore hole sensor analysis for contaminant monitoring of COCs.	8	6	6	64	M(3.20)	H	1.70	20
Need to develop a real time (or near real time), web based information on monitoring data for the public because of the episodic nature of the vadose zone.	8	6	6	64	M(3.20)	H	1.70	20
Need to improve the use of 3D tomography/other cross-hole geophysics for selected facilities to show changes in moisture.	8	5	7	62	M(3.10)	H	1.77	20
Need to develop bettor in situ sensors for chlorinated VOCs of the distal portion of the TAN TCE plume.	5	10	5	60	M(3.00)	M	1.45	20
Need to develop techniques for physical and chemical long-term transient monitoring in the individual fracture .	3	9	8	50	M(2.50)	M	1.43	20
5.Criterion 5								
Need to develop a sensitive real time bore hole sensor analysis for contaminant monitoring of COCs.	11	7	2	78	M(3.90)	H	1.37	20
Need a development and testing of the in situ geochemical probe to measure EH, Ph and ORP, selected ions in vadose zone studies.	11	5	4	74	M(3.70)	H	1.63	20
Need to develop techniques for physical and chemical long-term transient monitoring in the individual fracture .	12	3	5	74	M(3.70)	H	1.75	20
Need to develop bettor in situ sensors for chlorinated VOCs of the distal portion of the TAN TCE plume.	10	5	5	70	M(3.50)	H	1.70	20
Need to develop tools for micropurge sampling for deep depths (>200 ft.).	9	5	6	66	M(3.30)	H	1.75	20
Need to improve the use of 3D tomography/other cross-hole geophysics for selected facilities to show changes in moisture.	7	6	7	60	M(3.00)	??	1.72	20
Need to investigate the correlation of between sampling method (such as ceramic lysimeter cup) and sampling results.	8	4	8	60	M(3.00)	??	1.84	20

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need to investigate the correlation of between well construction and sampling results.	5	6	9	52	M(2.60)	L	1.67	20
Need to develop better methods for correction factors of measurement of water levels in a flat gradient environment.	4	7	9	50	M(2.50)	L	1.57	20
Need to develop a real time (or near real time), web based information on monitoring data for the public because of the episodic nature of the vadose zone.	3	8	9	48	M(2.40)	L	1.47	20
Need to evaluate long term (>100 years) metallurgical problems associated with using carbon and stainless steal casing.	4	3	13	42	M(2.10)	L	1.65	20
6.Criterion 6								
Need to develop a sensitive real time bore hole sensor analysis for contaminant monitoring of COCs.	7	5	7	57	M(3.00)	??	1.76	19
Need a development and testing of the in situ geochemical probe to measure EH, Ph and ORP, selected ions in vadose zone studies.	6	5	8	53	M(2.79)	L	1.75	19
Need to develop tools for micropurge sampling for deep depths (>200 ft.).	5	6	8	51	M(2.68)	L	1.67	19
Need to develop bettor in situ sensors for chlorinated VOCs of the distal portion of the TAN TCE plume.	3	8	8	47	M(2.47)	??	1.47	19
Need to investigate the correlation of between sampling method (such as ceramic lysimeter cup) and sampling results.	4	6	9	47	M(2.47)	L	1.61	19
Need to develop better methods for correction factors of measurement of water levels in a flat gradient environment.	2	8	9	43	M(2.26)	L	1.37	19
Need to develop techniques for physical and chemical long-term transient monitoring in the individual fracture .	4	4	11	43	M(2.26)	L	1.66	19
Need to improve the use of 3D Tomography/other cross-hole geophysics for selected facilities to show changes in moisture.	2	5	12	37	L(1.95)	L	1.39	19
Need to develop a real time (or near real time), web based information on monitoring data for the public because of the episodic nature of the vadose zone.	3	3	13	37	L(1.95)	L	1.54	19
Need to investigate the correlation of between well construction and sampling results.	2	4	13	35	L(1.84)	L	1.38	19
Need to evaluate long term (>100 years) metallurgical problems associated with using carbon and stainless steal casing.	3	2	14	35	L(1.84)	L	1.54	19

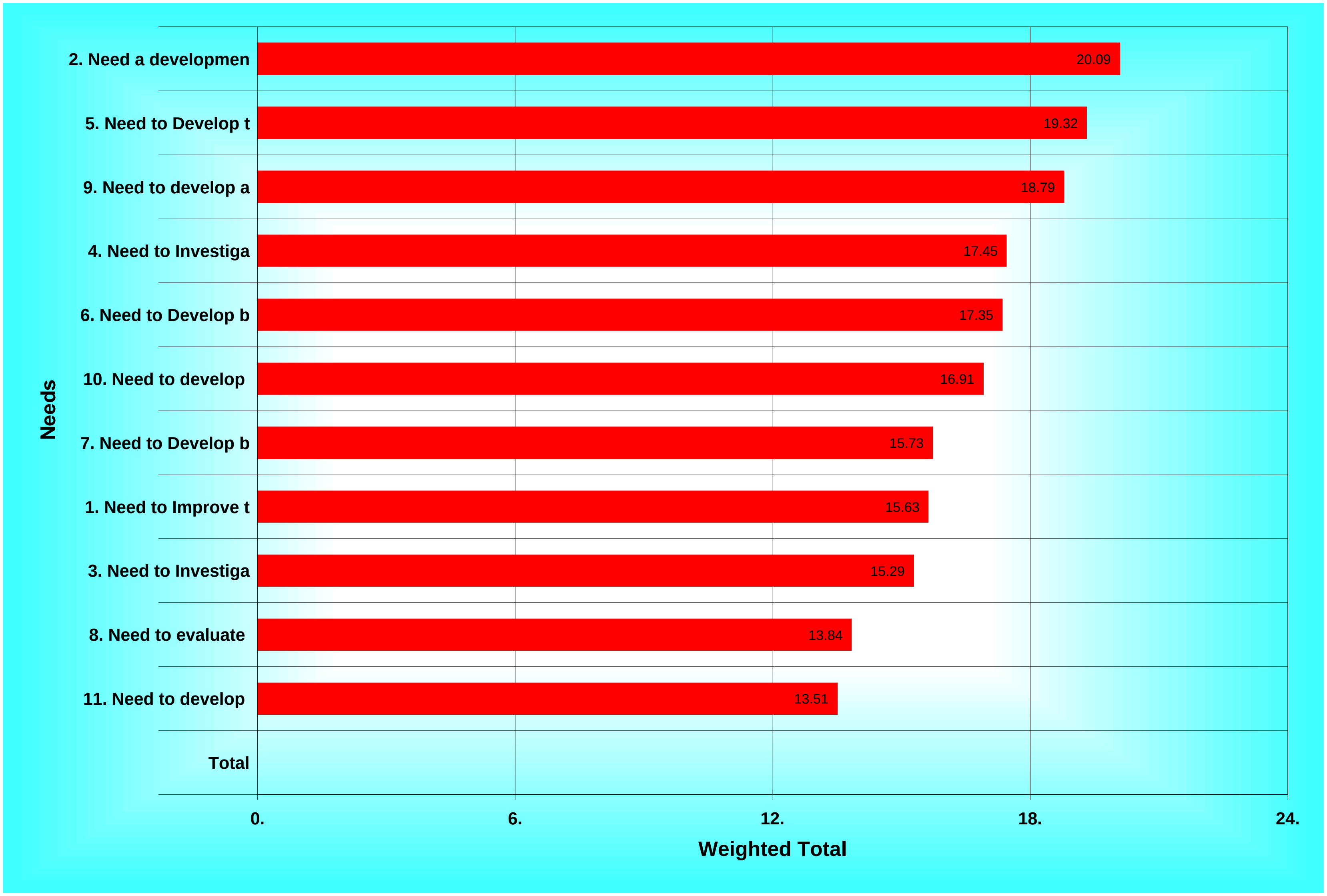

Figure 3. Weighted total scores of monitoring needs without criterion 1.

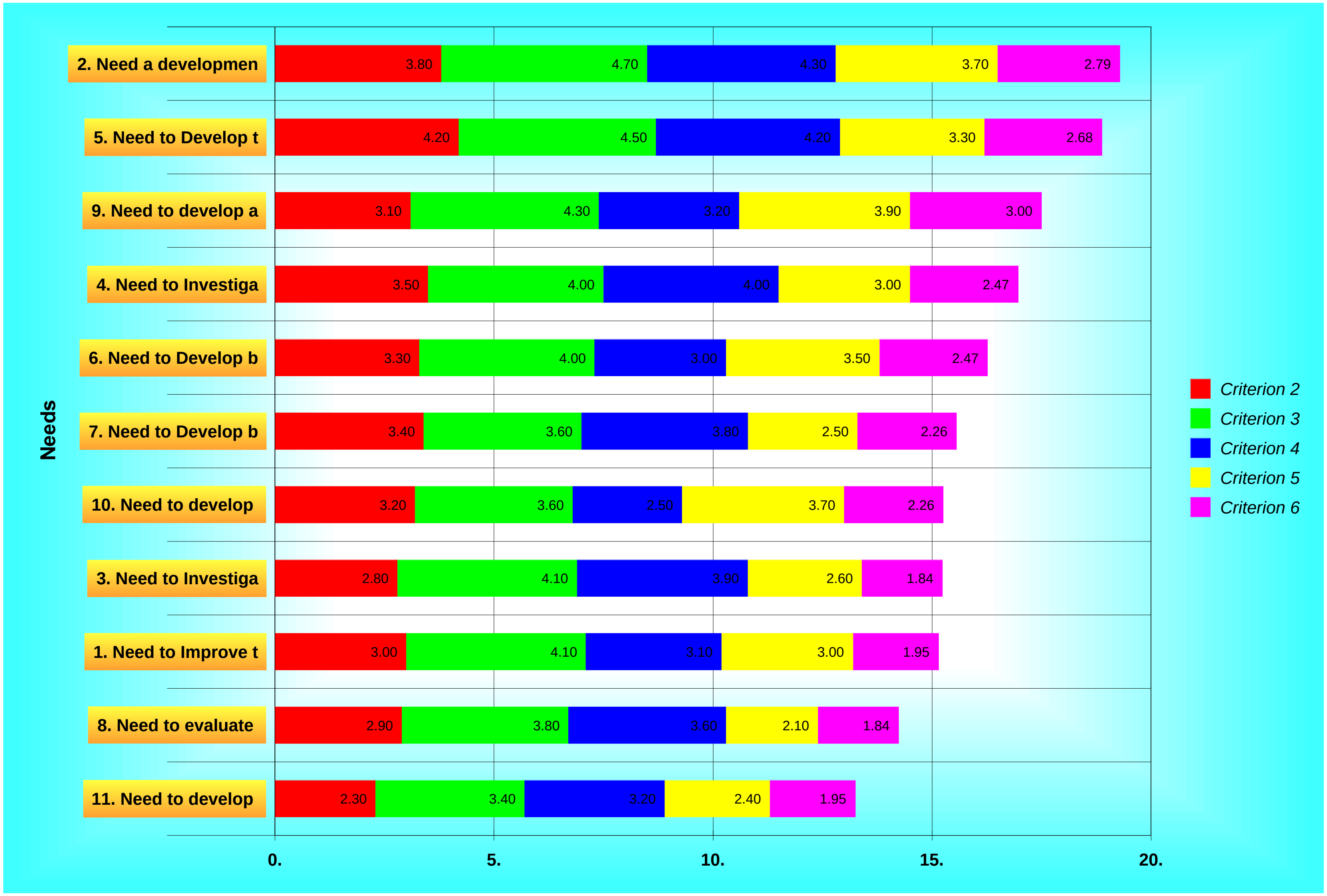

Figure 4. Unweighted criteria scores of monitoring needs without criterion 1.

Source Term Needs Group

Discussion and comments on the source term needs

1. Need research on contaminant release from treated waste forms (grout and vitrified waste).
    - (WAGs 7)(Uncertainties 9, 13, 18){#87}
    - Essential in support of remediation decisions. {#265}
    - This is critical for assessing the viability of any selected remedial alternative (residual risk from treated waste). {#269}
2. Need to improve source term release rate modeling (e.g. reactive transport code in the near field).
    - (WAGs 7)(Uncertainties 3, 5, 13, 15, 16, 17, 18){#95}
    - More associations and calibrations. {#258}
    - This should not require a sophisticated modeling effort just refinement of equations associating variables. {#259}
    - Calibration is implied in this topic, associating what has been observed with the current modeling would be a substantial improvement {#261}
    - We definitely need better understanding of this topic, whether or not traditional modeling is the main approach to it. {#275}
3. Need studies of physical waste form of contaminants in the SDA and other sites.
    - Basic information needed to evaluate and predict contaminant release. {#272}
    - Need to be specific. We already know what the waste form was when it was disposed. So, are we mostly interested in what changes have occurred in the waste form? {#273}
    - Yes, changes over time in the physical form are extremely important. Need real-time and accelerated studies if possible. {#276}
4. Need studies of corrosion rate of activated metals in the SDA and other sites.
    - Need to Perform activated metal corrosion rate studies for WAG 7.{#92}
      ✓ (WAGs 7)(Uncertainties 5, 9, 13){#93}[2]
    - These studies should be continued and expanded instead of being cut back as they have in the past. {#274}
5. Need studies of chemical state of the waste form in the SDA and other sites.
    - This would address the topic of what is an appropriate solubility to apply for depleted uranium waste disposed in the SDA which depends highly on the oxidation state of the disposed waste. {#263}
6. Need studies of processes that may accentuate fissile material accumulation.
    - The large body of literature on genesis of uranium ore bodies should be helpful here. {#266}
    - Processes include physical transport as a result of settlement
    - Chemical dissolution and redeposition on underlying sorbant media. {#267}
7. Need improved surface geophysics to allow better resolution of buried waste forms.
    - May be applicable to UXO sites {#264}
    - Will be applicable to numerous other sites. {#268}
    - I assume resolution means location, type, quantity, physical and chemical state {#270}
    - Potentially important cost savings in investigations relevant to source term. {#271}

[2] Comments with a checkmark indicated a comment under an original need that was merged with another need.

Unclear need, more information is needed for clarity

1. Need studies of fate and transport of contaminants in the SDA and other sites.

Needs addressed in the characterization group

1. Need studies of infiltration through waste - quantity and geochemistry.
    - (WAGs 7)(Uncertainties 5, 9, 13, 14, 15, 18){#89}
    - Addressed under need 17 in the characterization group. {#251}

Needs broken into separate needs

1. Need studies of source release/waste form/corrosion rate/fate and transport of contaminants in the SDA and other sites.
    - (WAGs 7)(Uncertainties 9, 13, 14, 15, 18){#85}
    - Need to Develop appropriate source term release rates for contaminant in buried waste. {#82}
        - ✓ (WAGs 7)(Uncertainties 9, 13, 14, 15, 18){#83}
    - This topic is very broad. This study needs to focus on the primary release mechanisms and COCs vs. all contaminants and wastes. {#247}
    - Need to Develop a better understanding of source term chemistry for Source Term Studies {#90}
        - ✓ (WAGs 3, 7)(Uncertainties 5, 9, 13, 15, 18){#91}
2. Need studies of source release of contaminants in the SDA and other sites

Source term needs rated against the criteria

This table shows the average scores for each of the criteria within a need. The color of the cell indicates the level of consensus of the scores within that cell. A green cell indicates a high level of consensus and a red cell indicates a low level of consensus. The blue cells were not rated by the participants during the meeting.

A consensus threshold value was set to help focus the group on those cells that had the most disagreement in the scores in the limited time available for discussion. It was not intended to imply that the group was in agreement on the score in that cell. The threshold level for consensus was set at 0.50. Typically, the threshold is set at 0.6 for discussion. The lower than normal threshold is indicative of the different perspectives of the participants.

Needs	Criterion									
	1	2	3	4	5	6	Total	Mean	STD	Weighted Total
Weight	0.65	0.95	0.26	1.06	2.29	0.80				
1.Need research on contaminant release from treated waste forms (grout and vitrified waste).		H(4.33)	M(3.89)	H(4.18)	H(4.56)	M(3.38)	20.33	H(4.07)	0.46	22.69
2.Need to improve source term release rate modeling (e.g. reactive transport code in the near field).		M(3.94)	M(3.47)	H(4.25)	H(4.29)	M(2.63)	18.58	M(3.72)	0.69	21.08
3.Need studies of physical waste form of contaminants in the SDA and other sites.		M(3.94)	M(2.53)	M(3.88)	H(4.41)	M(3.50)	18.26	M(3.65)	0.71	21.41
4.Need studies of corrosion rate of activated metals in the SDA and other sites.		M(3.71)	M(2.53)	H(4.13)	M(3.94)	M(3.13)	17.43	M(3.49)	0.65	20.08
5.Need studies of chemical state of the waste form in the SDA and other sites.		H(4.18)	M(2.76)	M(3.88)	H(4.06)	M(3.50)	18.38	M(3.67)	0.57	20.89
6.Need studies of processes that may accentuate fissile material accumulation.		M(2.89)	M(2.67)	M(3.24)	M(2.78)	M(2.13)	13.69	M(2.74)	0.40	14.93
7.Need improved surface geophysics to allow better resolution of buried waste forms.		H(4.00)	H(4.11)	H(4.06)	H(4.00)	M(3.25)	19.42	M(3.88)	0.36	20.93

Criteria scores by need

This table shows the distribution of scores (H, M, L) across the six criteria for each of the needs. The number within a criteria/score cell indicates the number of participants that used that score for that criteria. Within a need, the criteria are sorted from the highest to the lowest mean score.

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
1.Need research on contaminant release from treated waste forms (grout and vitrified waste).									
Criterion 5 (2.29)	15	2	1	82	H(4.56)	H	1.10	18	10.43
Criterion 2 (0.95)	14	2	2	78	H(4.33)	H	1.37	18	4.12
Criterion 4 (1.06)	11	5	1	71	H(4.18)	H	1.24	17	4.43
Criterion 3 (0.26)	10	6	2	70	M(3.89)	H	1.41	18	1.01
Criterion 6 (0.80)	8	3	5	54	M(3.38)	H	1.82	16	2.70
Criterion 1 (0.65)								0	
2.Need to improve source term release rate modeling (e.g. reactive transport code in the near field).									
Criterion 5 (2.29)	12	4	1	73	H(4.29)	H	1.21	17	9.83
Criterion 4 (1.06)	12	2	2	68	H(4.25)	H	1.44	16	4.50
Criterion 2 (0.95)	11	3	3	67	M(3.94)	H	1.60	17	3.74
Criterion 3 (0.26)	7	7	3	59	M(3.47)	??	1.50	17	0.90
Criterion 6 (0.80)	4	5	7	42	M(2.63)	L	1.67	16	2.10
Criterion 1 (0.65)								0	
3.Need studies of physical waste form of contaminants in the SDA and other sites.									
Criterion 5 (2.29)	13	3	1	75	H(4.41)	H	1.18	17	10.10
Criterion 2 (0.95)	10	5	2	67	M(3.94)	H	1.43	17	3.74
Criterion 4 (1.06)	8	7	1	62	M(3.88)	H	1.26	16	4.11
Criterion 6 (0.80)	10		6	56	M(3.50)	H	2.00	16	2.80
Criterion 3 (0.26)	4	5	8	43	M(2.53)	L	1.66	17	0.66
Criterion 1 (0.65)								0	
4.Need studies of corrosion rate of activated metals in the SDA and other sites.									
Criterion 4 (1.06)	11	3	2	66	H(4.13)	H	1.45	16	4.37
Criterion 5 (2.29)	10	5	2	67	M(3.94)	H	1.43	17	9.03

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 2 (0.95)	10	3	4	63	M(3.71)	H	1.72	17	3.52
Criterion 6 (0.80)	8	1	7	50	M(3.13)	H	2.00	16	2.50
Criterion 3 (0.26)	4	5	8	43	M(2.53)	L	1.66	17	0.66
Criterion 1 (0.65)								0	
5.Need studies of chemical state of the waste form in the SDA and other sites.									
Criterion 2 (0.95)	13	1	3	71	H(4.18)	H	1.59	17	3.97
Criterion 5 (2.29)	11	4	2	69	H(4.06)	H	1.43	17	9.29
Criterion 4 (1.06)	9	5	2	62	M(3.88)	H	1.45	16	4.11
Criterion 6 (0.80)	9	2	5	56	M(3.50)	H	1.86	16	2.80
Criterion 3 (0.26)	5	5	7	47	M(2.76)	L	1.71	17	0.72
Criterion 1 (0.65)								0	
6.Need studies of processes that may accentuate fissile material accumulation.									
Criterion 4 (1.06)	7	5	5	55	M(3.24)	H	1.71	17	3.43
Criterion 2 (0.95)	6	5	7	52	M(2.89)	L	1.75	18	2.74
Criterion 5 (2.29)	6	4	8	50	M(2.78)	L	1.80	18	6.36
Criterion 3 (0.26)	5	5	8	48	M(2.67)	L	1.71	18	0.69
Criterion 6 (0.80)	4	1	11	34	M(2.13)	L	1.78	16	1.70
Criterion 1 (0.65)								0	
7.Need improved surface geophysics to allow better resolution of buried waste forms.									
Criterion 3 (0.26)	13	2	3	74	H(4.11)	H	1.57	18	1.07
Criterion 4 (1.06)	9	8		69	H(4.06)	H	1.03	17	4.30
Criterion 2 (0.95)	12	3	3	72	H(4.00)	H	1.57	18	3.80
Criterion 5 (2.29)	12	3	3	72	H(4.00)	H	1.57	18	9.16
Criterion 6 (0.80)	8	2	6	52	M(3.25)	H	1.91	16	2.60
Criterion 1 (0.65)								0	

Need scores by criteria

This table shows the distribution of scores (H, M, L) across the needs for each of the six criteria. The number in each cell of the matrix indicates the number of participants who placed the criteria at that position on the list.

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
2.Criterion 2								
Need research on contaminant release from treated waste forms (grout and vitrified waste).	14	2	2	78	H(4.33)	H	1.37	18
Need studies of chemical state of the waste form in the SDA and other sites.	13	1	3	71	H(4.18)	H	1.59	17
Need improved surface geophysics to allow better resolution of buried waste forms.	12	3	3	72	H(4.00)	H	1.57	18
Need studies of physical waste form of contaminants in the SDA and other sites.	10	5	2	67	M(3.94)	H	1.43	17
Need to improve source term release rate modeling (e.g. reactive transport code in the near field).	11	3	3	67	M(3.94)	H	1.60	17
Need studies of corrosion rate of activated metals in the SDA and other sites.	10	3	4	63	M(3.71)	H	1.72	17
Need studies of processes that may accentuate fissile material accumulation.	6	5	7	52	M(2.89)	L	1.75	18
3.Criterion 3								
Need improved surface geophysics to allow better resolution of buried waste forms.	13	2	3	74	H(4.11)	H	1.57	18
Need research on contaminant release from treated waste forms (grout and vitrified waste).	10	6	2	70	M(3.89)	H	1.41	18
Need to improve source term release rate modeling (e.g. reactive transport code in the near field).	7	7	3	59	M(3.47)	??	1.50	17
Need studies of chemical state of the waste form in the SDA and other sites.	5	5	7	47	M(2.76)	L	1.71	17
Need studies of processes that may accentuate fissile material accumulation.	5	5	8	48	M(2.67)	L	1.71	18
Need studies of physical waste form of contaminants in the SDA and other sites.	4	5	8	43	M(2.53)	L	1.66	17
Need studies of corrosion rate of activated metals in the SDA and other sites.	4	5	8	43	M(2.53)	L	1.66	17
4.Criterion 4								
Need to improve source term release rate modeling (e.g. reactive transport code in the near field).	12	2	2	68	H(4.25)	H	1.44	16
Need research on contaminant release from treated waste forms (grout and vitrified waste).	11	5	1	71	H(4.18)	H	1.24	17
Need studies of corrosion rate of activated metals in the SDA and other sites.	11	3	2	66	H(4.13)	H	1.45	16
Need improved surface geophysics to allow better resolution of buried waste forms.	9	8		69	H(4.06)	H	1.03	17
Need studies of physical waste form of contaminants in the SDA and other sites.	8	7	1	62	M(3.88)	H	1.26	16
Need studies of chemical state of the waste form in the SDA and other sites.	9	5	2	62	M(3.88)	H	1.45	16
Need studies of processes that may accentuate fissile material accumulation.	7	5	5	55	M(3.24)	H	1.71	17
5.Criterion 5								
Need research on contaminant release from treated waste forms (grout and vitrified waste).	15	2	1	82	H(4.56)	H	1.10	18

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need studies of physical waste form of contaminants in the SDA and other sites.	13	3	1	75	H(4.41)	H	1.18	17
Need to improve source term release rate modeling (e.g. reactive transport code in the near field).	12	4	1	73	H(4.29)	H	1.21	17
Need studies of chemical state of the waste form in the SDA and other sites.	11	4	2	69	H(4.06)	H	1.43	17
Need improved surface geophysics to allow better resolution of buried waste forms.	12	3	3	72	H(4.00)	H	1.57	18
Need studies of corrosion rate of activated metals in the SDA and other sites.	10	5	2	67	M(3.94)	H	1.43	17
Need studies of processes that may accentuate fissile material accumulation.	6	4	8	50	M(2.78)	L	1.80	18
6.Criterion 6								
Need studies of chemical state of the waste form in the SDA and other sites.	9	2	5	56	M(3.50)	H	1.86	16
Need studies of physical waste form of contaminants in the SDA and other sites.	10		6	56	M(3.50)	H	2.00	16
Need research on contaminant release from treated waste forms (grout and vitrified waste).	8	3	5	54	M(3.38)	H	1.82	16
Need improved surface geophysics to allow better resolution of buried waste forms.	8	2	6	52	M(3.25)	H	1.91	16
Need studies of corrosion rate of activated metals in the SDA and other sites.	8	1	7	50	M(3.13)	H	2.00	16
Need to improve source term release rate modeling (e.g. reactive transport code in the near field).	4	5	7	42	M(2.63)	L	1.67	16
Need studies of processes that may accentuate fissile material accumulation.	4	1	11	34	M(2.13)	L	1.78	16

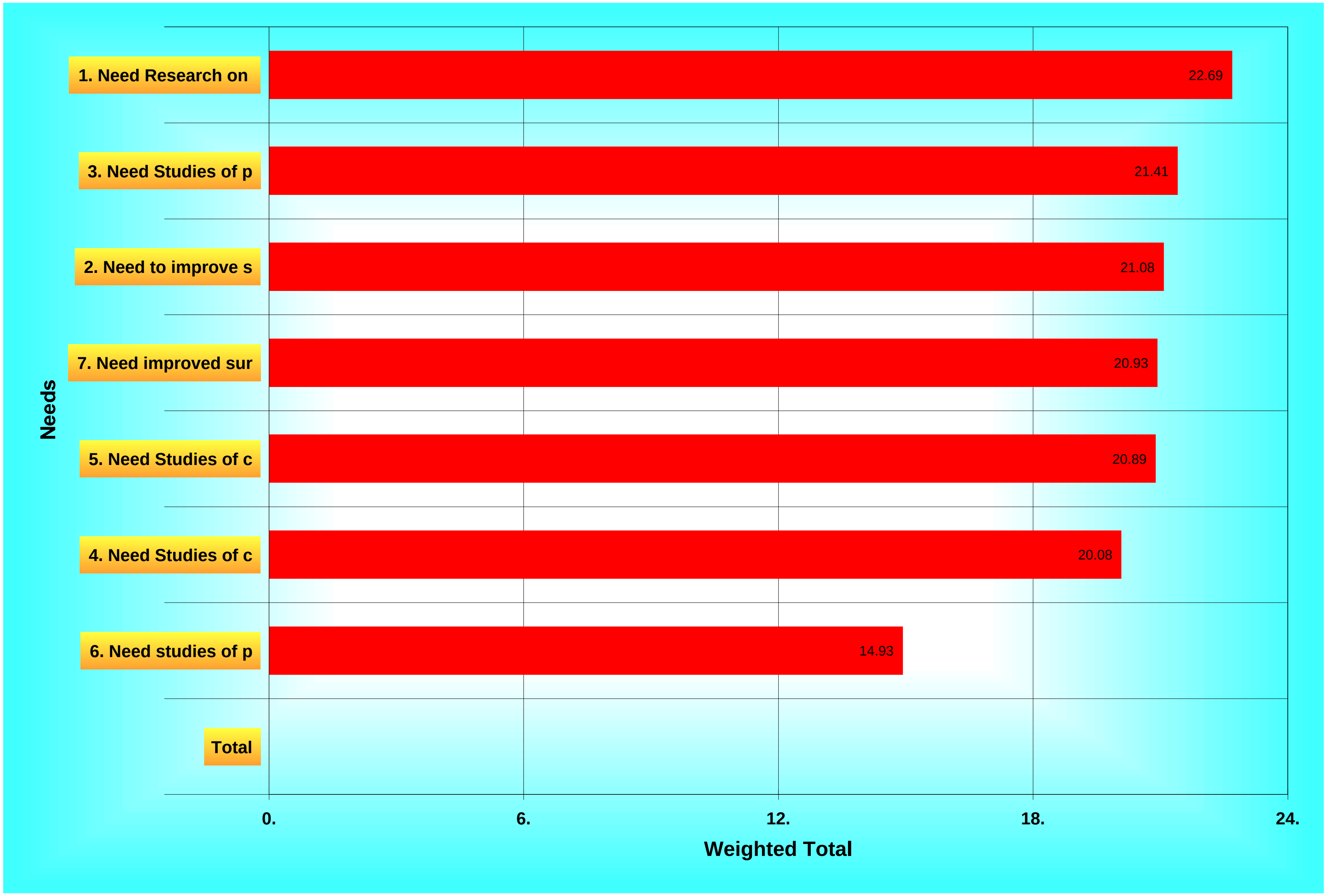

Figure 5. Weighted total scores of source term needs without criterion 1.

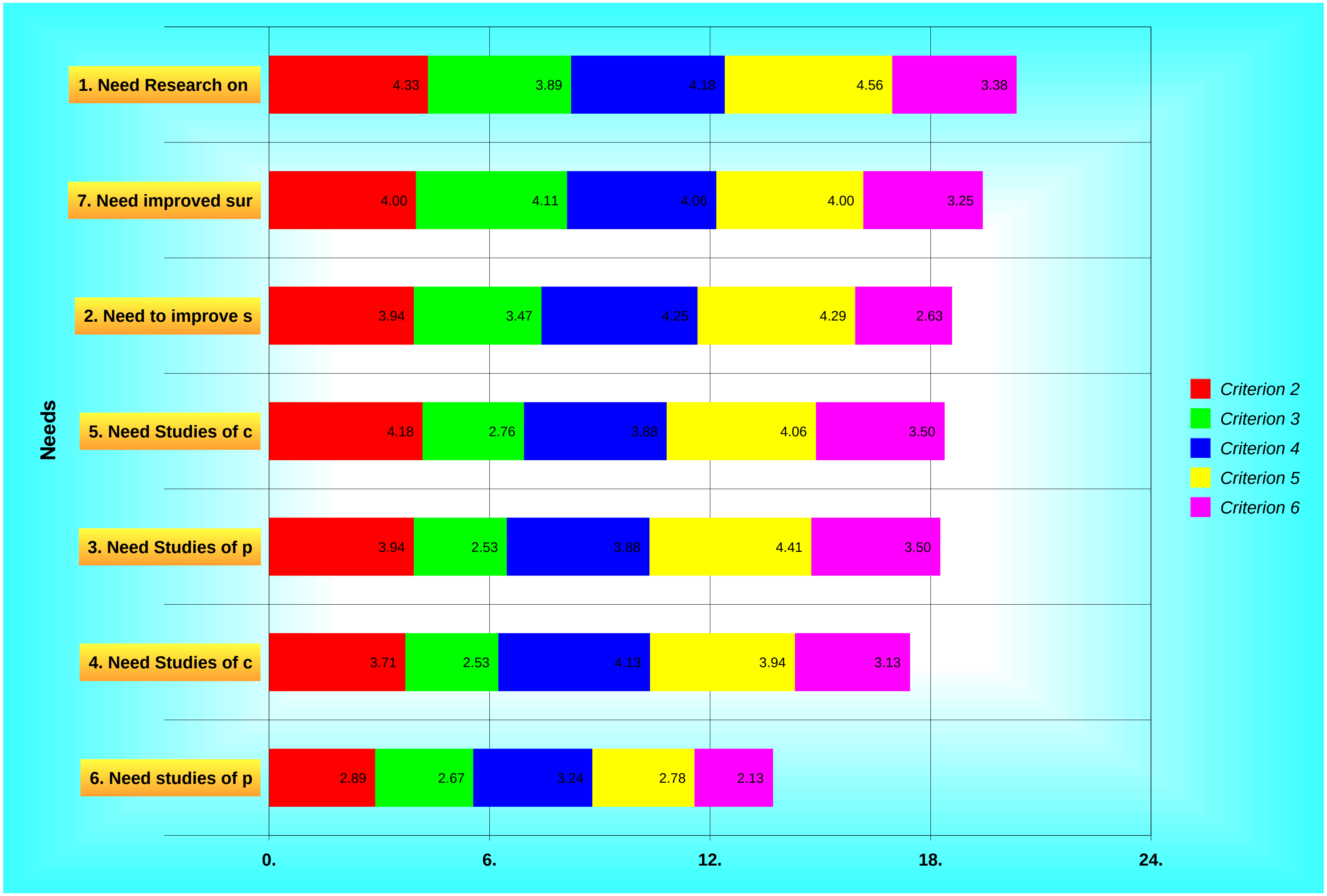

Figure 6. Unweighted criteria scores of source term needs without criterion 1.

Caps/Barriers/Grouting/Remediation Needs Group

Discussion and comments on the caps/barriers/grouting/remediation needs

1. Need an evaluation of the thrust block grouting technique for retrieval and production grouting.
    - (WAGs 7)(Uncertainties ?){#187}
    - Define thrust block grouting technique {#258}
    - Define what about this technique requires further research and development. {#293}
2. Need studies on grout formulation.
    - Need Studies of grout formulation: grout for retrieval vs. grout to be left in place; grout performance in high radiation environments; methods for simulation of long term testing; research on how to get boron to stay in solution.{#188}
        - ✓ (WAGs 7)(Uncertainties 3, 5, 15){#189}
    - Evaluate current work that has been completed to determine if there is any further work that needs to be completed. {#266}
    - This effort should evaluate the current method for grout emplacement and also look at the impacts of pressure grouting in an environment such as the SDA. {#279}
    - This should be preceded with a literature review to see if this need requires further study. {#303}
3. Need studies on long-term grout performance testing.
    - Long -term emphasis is crucial for grout. {#263}
    - Under what specific conditions? {#264}
4. Needs improved techniques on grout emplacement.
5. Need non-intrusive methods for in-situ testing of grout emplacement (e.g. consistency, binding with waste, compressive strength, where did it go).
    - (WAGs 7)(Uncertainties 3, 10, 13, 20){#191}
    - Vital need. How well does it work? How do you find out without destroying it? This is what needs to be attacked. {#275}
    - Site-specific to a large extent. {#277}
6. Need development of in situ methods for measuring hydraulic conductivity in a grouted mass.
    - (WAGs 7)(Uncertainties 13){#195}
    - Wayne mentioned that only destructive testing would be accepted. {#269}
    - Important aspect of evaluating and justifying grout technology. {#284}
    - For CQA purposes, in the testing of liners laboratory sample testing is required but may and has been supplemented by in-situ testing - Wayne {#289}
    - Some testing really has to be in-situ. {#302}
7. Need development of point measurement approaches for measuring infiltration through the CFA landfill cover and any other INEEL covers.
    - (WAGs 2)(Uncertainties 3, 13){#197}
    - This would obviously also have applications for whatever cover is eventually emplaced over the SDA {#286}
    - Preferentially of infiltration is of major importance, so this is a major need. {#290}
    - Would possibly have broad applicability. {#292}
    - For covers with a drainage layer, point measurement may not be practical {#299}
8. Need studies of long-term degradation of landfill covers including plant uptake, ability to simulate the effects of freeze/thaw cycles on soil covers over long periods of time, effects of evapotranspiration.
    - (WAGs 3)(Uncertainties 10){#199}

- This would include long-term climatic changes and their effects on barrier performance {#254}
- I agree with 254, this likely has the greatest effect on the plant/erosion issues {#262}
- Many studies have been conducted in this area, however the need is for climate specific data {#272}

9. Need development of long lasting, mobile, easily detected tracers that could be buried with the waste at landfills.

- (WAGs 3)(Uncertainties 5, 10, 13){#201}
- Long-lasting is probably the key {#274}
- Yes, for long-term monitoring. Important need. {#295}
- Given the presence of I-129, Sr-90, & H-3 in many of the wastes, an existing tracer may already exist? {#296}

10. Need development of reliable long-lasting sensors with low failure rate that could be either placed below the liners at landfills or be placed in the liner itself for long-term leak detection.

- (WAGs 3)(Uncertainties 10){#203}
- This may not be a need as the ICDF liner system construction is nearing completion and no new landfills are scheduled. {#294}
- There will probably be other landfills and liners in the future. {#298}
- Comment on #294 - this sets a bad precedent. I predict that the ICDF will someday be in the same position that the RWMC is today. No way to demonstrate how the facility is performing. Therefore, overly conservative actions will be necessary in order to make up for the uncertainty. {#301}

11. Need to investigate effects of the development of condensation beneath impermeable barriers.

- (WAGs 3)(Uncertainties 10, 15){#205}
- Effects on contaminant mobilization from the accumulation of condensate beneath barriers. {#273}
- How to evaluate if you have condensation or a leak - legal failure of the barrier {#283}

12. Need to develop alternatives for sodium lactate for ISB. Alternate electron donor.

- (WAGs 1)(Uncertainties 5, 10){#207}
- This work is already being done {#276}
- Issue w/ the sodium lactate is that the sodium may mobilize Sr-90. {#281}
- This study is already underway {#291}

13. Need to Investigate mechanism for aerobic degradation of TAN TCE plume far downgradient.

- (WAGs 1)(Uncertainties 5, 10, 17, 18, 19){#209}
- Any results would be inconsequential for remedial actions. {#261}
- Aerobic is important here as the distal portions of the TAN plume is at or close to atmospheric oxygen saturation {#267}
- Should include more than just aerobic degradation--there may also be physical and chemical processes at work. {#270}
- This appears to relate to MNA at 1-07B {#280}
- In response to 262 - not inconsequential - see other notes. {#288}

14. Need to develop in-situ remediation techniques such as subsurface reactive barriers and bioremediation.

- (WAGs Site-wide)(Uncertainties 10, 13, 15, 18){#211}
- Development of in-situ permeable vadose zone barriers could be a big payoff {#253}
- Could be either a sorption barrier or transformation barrier {#278}

- This is most important for future engineered facilities. Major issues with creating the barriers for current contaminants. {#285}
- Include your monitoring in this barrier so you can demonstrate performance in the future. {#287}

15. Need continued development of advanced detection of criticality sensor for the SDA subsurface (pit-9).
    - (WAGs 7)(Uncertainties 3, 9, 10){#217}
    - Can also apply to an in-situ subsurface detector {#268}
16. Need to develop a methods for collecting representative samples of sludge and sediments from tanks (i.e. from PM-2A).
    - (WAGs 3)(Uncertainties 9){#225}
    - Isn't the question really - get regulators to define what they will accept -it is next to impossible to get a repeatable sample. {#255}
    - 2 parts to the issue--deciding what is representative, and techniques for the sample grab. {#297}
17. Need a method to rehabilitate plugged OCVZ wells and methods to prevent plugging.
    - (WAGs 1)(Uncertainties 17, 21){#227}
    - Define OC {#256}
    - Not sure this is a research need {#265}
18. Develop a scientific justification to optimize lateral extent of surface caps.
    - This is largely driven by applicable regulations in terms of minimum thickness and slope {#259}
    - Reword as Develop technical-based techniques to determine optimum extent of caps/covers {#260}
    - Simply relying on engineering requirements on thickness and slope could result in cases where caps fail because the potential for lateral migration on the surficial sediment/basalt contact could defeat the purpose of the cap. This topic just asks for a more thorough evaluation of lateral migration in the subsurface when designing cover extents {#271}
    - #259 would determine the minimum extent of the cap but not provide enough protection in certain situations {#282}
    - Good thing to attack. Cost and time savings. {#300}

Unclear need, more information is needed for clarity

1. Need to develop better-engineered barriers, caps, and covers for Caps/Barriers/Grouting/Remediation
    - (WAGs Site-wide)(Uncertainties 10, 13){#213}
2. Need to develop methods for better optimization of TAN degradation.
    - (WAGs 1)(Uncertainties 5, 10, 13, 15, 18){#215}
3. Need research for decisions on WAG 3 injection well.
    - (WAGs 3)(Uncertainties 1, 5, 3, 8, 13, 15,){#223}

Need determined to not be a need

1. Need demonstration of the SMART barrier system.
    - (WAGs 7, 3?)(Uncertainties ?){#193}
    - Define SMART {#251}
2. Need a review of VOC destruction units.
    - (WAGs 7)(Uncertainties ?){#219}
3. Need to develop technically defensible zoning concept to support management of TSCA (PCBs) requirements during Pit 9 retrieval.
    - (WAGs 7)(Uncertainties 1, 3, 5, 9, 10, 13, 15, 17, 18, 19){#221}

Caps/barriers/grouting/remediation needs rated against the criteria

This table shows the average scores for each of the criteria within a need. The color of the cell indicates the level of consensus of the scores within that cell. A green cell indicates a high level of consensus and a red cell indicates a low level of consensus. The blue cells were not rated by the participants during the meeting.

A consensus threshold value was set to help focus the group on those cells that had the most disagreement in the scores in the limited time available for discussion. It was not intended to imply that the group was in agreement on the score in that cell. The threshold level for consensus was set at 0.50. Typically, the threshold is set at 0.6 for discussion. The lower than normal threshold is indicative of the different perspectives of the participants.

Need	Criterion 1	2	3	4	5	6	Total	Mean	STD	Weighted Total
Weight	0.65	0.95	0.26	1.06	2.29	0.80				
1.Need an evaluation of the thrust block grouting technique for retrieval and production grouting.		M(2.47)	M(3.12)	M(3.88)	M(2.86)	M(2.73)	15.05	M(3.01)	0.54	15.99
2.Need studies on grout formulation.		M(2.87)	M(3.50)	H(4.13)	M(3.14)	M(2.60)	16.23	M(3.25)	0.59	17.28
3.Need studies on long-term grout performance testing.		M(3.82)	H(4.41)	M(3.35)	M(3.80)	M(2.47)	17.85	M(3.57)	0.72	19.01
4.Needs improved techniques on grout emplacement.		M(3.59)	M(3.89)	H(4.18)	H(4.00)	M(3.00)	18.65	M(3.73)	0.46	20.41
5.Need non-intrusive methods for in-situ testing of grout emplacement (e.g. consistency, binding with waste, compressive strength, where did it go).		M(3.53)	H(4.06)	M(3.50)	H(4.38)	M(3.25)	18.72	M(3.74)	0.46	20.74
6.Need development of in situ methods for measuring hydraulic conductivity in a grouted mass.		M(3.27)	H(4.18)	M(3.75)	M(3.13)	M(2.47)	16.78	M(3.36)	0.65	17.29
7.Need development of point measurement approaches for measuring infiltration through the CFA landfill cover and any other INEEL covers.		M(3.63)	M(3.59)	M(3.80)	M(3.00)	M(2.00)	16.01	M(3.20)	0.74	16.87
8.Need studies of long-term degradation of landfill covers including plant uptake, ability to simulate the effects of freeze/thaw cycles on soil covers over long periods of time, effects of evapotranspiration.		M(3.38)	M(3.82)	M(2.88)	M(3.25)	M(2.33)	15.66	M(3.13)	0.56	16.56
9.Need development of long lasting, mobile, easily detected tracers that could be buried with the waste at landfills.		M(3.75)	M(3.94)	H(4.00)	M(3.38)	L(1.75)	16.82	M(3.36)	0.93	17.96

Need	Criterion 1	2	3	4	5	6	Total	Mean	STD	Weighted Total
10.Need development of reliable long-lasting sensors with low failure rate that could be either placed below the liners at landfills or be placed in the liner itself for long-term leak detection.		H(4.47)	H(4.53)	M(3.75)	H(4.38)	M(2.88)	20.00	M(4.00)	0.70	21.71
11.Need to investigate effects of the development of condensation beneath impermeable barriers.		M(2.57)	M(3.80)	M(3.43)	M(2.57)	L(1.75)	14.12	M(2.82)	0.81	14.35
12.Need to develop alternatives for sodium lactate for ISB. Alternate electron donor.		M(2.57)	M(2.60)	M(3.43)	M(2.60)	L(1.71)	12.91	M(2.58)	0.61	14.08
13.Need to investigate mechanism for aerobic degradation of TAN TCE plume far downgradient.		M(2.60)	M(2.25)	M(3.00)	M(2.87)	L(1.80)	12.52	M(2.50)	0.49	14.24
14.Need to develop in-situ remediation techniques such as subsurface reactive barriers and bioremediation.		H(4.47)	H(4.25)	H(4.60)	H(4.47)	M(2.87)	20.65	H(4.13)	0.72	22.75
15.Need continued development of advanced detection of criticality sensor for the SDA subsurface (pit-9).		M(3.53)	M(2.88)	M(3.63)	M(3.13)	M(2.75)	15.92	M(3.18)	0.39	17.32
16.Need to develop a methods for collecting representative samples of sludge and sediments from tanks (i.e. from PM-2A).		M(3.40)	M(3.38)	M(3.43)	M(3.57)	M(2.87)	16.64	M(3.33)	0.27	18.21
17.Need a method to rehabilitate plugged OCVZ wells and methods to prevent plugging.		M(3.75)	M(2.29)	M(3.27)	M(3.00)	M(2.87)	15.18	M(3.04)	0.53	16.78
18.Develop a scientific justification to optimize lateral extent of surface caps.		M(3.25)	M(3.94)	M(3.82)	M(3.50)	M(2.73)	17.25	M(3.45)	0.48	18.37

Criteria scores by need

This table shows the distribution of scores (H, M, L) across the six criteria for each of the needs. The number within a criteria/score cell indicates the number of participants that used that score for that criteria. Within a need, the criteria are sorted from the highest to the lowest mean score.

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
1.Need an evaluation of the thrust block grouting technique for retrieval and production grouting.									
Criterion 4 (1.06)	8	7	1	62	M(3.88)	H	1.26	16	4.11

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 3 (0.26)	6	6	5	53	M(3.12)	??	1.65	17	0.81
Criterion 5 (2.29)	3	7	4	40	M(2.86)	M	1.46	14	6.54
Criterion 6 (0.80)	4	5	6	41	M(2.73)	L	1.67	15	2.19
Criterion 2 (0.95)	3	5	7	37	M(2.47)	L	1.60	15	2.34
Criterion 1 (0.65)								0	
2.Need studies on grout formulation.									
Criterion 4 (1.06)	10	5	1	66	H(4.13)	H	1.26	16	4.37
Criterion 3 (0.26)	7	6	3	56	M(3.50)	H	1.55	16	0.91
Criterion 5 (2.29)	5	5	4	44	M(3.14)	??	1.66	14	7.20
Criterion 2 (0.95)	6	2	7	43	M(2.87)	L	1.92	15	2.72
Criterion 6 (0.80)	5	2	8	39	M(2.60)	L	1.88	15	2.08
Criterion 1 (0.65)								0	
3.Need studies on long-term grout performance testing.									
Criterion 3 (0.26)	12	5		75	H(4.41)	H	0.94	17	1.15
Criterion 2 (0.95)	11	2	4	65	M(3.82)	H	1.74	17	3.63
Criterion 5 (2.29)	8	5	2	57	M(3.80)	H	1.47	15	8.70
Criterion 4 (1.06)	6	8	3	57	M(3.35)	M	1.46	17	3.55
Criterion 6 (0.80)	5	1	9	37	M(2.47)	L	1.92	15	1.97
Criterion 1 (0.65)								0	
4.Needs improved techniques on grout emplacement.									
Criterion 4 (1.06)	12	3	2	71	H(4.18)	H	1.42	17	4.43
Criterion 5 (2.29)	9	6	1	64	H(4.00)	H	1.26	16	9.16
Criterion 3 (0.26)	10	6	2	70	M(3.89)	H	1.41	18	1.01
Criterion 2 (0.95)	9	4	4	61	M(3.59)	H	1.70	17	3.41
Criterion 6 (0.80)	6	4	6	48	M(3.00)	??	1.79	16	2.40

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 1 (0.65)								0	
5.Need non-intrusive methods for in-situ testing of grout emplacement (e.g. consistency, binding with waste, compressive strength, where did it go).									
Criterion 5 (2.29)	12	3	1	70	H(4.38)	H	1.20	16	10.02
Criterion 3 (0.26)	12	2	3	69	H(4.06)	H	1.60	17	1.06
Criterion 2 (0.95)	8	3	4	53	M(3.53)	H	1.77	15	3.36
Criterion 4 (1.06)	7	6	3	56	M(3.50)	H	1.55	16	3.71
Criterion 6 (0.80)	8	2	6	52	M(3.25)	H	1.91	16	2.60
Criterion 1 (0.65)								0	
6.Need development of in situ methods for measuring hydraulic conductivity in a grouted mass.									
Criterion 3 (0.26)	11	5	1	71	H(4.18)	H	1.24	17	1.09
Criterion 4 (1.06)	9	4	3	60	M(3.75)	H	1.61	16	3.97
Criterion 2 (0.95)	7	3	5	49	M(3.27)	H	1.83	15	3.10
Criterion 5 (2.29)	7	3	6	50	M(3.13)	H	1.86	16	7.16
Criterion 6 (0.80)	5	1	9	37	M(2.47)	L	1.92	15	1.97
Criterion 1 (0.65)								0	
7.Need development of point measurement approaches for measuring infiltration through the CFA landfill cover and any other INEEL covers.									
Criterion 4 (1.06)	9	3	3	57	M(3.80)	H	1.66	15	4.03
Criterion 2 (0.95)	8	5	3	58	M(3.63)	H	1.59	16	3.44
Criterion 3 (0.26)	8	6	3	61	M(3.59)	H	1.54	17	0.93
Criterion 5 (2.29)	5	5	5	45	M(3.00)	??	1.69	15	6.87
Criterion 6 (0.80)	2	4	10	32	M(2.00)	L	1.46	16	1.60
Criterion 1 (0.65)								0	
8.Need studies of long-term degradation of landfill covers including plant uptake, ability to simulate the effects of freeze/thaw cycles on soil covers over long periods of time, effects of evapotranspiration.									
Criterion 3 (0.26)	10	4	3	65	M(3.82)	H	1.59	17	0.99

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 2 (0.95)	9	1	6	54	M(3.38)	H	1.96	16	3.21
Criterion 5 (2.29)	7	4	5	52	M(3.25)	H	1.77	16	7.44
Criterion 4 (1.06)	5	6	6	49	M(2.88)	??	1.65	17	3.06
Criterion 6 (0.80)	4	2	9	35	M(2.33)	L	1.80	15	1.87
Criterion 1 (0.65)								0	
9.Need development of long lasting, mobile, easily detected tracers that could be buried with the waste at landfills.									
Criterion 4 (1.06)	8	8		64	H(4.00)	??	1.03	16	4.24
Criterion 3 (0.26)	10	5	2	67	M(3.94)	H	1.43	17	1.02
Criterion 2 (0.95)	9	4	3	60	M(3.75)	H	1.61	16	3.56
Criterion 5 (2.29)	6	7	3	54	M(3.38)	M	1.50	16	7.73
Criterion 6 (0.80)	2	2	12	28	L(1.75)	L	1.44	16	1.40
Criterion 1 (0.65)								0	
10.Need development of reliable long-lasting sensors with low failure rate that could be either placed below the liners at landfills or be placed in the liner itself for long-term leak detection.									
Criterion 3 (0.26)	13	4		77	H(4.53)	H	0.87	17	1.18
Criterion 2 (0.95)	11	4		67	H(4.47)	H	0.92	15	4.24
Criterion 5 (2.29)	12	3	1	70	H(4.38)	H	1.20	16	10.02
Criterion 4 (1.06)	9	4	3	60	M(3.75)	H	1.61	16	3.97
Criterion 6 (0.80)	6	3	7	46	M(2.88)	L	1.86	16	2.30
Criterion 1 (0.65)								0	
11.Need to investigate effects of the development of condensation beneath impermeable barriers.									
Criterion 3 (0.26)	8	5	2	57	M(3.80)	H	1.47	15	0.99
Criterion 4 (1.06)	5	7	2	48	M(3.43)	M	1.40	14	3.63
Criterion 2 (0.95)	3	5	6	36	M(2.57)	L	1.60	14	2.44
Criterion 5 (2.29)	4	3	7	36	M(2.57)	L	1.79	14	5.89

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 6 (0.80)	1	4	11	28	L(1.75)	L	1.24	16	1.40
Criterion 1 (0.65)								0	
12.Need to develop alternatives for sodium lactate for ISB. Alternate electron donor.									
Criterion 4 (1.06)	6	5	3	48	M(3.43)	H	1.60	14	3.63
Criterion 3 (0.26)	2	8	5	39	M(2.60)	M	1.35	15	0.68
Criterion 5 (2.29)	4	4	7	39	M(2.60)	L	1.72	15	5.95
Criterion 2 (0.95)	4	3	7	36	M(2.57)	L	1.79	14	2.44
Criterion 6 (0.80)	2	1	11	24	L(1.71)	L	1.49	14	1.37
Criterion 1 (0.65)								0	
13.Need to investigate mechanism for aerobic degradation of TAN TCE plume far downgradient.									
Criterion 4 (1.06)	5	5	5	45	M(3.00)	??	1.69	15	3.18
Criterion 5 (2.29)	3	8	4	43	M(2.87)	M	1.41	15	6.56
Criterion 2 (0.95)	4	4	7	39	M(2.60)	L	1.72	15	2.47
Criterion 3 (0.26)	1	8	7	36	M(2.25)	M	1.24	16	0.58
Criterion 6 (0.80)	2	2	11	27	L(1.80)	L	1.47	15	1.44
Criterion 1 (0.65)								0	
14.Need to develop in-situ remediation techniques such as subsurface reactive barriers and bioremediation.									
Criterion 4 (1.06)	12	3		69	H(4.60)	H	0.83	15	4.88
Criterion 2 (0.95)	11	4		67	H(4.47)	H	0.92	15	4.24
Criterion 5 (2.29)	11	4		67	H(4.47)	H	0.92	15	10.23
Criterion 3 (0.26)	10	6		68	H(4.25)	H	1.00	16	1.10
Criterion 6 (0.80)	5	4	6	43	M(2.87)	L	1.77	15	2.29
Criterion 1 (0.65)								0	
15.Need continued development of advanced detection of criticality sensor for the SDA subsurface (pit-9).									
Criterion 4 (1.06)	9	3	4	58	M(3.63)	H	1.75	16	3.84

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 2 (0.95)	8	3	4	53	M(3.53)	H	1.77	15	3.36
Criterion 5 (2.29)	7	2	6	47	M(3.13)	H	1.92	15	7.18
Criterion 3 (0.26)	6	3	7	46	M(2.88)	L	1.86	16	0.75
Criterion 6 (0.80)	6	2	8	44	M(2.75)	L	1.91	16	2.20
Criterion 1 (0.65)								0	
16.Need to develop a methods for collecting representative samples of sludge and sediments from tanks (i.e. from PM-2A).									
Criterion 5 (2.29)	8	2	4	50	M(3.57)	H	1.83	14	8.18
Criterion 4 (1.06)	6	5	3	48	M(3.43)	H	1.60	14	3.63
Criterion 2 (0.95)	5	8	2	51	M(3.40)	M	1.35	15	3.23
Criterion 3 (0.26)	9	1	6	54	M(3.38)	H	1.96	16	0.88
Criterion 6 (0.80)	5	4	6	43	M(2.87)	L	1.77	15	2.29
Criterion 1 (0.65)								0	
17.Need a method to rehabilitate plugged OCVZ wells and methods to prevent plugging.									
Criterion 2 (0.95)	9	4	3	60	M(3.75)	H	1.61	16	3.56
Criterion 4 (1.06)	5	7	3	49	M(3.27)	M	1.49	15	3.46
Criterion 5 (2.29)	4	7	4	45	M(3.00)	M	1.51	15	6.87
Criterion 6 (0.80)	5	4	6	43	M(2.87)	L	1.77	15	2.29
Criterion 3 (0.26)	3	5	9	39	M(2.29)	L	1.57	17	0.60
Criterion 1 (0.65)								0	
18.Develop a scientific justification to optimize lateral extent of surface caps.									
Criterion 3 (0.26)	11	3	3	67	M(3.94)	H	1.60	17	1.02
Criterion 4 (1.06)	10	4	3	65	M(3.82)	H	1.59	17	4.05
Criterion 5 (2.29)	8	4	4	56	M(3.50)	H	1.71	16	8.01
Criterion 2 (0.95)	7	4	5	52	M(3.25)	H	1.77	16	3.09
Criterion 6 (0.80)	5	3	7	41	M(2.73)	L	1.83	15	2.19

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 1 (0.65)								0	

Need scores by criteria

This table shows the distribution of scores (H, M, L) across the needs for each of the six criteria. The number in each cell of the matrix indicates the number of participants who placed the criteria at that position on the list.

Need	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
2.Criterion 2								
Need development of reliable long-lasting sensors with low failure rate that could be either placed below the liners at landfills or be placed in the liner itself for long-term leak detection.	11	4		67	H(4.47)	H	0.92	15
Need to develop in-situ remediation techniques such as subsurface reactive barriers and bioremediation.	11	4		67	H(4.47)	H	0.92	15
Need studies on long-term grout performance testing.	11	2	4	65	M(3.82)	H	1.74	17
Need development of long lasting, mobile, easily detected tracers that could be buried with the waste at landfills.	9	4	3	60	M(3.75)	H	1.61	16
Need a method to rehabilitate plugged OCVZ wells and methods to prevent plugging.	9	4	3	60	M(3.75)	H	1.61	16
Need development of point measurement approaches for measuring infiltration through the CFA landfill cover and any other INEEL covers.	8	5	3	58	M(3.63)	H	1.59	16
Needs improved techniques on grout emplacement.	9	4	4	61	M(3.59)	H	1.70	17
Need non-intrusive methods for in-situ testing of grout emplacement (e.g. consistency, binding with waste, compressive strength, where did it go).	8	3	4	53	M(3.53)	H	1.77	15
Need continued development of advanced detection of criticality sensor for the SDA subsurface (pit-9).	8	3	4	53	M(3.53)	H	1.77	15
Need to develop a methods for collecting representative samples of sludge and sediments from tanks (i.e. from PM-2A).	5	8	2	51	M(3.40)	M	1.35	15
Need studies of long-term degradation of landfill covers including plant uptake, ability to simulate the effects of freeze/thaw cycles on soil covers over long periods of time, effects of evapotranspiration.	9	1	6	54	M(3.38)	H	1.96	16
Need development of in situ methods for measuring hydraulic conductivity in a grouted mass.	7	3	5	49	M(3.27)	H	1.83	15
Develop a scientific justification to optimize lateral extent of surface caps.	7	4	5	52	M(3.25)	H	1.77	16
Need studies on grout formulation.	6	2	7	43	M(2.87)	L	1.92	15
Need to investigate mechanism for aerobic degradation of TAN TCE plume far downgradient.	4	4	7	39	M(2.60)	L	1.72	15
Need to investigate effects of the development of condensation beneath impermeable barriers.	3	5	6	36	M(2.57)	L	1.60	14
Need to develop alternatives for sodium lactate for ISB. Alternate electron donor.	4	3	7	36	M(2.57)	L	1.79	14

Need	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need an evaluation of the thrust block grouting technique for retrieval and production grouting.	3	5	7	37	M(2.47)	L	1.60	15
3.Criterion 3								
Need development of reliable long-lasting sensors with low failure rate that could be either placed below the liners at landfills or be placed in the liner itself for long-term leak detection.	13	4		77	H(4.53)	H	0.87	17
Need studies on long-term grout performance testing.	12	5		75	H(4.41)	H	0.94	17
Need to develop in-situ remediation techniques such as subsurface reactive barriers and bioremediation.	10	6		68	H(4.25)	H	1.00	16
Need development of in situ methods for measuring hydraulic conductivity in a grouted mass.	11	5	1	71	H(4.18)	H	1.24	17
Need non-intrusive methods for in-situ testing of grout emplacement (e.g. consistency, binding with waste, compressive strength, where did it go).	12	2	3	69	H(4.06)	H	1.60	17
Need development of long lasting, mobile, easily detected tracers that could be buried with the waste at landfills.	10	5	2	67	M(3.94)	H	1.43	17
Develop a scientific justification to optimize lateral extent of surface caps.	11	3	3	67	M(3.94)	H	1.60	17
Needs improved techniques on grout emplacement.	10	6	2	70	M(3.89)	H	1.41	18
Need studies of long-term degradation of landfill covers including plant uptake, ability to simulate the effects of freeze/thaw cycles on soil covers over long periods of time, effects of evapotranspiration.	10	4	3	65	M(3.82)	H	1.59	17
Need to investigate effects of the development of condensation beneath impermeable barriers.	8	5	2	57	M(3.80)	H	1.47	15
Need development of point measurement approaches for measuring infiltration through the CFA landfill cover and any other INEEL covers.	8	6	3	61	M(3.59)	H	1.54	17
Need studies on grout formulation.	7	6	3	56	M(3.50)	H	1.55	16
Need to develop a methods for collecting representative samples of sludge and sediments from tanks (i.e. from PM-2A).	9	1	6	54	M(3.38)	H	1.96	16
Need an evaluation of the thrust block grouting technique for retrieval and production grouting.	6	6	5	53	M(3.12)	??	1.65	17
Need continued development of advanced detection of criticality sensor for the SDA subsurface (pit-9).	6	3	7	46	M(2.88)	L	1.86	16
Need to develop alternatives for sodium lactate for ISB. Alternate electron donor.	2	8	5	39	M(2.60)	M	1.35	15
Need a method to rehabilitate plugged OCVZ wells and methods to prevent plugging.	3	5	9	39	M(2.29)	L	1.57	17
Need to investigate mechanism for aerobic degradation of TAN TCE plume far downgradient.	1	8	7	36	M(2.25)	M	1.24	16
4.Criterion 4								
Need to develop in-situ remediation techniques such as subsurface reactive barriers and bioremediation.	12	3		69	H(4.60)	H	0.83	15
Needs improved techniques on grout emplacement.	12	3	2	71	H(4.18)	H	1.42	17

Need	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need studies on grout formulation.	10	5	1	66	H(4.13)	H	1.26	16
Need development of long lasting, mobile, easily detected tracers that could be buried with the waste at landfills.	8	8		64	H(4.00)	??	1.03	16
Need an evaluation of the thrust block grouting technique for retrieval and production grouting.	8	7	1	62	M(3.88)	H	1.26	16
Develop a scientific justification to optimize lateral extent of surface caps.	10	4	3	65	M(3.82)	H	1.59	17
Need development of point measurement approaches for measuring infiltration through the CFA landfill cover and any other INEEL covers.	9	3	3	57	M(3.80)	H	1.66	15
Need development of in situ methods for measuring hydraulic conductivity in a grouted mass.	9	4	3	60	M(3.75)	H	1.61	16
Need development of reliable long-lasting sensors with low failure rate that could be either placed below the liners at landfills or be placed in the liner itself for long-term leak detection.	9	4	3	60	M(3.75)	H	1.61	16
Need continued development of advanced detection of criticality sensor for the SDA subsurface (pit-9).	9	3	4	58	M(3.63)	H	1.75	16
Need non-intrusive methods for in-situ testing of grout emplacement (e.g. consistency, binding with waste, compressive strength, where did it go).	7	6	3	56	M(3.50)	H	1.55	16
Need to investigate effects of the development of condensation beneath impermeable barriers.	5	7	2	48	M(3.43)	M	1.40	14
Need to develop alternatives for sodium lactate for ISB. Alternate electron donor.	6	5	3	48	M(3.43)	H	1.60	14
Need to develop a methods for collecting representative samples of sludge and sediments from tanks (i.e. from PM-2A).	6	5	3	48	M(3.43)	H	1.60	14
Need studies on long-term grout performance testing.	6	8	3	57	M(3.35)	M	1.46	17
Need a method to rehabilitate plugged OCVZ wells and methods to prevent plugging.	5	7	3	49	M(3.27)	M	1.49	15
Need to Investigate mechanism for aerobic degradation of TAN TCE plume far downgradient.	5	5	5	45	M(3.00)	??	1.69	15
Need studies of long-term degradation of landfill covers including plant uptake, ability to simulate the effects of freeze/thaw cycles on soil covers over long periods of time, effects of evapotranspiration.	5	6	6	49	M(2.88)	??	1.65	17
5.Criterion 5								
Need to develop in-situ remediation techniques such as subsurface reactive barriers and bioremediation.	11	4		67	H(4.47)	H	0.92	15
Need non-intrusive methods for in-situ testing of grout emplacement (e.g. consistency, binding with waste, compressive strength, where did it go).	12	3	1	70	H(4.38)	H	1.20	16
Need development of reliable long-lasting sensors with low failure rate that could be either placed below the liners at landfills or be placed in the liner itself for long-term leak detection.	12	3	1	70	H(4.38)	H	1.20	16
Needs improved techniques on grout emplacement.	9	6	1	64	H(4.00)	H	1.26	16
Need studies on long-term grout performance testing.	8	5	2	57	M(3.80)	H	1.47	15

Need	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need to develop a methods for collecting representative samples of sludge and sediments from tanks (i.e. from PM-2A).	8	2	4	50	M(3.57)	H	1.83	14
Develop a scientific justification to optimize lateral extent of surface caps.	8	4	4	56	M(3.50)	H	1.71	16
Need development of long lasting, mobile, easily detected tracers that could be buried with the waste at landfills.	6	7	3	54	M(3.38)	M	1.50	16
Need studies of long-term degradation of landfill covers including plant uptake, ability to simulate the effects of freeze/thaw cycles on soil covers over long periods of time, effects of evapotranspiration.	7	4	5	52	M(3.25)	H	1.77	16
Need studies on grout formulation.	5	5	4	44	M(3.14)	??	1.66	14
Need continued development of advanced detection of criticality sensor for the SDA subsurface (pit-9).	7	2	6	47	M(3.13)	H	1.92	15
Need development of in situ methods for measuring hydraulic conductivity in a grouted mass.	7	3	6	50	M(3.13)	H	1.86	16
Need a method to rehabilitate plugged OCVZ wells and methods to prevent plugging.	4	7	4	45	M(3.00)	M	1.51	15
Need development of point measurement approaches for measuring infiltration through the CFA landfill cover and any other INEEL covers.	5	5	5	45	M(3.00)	??	1.69	15
Need to investigate mechanism for aerobic degradation of TAN TCE plume far downgradient.	3	8	4	43	M(2.87)	M	1.41	15
Need an evaluation of the thrust block grouting technique for retrieval and production grouting.	3	7	4	40	M(2.86)	M	1.46	14
Need to develop alternatives for sodium lactate for ISB. Alternate electron donor.	4	4	7	39	M(2.60)	L	1.72	15
Need to investigate effects of the development of condensation beneath impermeable barriers.	4	3	7	36	M(2.57)	L	1.79	14
6.Criterion 6								
Need non-intrusive methods for in-situ testing of grout emplacement (e.g. consistency, binding with waste, compressive strength, where did it go).	8	2	6	52	M(3.25)	H	1.91	16
Needs improved techniques on grout emplacement.	6	4	6	48	M(3.00)	??	1.79	16
Need development of reliable long-lasting sensors with low failure rate that could be either placed below the liners at landfills or be placed in the liner itself for long-term leak detection.	6	3	7	46	M(2.88)	L	1.86	16
Need to develop a methods for collecting representative samples of sludge and sediments from tanks (i.e. from PM-2A).	5	4	6	43	M(2.87)	L	1.77	15
Need to develop in-situ remediation techniques such as subsurface reactive barriers and bioremediation.	5	4	6	43	M(2.87)	L	1.77	15
Need a method to rehabilitate plugged OCVZ wells and methods to prevent plugging.	5	4	6	43	M(2.87)	L	1.77	15
Need continued development of advanced detection of criticality sensor for the SDA subsurface (pit-9).	6	2	8	44	M(2.75)	L	1.91	16
Need an evaluation of the thrust block grouting technique for retrieval and production grouting.	4	5	6	41	M(2.73)	L	1.67	15

Need	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Develop a scientific justification to optimize lateral extent of surface caps.	5	3	7	41	M(2.73)	L	1.83	15
Need studies on grout formulation.	5	2	8	39	M(2.60)	L	1.88	15
Need studies on long-term grout performance testing.	5	1	9	37	M(2.47)	L	1.92	15
Need development of in situ methods for measuring hydraulic conductivity in a grouted mass.	5	1	9	37	M(2.47)	L	1.92	15
Need studies of long-term degradation of landfill covers including plant uptake, ability to simulate the effects of freeze/thaw cycles on soil covers over long periods of time, effects of evapotranspiration.	4	2	9	35	M(2.33)	L	1.80	15
Need development of point measurement approaches for measuring infiltration through the CFA landfill cover and any other INEEL covers.	2	4	10	32	M(2.00)	L	1.46	16
Need to investigate mechanism for aerobic degradation of TAN TCE plume far downgradient.	2	2	11	27	L(1.80)	L	1.47	15
Need to investigate effects of the development of condensation beneath impermeable barriers.	1	4	11	28	L(1.75)	L	1.24	16
Need development of long lasting, mobile, easily detected tracers that could be buried with the waste at landfills.	2	2	12	28	L(1.75)	L	1.44	16
Need to develop alternatives for sodium lactate for ISB. Alternate electron donor.	2	1	11	24	L(1.71)	L	1.49	14

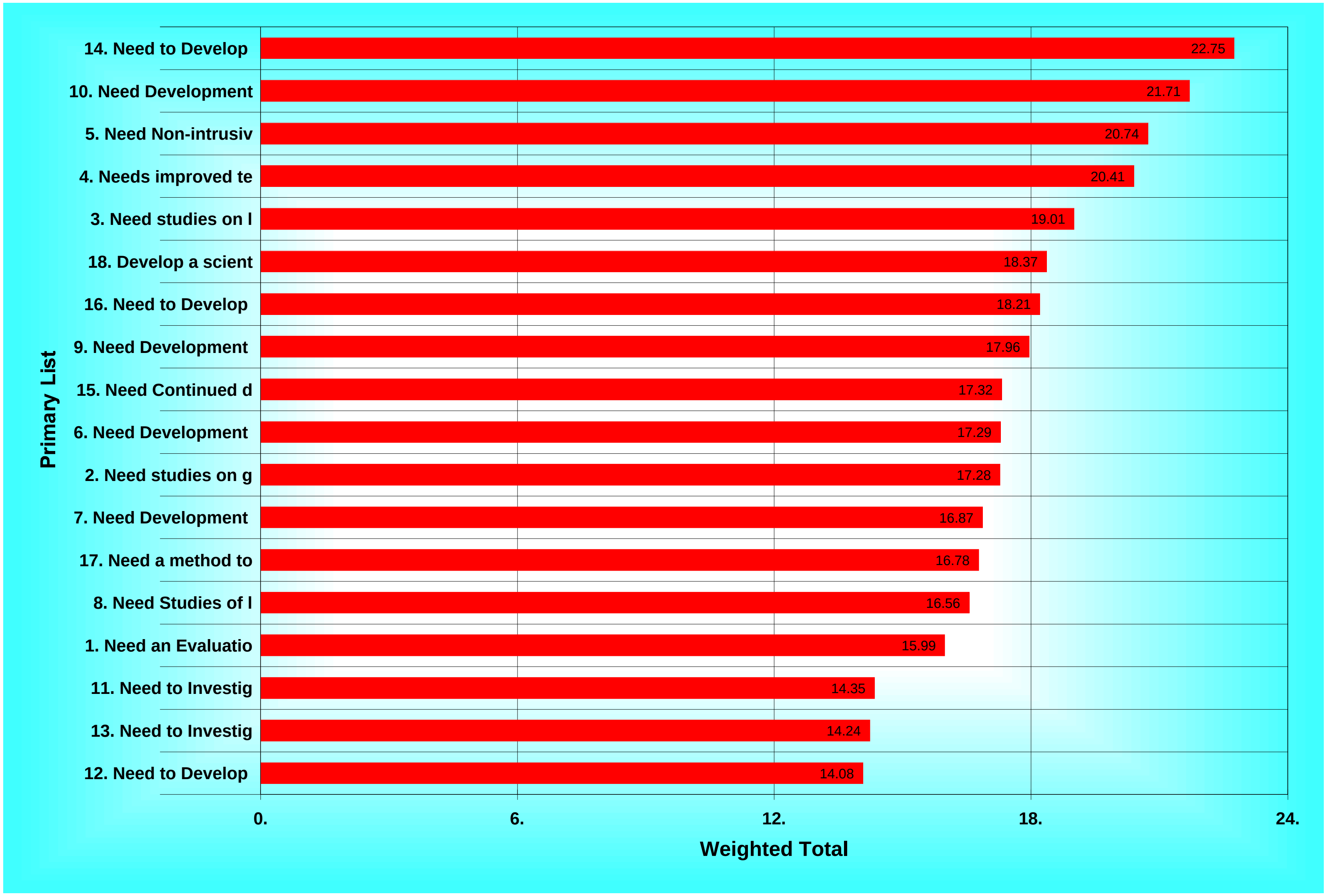

Figure 7. Weighted total scores of caps/barriers/grouting/remediation needs without criterion 1.

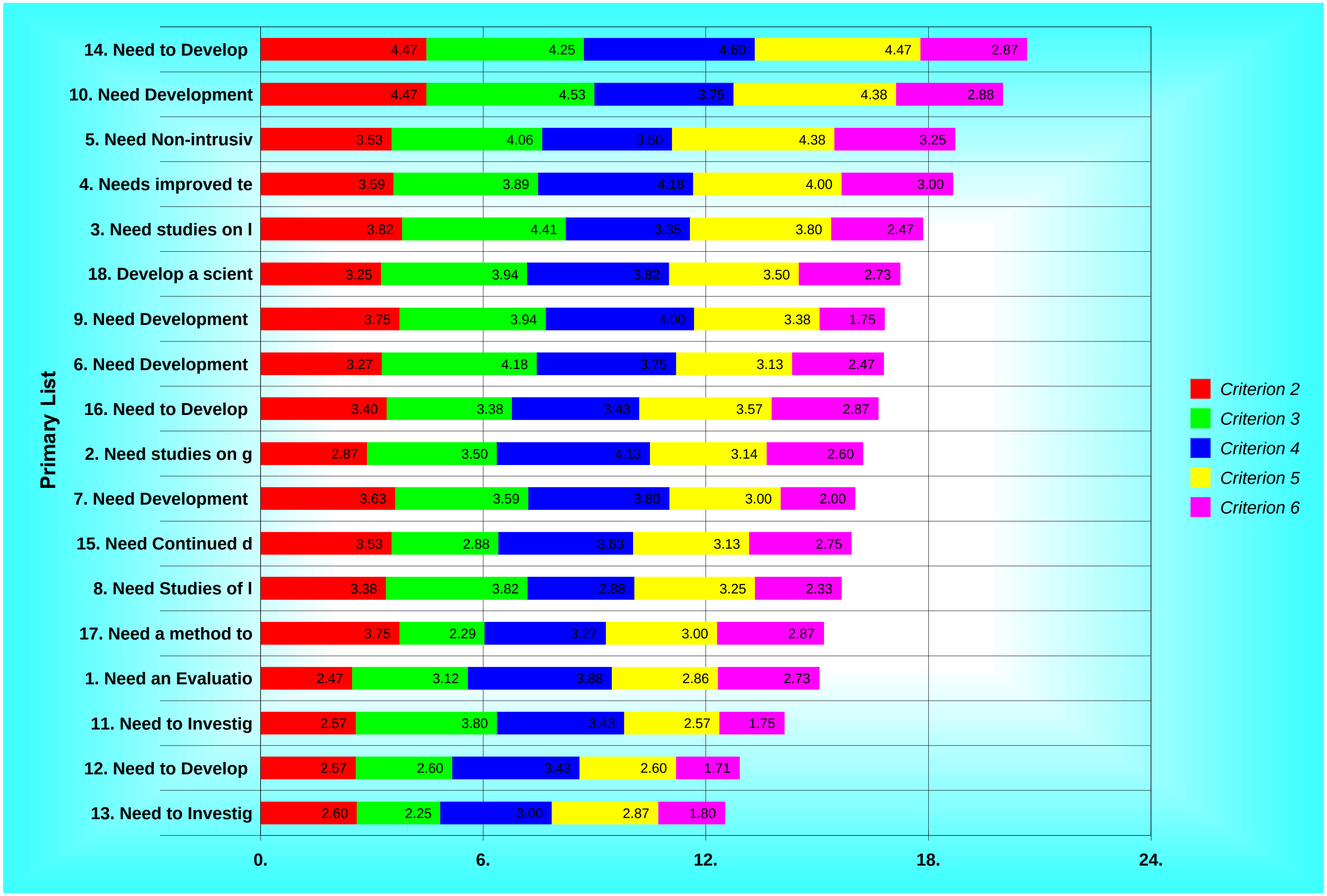

Figure 8. Unweighted criteria scores of caps/barriers/grouting/remediation needs without criterion 1.

Actinide Geochemistry Needs Group

Discussion and comments on the actinide geochemistry needs

1. Need solubility studies for actinide at selected sources.
    - (WAGs 7)(Uncertainties 5, 7, 13, 14, 16, 17, 18, 22){#33}
    - Depleted uranium {#248}
    - This defines whether or not the release is solubility dependent or sorption dependent. {#249}
    - Need Studies of solubility and release of U from waste forms. {#42}
        - ✓ (WAGs 7)(Uncertainties 5, 13, 14, 15, 18, 22){#43}
    - Effects of multiple waste streams with multiple oxidation states on solubility's is not necessarily well defined. {#253}
    - Solubility studies also need to evaluate physical form of source material. {#256}
    - This seems to be a source term issue that could easily apply to more than just the actinides. {#257}
2. Need studies to improve understanding of facilitated transport of actinide (e.g. colloid).
    - (WAGs 7)(Uncertainties 5, 7, 13, 14, 16, 17, 18, 22){#37}
    - Colloid-assisted transport modes may be the most important for some colloids. High priority. {#254}
    - Improving understanding of colloids should involve measurement of whether colloids even exist, and to what extent they exist, beneath the SDA. {#255}
    - Re #255, small-scale studies have measured the amounts of colloids in vadose zone samples. What hasn't been done is to ascertain how actinides are or are not associated with the colloids. Or what conditions would lead to the actinides being associated with the colloids and becoming mobile. The Clemson column studies are the starting point for this investigation. {#261}
    - May be difficult to simulate the variations in underburden thickness and vertical fracturing in basalt to provide useful information for the OU 7-13/14 RI {#262}
    - Very important from a perception and explaining irregular hits of actinides. Probably not important from an actual risk assessment (exposure for many decades) point of view. Whether it is important or not depends on the need you are evaluating it against. {#264}
    - Field studies with traceable artificial colloids would be of great value. {#265}
3. Need studies to better define source of elevated U in the vadose zone at Pit 5 and west end of SDA.
    - (WAGs 7)(Uncertainties 3, 5, 7, 9, 13, 15, 17, 18, 22){#45}
    - Not sure this is an R&D need {#252}
    - This is a need for the RI at WAG 7. This information is needed within the next two years {#266}
    - Re #252, I think it is a R&D need because it is a phenomenon that is not explainable with current understanding of transport at the SDA. To demonstrate linkage between R&D and Operations, this is the type of research that could be performed under the constraint that it has to benefit Operations. {#267}
4. Need to know the geochemical characteristics (e.g. oxidation states) of the near field environment for actinides.
    - Need a better understanding of Oxidation States for actinide within selected sources. {#34}
        - ✓ (WAGs 7)(Uncertainties 5, 7, 13, 14, 16, 17, 18, 22){#35}
    - This need applies to COC's other than actinides. Near field geochemistry can affect the release and transport of other chemical species. {#258}

- This is critical information for Pu groundwater risk assessment fate & transport modeling for the SDA {#259}
- This information is needed for both pre- and post-remediation. The post remediation information is needed to assess residual risk for the remedial actions that will be considered in the feasibility study for WAG 7. {#260}
- This information is needed within the next two years {#263}

Unclear need, more information is needed for clarity

1. Need better monitoring of Clemson Studies.
   - (WAGs 7)(Uncertainties 10, 14, 16){#39}
2. Need better Utilization of larger column studies than Clemson.
   - (WAGs 7)(Uncertainties 10, 14, 16){#41}

Actinide geochemistry needs rated against the criteria

This table shows the average scores for each of the criteria within a need. The color of the cell indicates the level of consensus of the scores within that cell. A green cell indicates a high level of consensus and a red cell indicates a low level of consensus. The blue cells were not rated by the participants during the meeting.

A consensus threshold value was set to help focus the group on those cells that had the most disagreement in the scores in the limited time available for discussion. It was not intended to imply that the group was in agreement on the score in that cell. The threshold level for consensus was set at 0.50. Typically, the threshold is set at 0.6 for discussion. The lower than normal threshold is indicative of the different perspectives of the participants.

Need	Criterion						Total	Mean	STD	Weighted Total
	1	2	3	4	5	6				
Weight	0.65	0.95	0.26	1.06	2.29	0.80				
1.Need solubility studies for actinide at selected sources.		M(3.80)	L(1.80)	M(3.53)	M(3.40)	M(2.87)	15.40	M(3.08)	0.79	17.90
2.Need studies to improve understanding of facilitated transport of actinide (e.g. colloid).		H(5.00)	M(3.80)	M(3.93)	H(4.33)	M(3.40)	20.47	H(4.09)	0.61	22.55
3.Need studies to better define source of elevated U in the vadose zone at Pit 5 and west end of SDA.		M(3.53)	L(1.53)	M(3.80)	H(4.07)	M(3.53)	16.47	M(3.29)	1.01	19.92
4.Need to know the geochemical characteristics (e.g. oxidation states) of the near field environment for actinides.		H(4.47)	M(3.13)	M(3.53)	H(4.20)	M(3.40)	18.73	M(3.75)	0.56	21.14

Criteria scores by need

This table shows the distribution of scores (H, M, L) across the six criteria for each of the needs. The number within a criteria/score cell indicates the number of participants that used that score for that criteria. Within a need, the criteria are sorted from the highest to the lowest mean score.

Criterion	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
1.Need solubility studies for actinide at selected sources.									

Criterion	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 2 (0.95)	10	1	4	57	M(3.80)	H	1.82	15	3.61
Criterion 4 (1.06)	6	7	2	53	M(3.53)	M	1.41	15	3.75
Criterion 5 (2.29)	8	2	5	51	M(3.40)	H	1.88	15	7.79
Criterion 6 (0.80)	6	2	7	43	M(2.87)	L	1.92	15	2.29
Criterion 3 (0.26)	1	4	10	27	L(1.80)	L	1.26	15	0.47
Criterion 1 (0.65)								0	
2.Need studies to improve understanding of facilitated transport of actinide (e.g. colloid).									
Criterion 2 (0.95)	15			75	H(5.00)	H	0.00	15	4.75
Criterion 5 (2.29)	11	3	1	65	H(4.33)	H	1.23	15	9.92
Criterion 4 (1.06)	8	6	1	59	M(3.93)	H	1.28	15	4.17
Criterion 3 (0.26)	9	3	3	57	M(3.80)	H	1.66	15	0.99
Criterion 6 (0.80)	8	2	5	51	M(3.40)	H	1.88	15	2.72
Criterion 1 (0.65)								0	
3.Need studies to better define source of elevated U in the vadose zone at Pit 5 and west end of SDA.									
Criterion 5 (2.29)	9	5	1	61	H(4.07)	H	1.28	15	9.31
Criterion 4 (1.06)	8	5	2	57	M(3.80)	H	1.47	15	4.03
Criterion 2 (0.95)	6	7	2	53	M(3.53)	M	1.41	15	3.36
Criterion 6 (0.80)	7	5	3	53	M(3.53)	H	1.60	15	2.83
Criterion 3 (0.26)		4	11	23	L(1.53)	L	0.92	15	0.40
Criterion 1 (0.65)								0	
4.Need to know the geochemical characteristics (e.g. oxidation states) of the near field environment for actinides.									
Criterion 2 (0.95)	11	4		67	H(4.47)	H	0.92	15	4.24
Criterion 5 (2.29)	11	2	2	63	H(4.20)	H	1.47	15	9.62
Criterion 4 (1.06)	7	5	3	53	M(3.53)	H	1.60	15	3.75
Criterion 6 (0.80)	7	4	4	51	M(3.40)	H	1.72	15	2.72

Criterion	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 3 (0.26)	6	4	5	47	M(3.13)	H	1.77	15	0.81
Criterion 1 (0.65)								0	

Need scores by criteria

This table shows the distribution of scores (H, M, L) across the needs for each of the six criteria. The number in each cell of the matrix indicates the number of participants who placed the criteria at that position on the list.

Need	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
2.Criterion 2								
Need studies to improve understanding of facilitated transport of actinide (e.g. colloid).	15			75	H(5.00)	H	0.00	15
Need to know the geochemical characteristics (e.g. oxidation states) of the near field environment for actinides.	11	4		67	H(4.47)	H	0.92	15
Need solubility Studies for actinide at selected sources.	10	1	4	57	M(3.80)	H	1.82	15
Need studies to better define source of elevated U in the vadose zone at Pit 5 and west end of SDA.	6	7	2	53	M(3.53)	M	1.41	15
3.Criterion 3								
Need studies to improve understanding of facilitated transport of actinide (e.g. colloid).	9	3	3	57	M(3.80)	H	1.66	15
Need to know the geochemical characteristics (e.g. oxidation states) of the near field environment for actinides.	6	4	5	47	M(3.13)	H	1.77	15
Need solubility Studies for actinide at selected sources.	1	4	10	27	L(1.80)	L	1.26	15
Need studies to better define source of elevated U in the vadose zone at Pit 5 and west end of SDA.		4	11	23	L(1.53)	L	0.92	15
4.Criterion 4								
Need studies to improve understanding of facilitated transport of actinide (e.g. colloid).	8	6	1	59	M(3.93)	H	1.28	15
Need studies to better define source of elevated U in the vadose zone at Pit 5 and west end of SDA.	8	5	2	57	M(3.80)	H	1.47	15
Need solubility Studies for actinide at selected sources.	6	7	2	53	M(3.53)	M	1.41	15
Need to know the geochemical characteristics (e.g. oxidation states) of the near field environment for actinides.	7	5	3	53	M(3.53)	H	1.60	15
5.Criterion 5								
Need studies to improve understanding of facilitated transport of actinide (e.g. colloid).	11	3	1	65	H(4.33)	H	1.23	15

Need	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need to know the geochemical characteristics (e.g. oxidation states) of the near field environment for actinides.	11	2	2	63	H(4.20)	H	1.47	15
Need studies to better define source of elevated U in the vadose zone at Pit 5 and west end of SDA.	9	5	1	61	H(4.07)	H	1.28	15
Need solubility Studies for actinide at selected sources.	8	2	5	51	M(3.40)	H	1.88	15
6.Criterion 6								
Need studies to better define source of elevated U in the vadose zone at Pit 5 and west end of SDA.	7	5	3	53	M(3.53)	H	1.60	15
Need to know the geochemical characteristics (e.g. oxidation states) of the near field environment for actinides.	7	4	4	51	M(3.40)	H	1.72	15
Need studies to improve understanding of facilitated transport of actinide (e.g. colloid).	8	2	5	51	M(3.40)	H	1.88	15
Need solubility Studies for actinide at selected sources.	6	2	7	43	M(2.87)	L	1.92	15

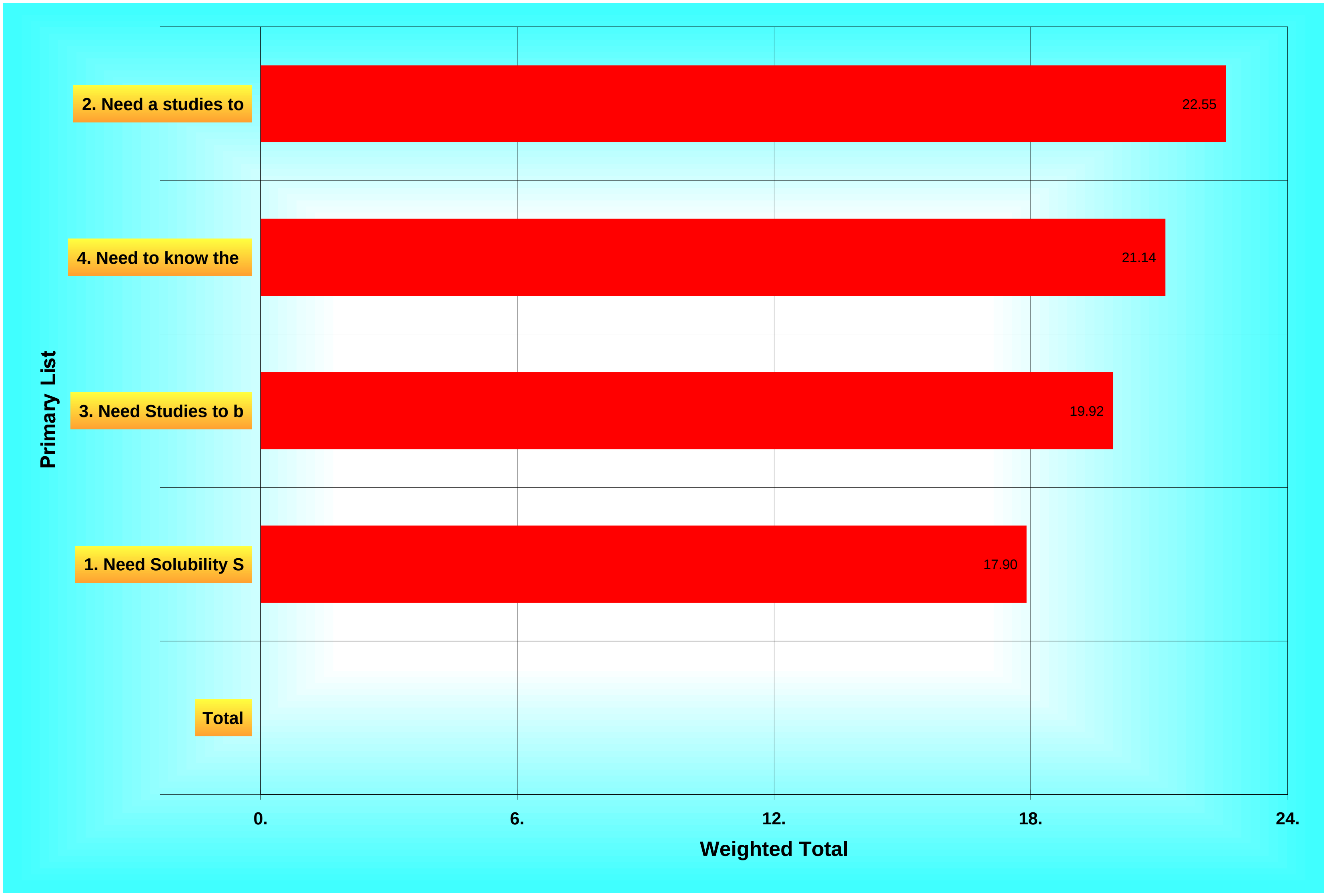

Figure 9. Weighted total scores of actinide geochemistry needs without criterion 1.

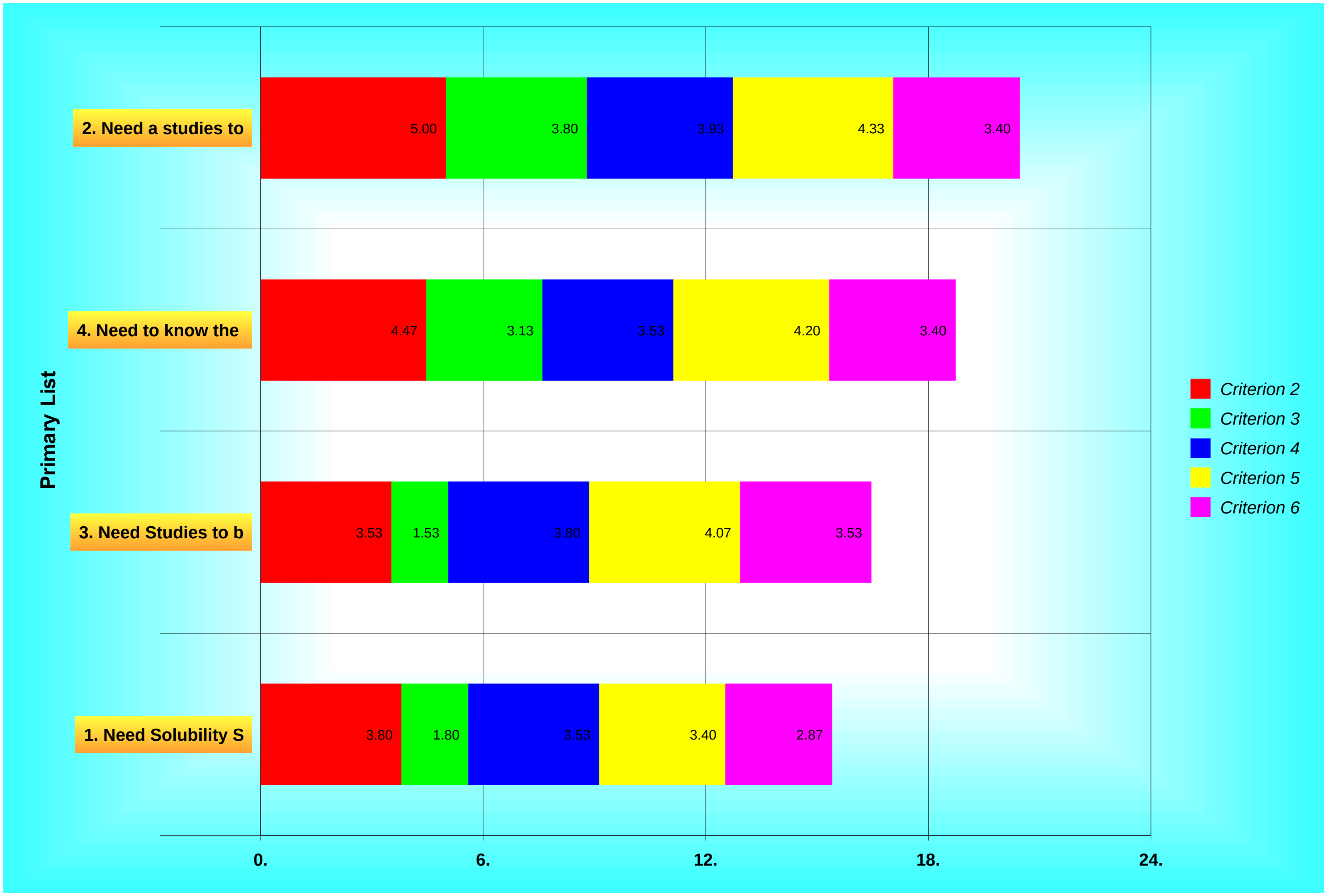

Figure 10. Unweighted criteria scores of actinide geochemistry needs without criterion 1.

Plutonium Needs Group

Discussion and comments on the plutonium needs

1. Need a better understanding of the spatial distribution of Kd values for Pu at selected sites.
    - (WAGs 3,7)(Uncertainties 5, 7, 16, 17, 19){#3}
    - Not important. Kd values are virtually useless for evaluating Pu transport. {#256}
2. Need a better understanding of absorption process (including competing process, non equilibrium).
    - Need to Develop a partitioning model for Pu.{#16}
        - ✓ (WAGs 3, 7)(Uncertainties 5, 7, 17, 22, 25){#17}
    - Need to Investigate Pu partitioning after movement into the basalt. {#18}
        - ✓ (WAGs 7)(Uncertainties 5, 7, 10, 17){#19}
    - Extremely important. Absorption is the key issue in transport of Pu and it is not realistically represented by Kd methods. {#255}
3. Need to take samples to reflect ambient water and soil conditions across the site.
    - (WAGs 3, Site-wide)(Uncertainties 1, 2, 3, 4, 7, 8){#7}
    - I suspect that isotope speciation should be able to tell you if the Pu comes from the INEEL source, in many cases. {#260}
    - The real need is to establish a baseline for the INEEL to show where additional contamination may or may not have been detected. {#261}
    - The need should really be to develop a background for Pu at the INEEL. {#262}
4. Need improved understanding of the mechanisms of facilitated transport and how to represent it in models.
    - (WAGs 3, 7)(Uncertainties 7, 10, 15, 16, 17, 18, 23){#9}
    - This should also be applied to actinides other than Pu. {#250}
    - Need to better understand Migration and Transport for Pu.{#4}
        - ✓ (WAGs 3)(Uncertainties 1, 5, 7, 12, 14, 15, 16, 17, 18, 19, 21, 22){#5}
    - Need a better understanding of Pu Mobility and formation of colloids.{#10}
        - ✓ (WAGs 7)(Uncertainties 5, 7, 15, 17, 18, 22, 23){#11}
    - Important for Pu as for most other COCs. {#258}
5. Need to evaluate how installation of monitoring equipment affects how Pu is detected.
    - (WAGs 7)(Uncertainties 3, 7, 9, 21){#15}
6. Need to have improved methods for public communication of the risks due to Pu compared to other contaminants.
    - Exists {#254}
    - Need to integrate R&D and Public Relations so that a clear and informative risk picture is presented. {#257}
    - I doubt that we can undo all the flaws in public education, nor eliminate that aspect of the public persona that responds to fear-mongering. {#259}
    - This addresses a real problem, and one that has not been effectively dealt with yet. {#263}
    - Maybe the funding for this can come out of the State Budget. After all, this is Dirk's "The Decade of the Child." {#264}

Unclear need, more information is needed for clarity

1. Need to develop better monitoring methods.
    - (WAGs 7)(Uncertainties 1, 3, 5, 7, 16, 21, 22){#13}

Plutonium geochemistry needs rated against the criteria

This table shows the average scores for each of the criteria within a need. The color of the cell indicates the level of consensus of the scores within that cell. A green cell indicates a high level of consensus and a red cell indicates a low level of consensus. The blue cells were not rated by the participants during the meeting.

A consensus threshold value was set to help focus the group on those cells that had the most disagreement in the scores in the limited time available for discussion. It was not intended to imply that the group was in agreement on the score in that cell. The threshold level for consensus was set at 0.50. Typically, the threshold is set at 0.6 for discussion. The lower than normal threshold is indicative of the different perspectives of the participants.

Need	Criterion						Total	Mean	STD	Weighted Total
	1	2	3	4	5	6				
Weight	0.65	0.05	0.26	1.06	2.29	0.80				
1.Need a better understanding of the spatial distribution of Kd values for Pu at selected sites.		M(2.45)	L(1.91)	M(2.09)	M(2.09)	L(1.55)	10.09	M(2.02)	0.33	8.86
2.Need a better understanding of absorption process (including competing process, non equilibrium).		H(4.33)	M(3.67)	H(4.00)	H(4.09)	M(3.91)	20.00	H(4.00)	0.24	17.91
3.Need to take samples to reflect ambient water and soil conditions across the site.		M(3.00)	M(2.00)	H(4.17)	M(2.67)	M(2.33)	14.17	M(2.83)	0.83	13.06
4.Need improved understanding of the mechanisms of facilitated transport and how to represent it in models.		H(4.67)	H(4.27)	H(4.45)	H(4.27)	M(3.36)	21.03	H(4.21)	0.50	18.54
5.Need to evaluate how installation of monitoring equipment affects how Pu is detected.		M(2.27)	M(2.45)	M(3.00)	M(2.09)	L(1.73)	11.55	M(2.31)	0.47	10.10
6.Need to have improved methods for public communication of the risks due to Pu compared to other contaminants.		M(3.77)	M(3.46)	M(3.77)	M(3.33)	M(3.50)	17.83	M(3.57)	0.19	15.52

Criteria scores by need

This table shows the distribution of scores (H, M, L) across the six criteria for each of the needs. The number within a criteria/score cell indicates the number of participants that used that score for that criteria. Within a need, the criteria are sorted from the highest to the lowest mean score.

Criterion	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
1.Need a better understanding of the spacial distribution of Kd values for Pu at selected sites.									
Criterion 2 (0.05)	2	4	5	27	M(2.45)	L	1.57	11	0.12
Criterion 4 (1.06)	1	4	6	23	M(2.09)	L	1.38	11	2.22
Criterion 5 (2.29)	2	2	7	23	M(2.09)	L	1.64	11	4.79
Criterion 3 (0.26)	1	3	7	21	L(1.91)	L	1.38	11	0.50
Criterion 6 (0.80)	1	1	9	17	L(1.55)	L	1.29	11	1.24
Criterion 1 (0.65)								0	
2.Need a better understanding of absorption process (including competing process, non equilibrium).									
Criterion 2 (0.05)	10		2	52	H(4.33)	H	1.56	12	0.22
Criterion 5 (2.29)	8	1	2	45	H(4.09)	H	1.64	11	9.37
Criterion 4 (1.06)	7	4	1	48	H(4.00)	H	1.35	12	4.24
Criterion 6 (0.80)	8		3	43	M(3.91)	H	1.87	11	3.13
Criterion 3 (0.26)	6	4	2	44	M(3.67)	H	1.56	12	0.95
Criterion 1 (0.65)								0	
3.Need to take samples to reflect ambient water and soil conditions across the site.									
Criterion 4 (1.06)	8	3	1	50	H(4.17)	H	1.34	12	4.42
Criterion 2 (0.05)	4	4	4	36	M(3.00)	??	1.71	12	0.15
Criterion 5 (2.29)	3	4	5	32	M(2.67)	L	1.67	12	6.11
Criterion 6 (0.80)	1	6	5	28	M(2.33)	M	1.30	12	1.87
Criterion 3 (0.26)		6	6	24	M(2.00)	??	1.04	12	0.52
Criterion 1 (0.65)								0	

Criterion	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
4.Need improved understanding of the mechanisms of facilitated transport and how to represent it in models.									
Criterion 2 (0.05)	11		1	56	H(4.67)	H	1.15	12	0.23
Criterion 4 (1.06)	8	3		49	H(4.45)	H	0.93	11	4.72
Criterion 3 (0.26)	8	2	1	47	H(4.27)	H	1.35	11	1.11
Criterion 5 (2.29)	9		2	47	H(4.27)	H	1.62	11	9.78
Criterion 6 (0.80)	5	3	3	37	M(3.36)	H	1.75	11	2.69
Criterion 1 (0.65)								0	
5.Need to evaluate how installation of monitoring equipment affects how Pu is detected.									
Criterion 4 (1.06)	3	5	3	33	M(3.00)	M	1.55	11	3.18
Criterion 3 (0.26)	1	6	4	27	M(2.45)	M	1.29	11	0.64
Criterion 2 (0.05)		7	4	25	M(2.27)	M	1.01	11	0.11
Criterion 5 (2.29)	2	2	7	23	M(2.09)	L	1.64	11	4.79
Criterion 6 (0.80)		4	7	19	L(1.73)	L	1.01	11	1.38
Criterion 1 (0.65)								0	
6.Need to have improved methods for public communication of the risks due to Pu compared to other contaminants.									
Criterion 4 (1.06)	7	4	2	49	M(3.77)	H	1.54	13	4.00
Criterion 2 (0.05)	8	2	3	49	M(3.77)	H	1.74	13	0.19
Criterion 6 (0.80)	7	1	4	42	M(3.50)	H	1.93	12	2.80
Criterion 3 (0.26)	7	2	4	45	M(3.46)	H	1.85	13	0.90
Criterion 5 (2.29)	5	4	3	40	M(3.33)	H	1.67	12	7.63
Criterion 1 (0.65)								0	

Need scores by criteria

This table shows the distribution of scores (H, M, L) across the needs for each of the six criteria. The number in each cell of the matrix indicates the number of participants who placed the criteria at that position on the list.

Need	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
2.Criterion 2								
Need improved understanding of the mechanisms of facilitated transport and how to represent it in models.	11		1	56	H(4.67)	H	1.15	12
Need a better understanding of absorption process (including competing process, non equilibrium).	10		2	52	H(4.33)	H	1.56	12
Need to have improved methods for public communication of the risks due to Pu compared to other contaminants.	8	2	3	49	M(3.77)	H	1.74	13
Need to take samples to reflect ambient water and soil conditions across the site.	4	4	4	36	M(3.00)	??	1.71	12
Need a better understanding of the spatial distribution of Kd values for Pu at selected sites.	2	4	5	27	M(2.45)	L	1.57	11
Need to evaluate how installation of monitoring equipment affects how Pu is detected.		7	4	25	M(2.27)	M	1.01	11
3.Criterion 3								
Need improved understanding of the mechanisms of facilitated transport and how to represent it in models.	8	2	1	47	H(4.27)	H	1.35	11
Need a better understanding of absorption process (including competing process, non equilibrium).	6	4	2	44	M(3.67)	H	1.56	12
Need to have improved methods for public communication of the risks due to Pu compared to other contaminants.	7	2	4	45	M(3.46)	H	1.85	13
Need to evaluate how installation of monitoring equipment affects how Pu is detected.	1	6	4	27	M(2.45)	M	1.29	11
Need to take samples to reflect ambient water and soil conditions across the site.		6	6	24	M(2.00)	??	1.04	12
Need a better understanding of the spatial distribution of Kd values for Pu at selected sites.	1	3	7	21	L(1.91)	L	1.38	11
4.Criterion 4								
Need improved understanding of the mechanisms of facilitated transport and how to represent it in models.	8	3		49	H(4.45)	H	0.93	11
Need to take samples to reflect ambient water and soil conditions across the site.	8	3	1	50	H(4.17)	H	1.34	12
Need a better understanding of absorption process (including competing process, non equilibrium).	7	4	1	48	H(4.00)	H	1.35	12
Need to have improved methods for public communication of the risks due to Pu compared to other contaminants.	7	4	2	49	M(3.77)	H	1.54	13
Need to evaluate how installation of monitoring equipment affects how Pu is detected.	3	5	3	33	M(3.00)	M	1.55	11

Need	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need a better understanding of the spatial distribution of Kd values for Pu at selected sites.	1	4	6	23	M(2.09)	L	1.38	11
5.Criterion 5								
Need improved understanding of the mechanisms of facilitated transport and how to represent it in models.	9		2	47	H(4.27)	H	1.62	11
Need a better understanding of absorption process (including competing process, non equilibrium).	8	1	2	45	H(4.09)	H	1.64	11
Need to have improved methods for public communication of the risks due to Pu compared to other contaminants.	5	4	3	40	M(3.33)	H	1.67	12
Need to take samples to reflect ambient water and soil conditions across the site.	3	4	5	32	M(2.67)	L	1.67	12
Need a better understanding of the spatial distribution of Kd values for Pu at selected sites.	2	2	7	23	M(2.09)	L	1.64	11
Need to evaluate how installation of monitoring equipment affects how Pu is detected.	2	2	7	23	M(2.09)	L	1.64	11
6.Criterion 6								
Need a better understanding of absorption process (including competing process, non equilibrium).	8		3	43	M(3.91)	H	1.87	11
Need to have improved methods for public communication of the risks due to Pu compared to other contaminants.	7	1	4	42	M(3.50)	H	1.93	12
Need improved understanding of the mechanisms of facilitated transport and how to represent it in models.	5	3	3	37	M(3.36)	H	1.75	11
Need to take samples to reflect ambient water and soil conditions across the site.	1	6	5	28	M(2.33)	M	1.30	12
Need to evaluate how installation of monitoring equipment affects how Pu is detected.		4	7	19	L(1.73)	L	1.01	11
Need a better understanding of the spatial distribution of Kd values for Pu at selected sites.	1	1	9	17	L(1.55)	L	1.29	11

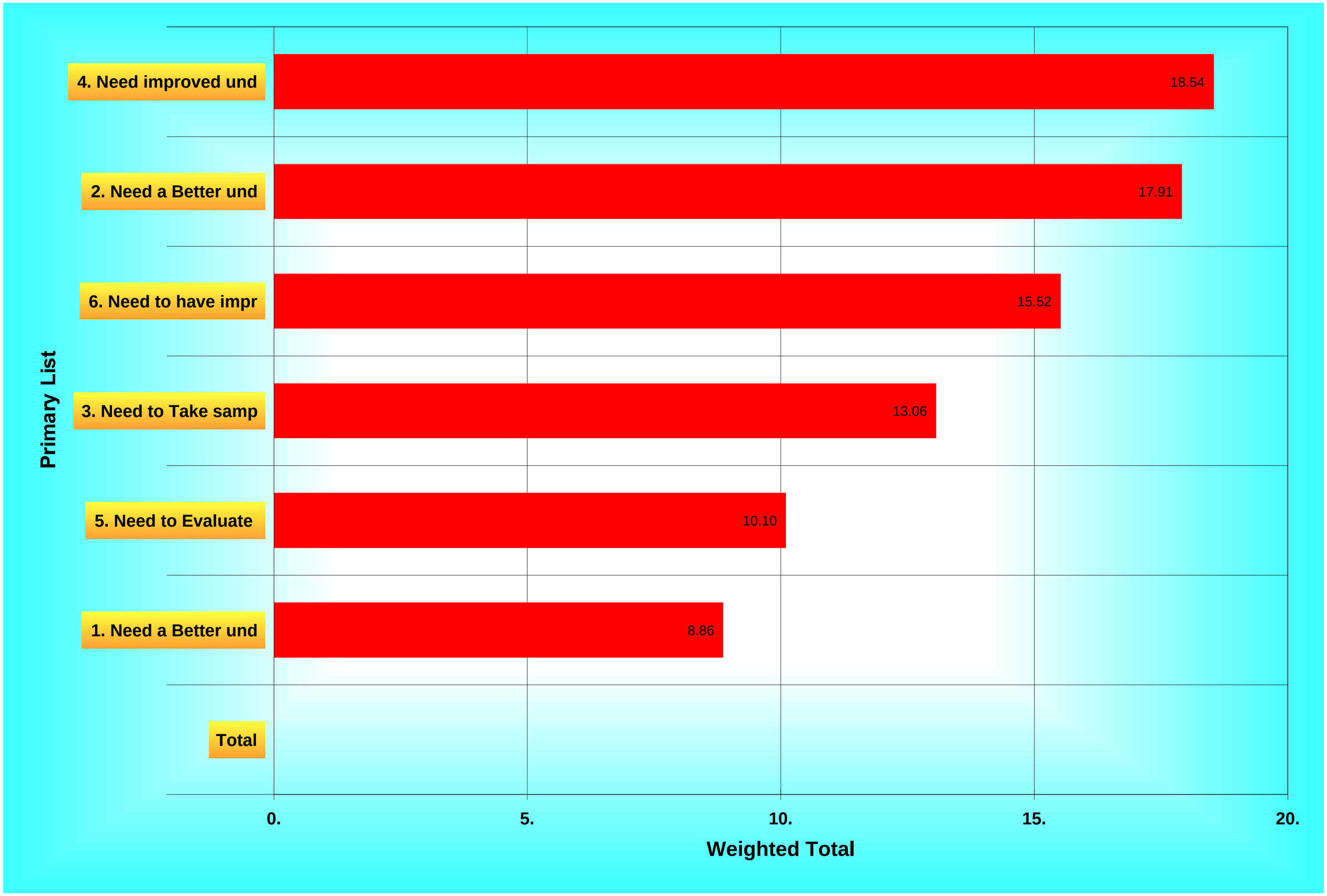

Figure 11. Weighted total scores of Plutonium needs without criterion 1.

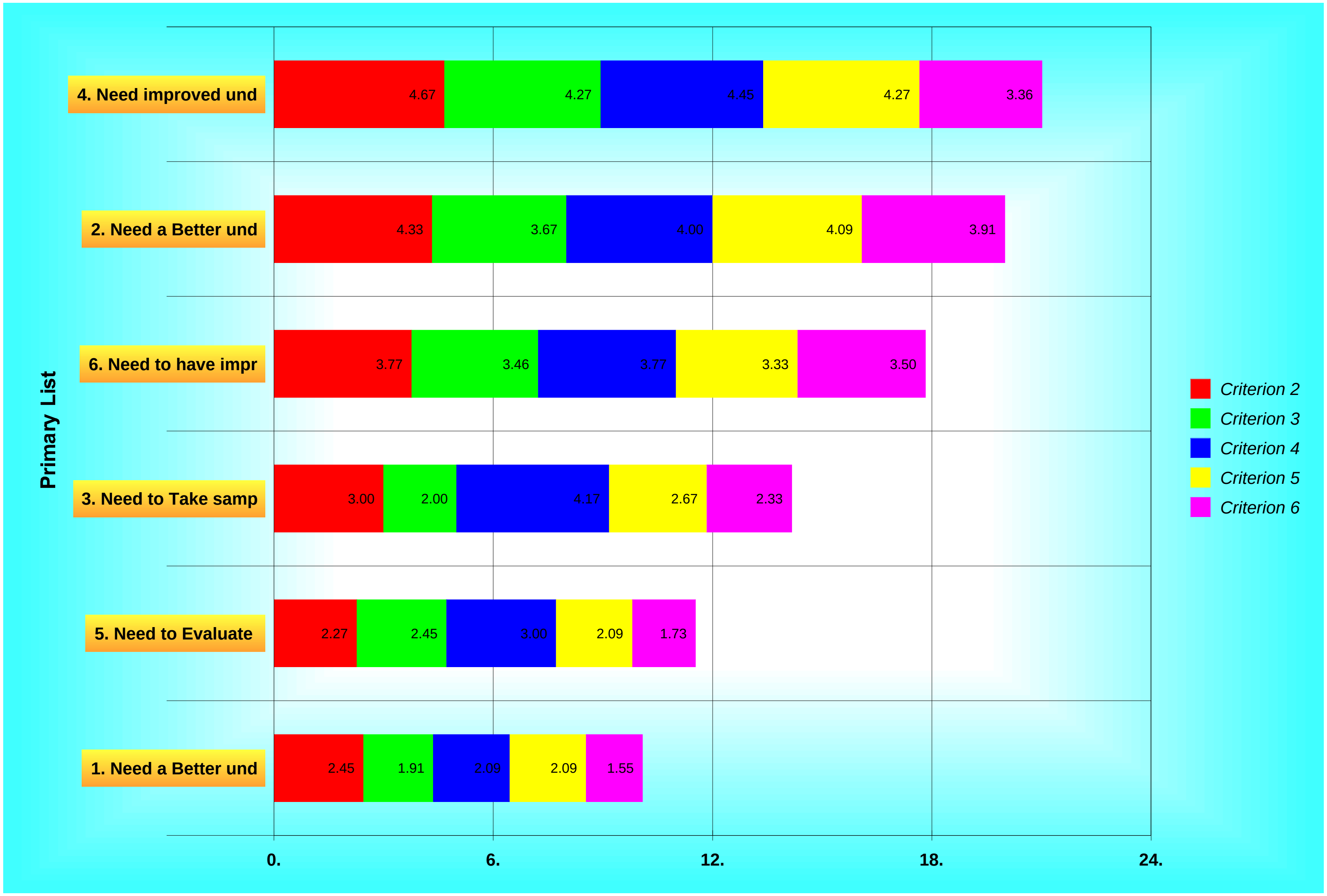

Figure 12. Unweighted criteria scores of Plutonium needs without criterion 1.

C_{14} Needs Group

Discussion and comments on the C_{14} needs

1. Need a better understanding of multi-phase transport of C14 at the SDA.
    - (WAGs 7)(Uncertainties 5, 12, 15, 17, 18){#21}
    - Need a better understanding of isotope mobility.{#22}
        - ✓ (WAGs 7)(Uncertainties 5, 11, 12, 15, 17, 18, 19, 22){#23}
    - Need a better understanding of movement in the subsurface.{#24}
        - ✓ (WAGs 7)(Uncertainties 5, 11, 12, 15, 17, 18, 19, 22){#25}
    - Emphasis on multiple phases is essential. {#250}
2. Need more data and better analysis of C14 concentration trends in all media at the SDA.
    - (WAGs 7)(Uncertainties 3, 5, 12, 16, 17, 18, 19, 21, 22){#27}
    - Aquifer, vadose zone, source, and atmosphere. {#247}
3. Need a better understanding of the origin of the C14 detected between WAGS 3,2, &7.
    - (WAGs 2, 3, 7)(Uncertainties 2, 3, 5, 6, 8, 12, 15, 16, 17, 18, 19, 21, 22, 23){#29}

Unclear need, more information is needed for clarity

1. Need studies of degradation products from C14.
    - (WAGs 7)(Uncertainties 1, 3, 5, 8, 9, 10, 15, 16, 17, 18, 19){#31}
    - If this was a request to evaluate daughter products of C-14 for evidence of historical migration of C-14, it may be included as a potential subset of the new #2. {#251}

C_{14} needs rated against the criteria

This table shows the average scores for each of the criteria within a need. The color of the cell indicates the level of consensus of the scores within that cell. A green cell indicates a high level of consensus and a red cell indicates a low level of consensus. The blue cells were not rated by the participants during the meeting.

A consensus threshold value was set to help focus the group on those cells that had the most disagreement in the scores in the limited time available for discussion. It was not intended to imply that the group was in agreement on the score in that cell. The threshold level for consensus was set at 0.50. Typically, the threshold is set at 0.6 for discussion. The lower than normal threshold is indicative of the different perspectives of the participants.

	Criterion									
Needs	**1**	**2**	**3**	**4**	**5**	**6**	**Total**	**Mean**	**STD**	**Weighted Total**
Weight	0.65	0.95	0.26	1.06	2.29	0.80				
1.Need a better understanding of multi-phase transport of C14 at the SDA.		H(4.57)	H(4.14)	H(4.00)	H(4.57)	M(3.71)	21.00	H(4.20)	0.37	23.10
2.Need more data and better analysis of C14 concentration trends in all media at the SDA.		H(4.14)	M(2.29)	H(4.29)	H(4.14)	M(3.14)	18.00	M(3.60)	0.87	21.07
3.Need a better understanding of the origin of the C14 detected between WAGS 3,2, &7.		M(3.57)	L(1.57)	M(3.43)	M(2.86)	M(2.29)	13.71	M(2.74)	0.83	15.81
4.Need to better understand the effect OCVZ vapor extraction system on interbed moisture contents and C14 transport.		M(3.46)	M(2.38)	M(3.62)	M(3.77)	M(3.00)	16.23	M(3.25)	0.56	18.77

Criteria scores by need

This table shows the distribution of scores (H, M, L) across the six criteria for each of the needs. The number within a criteria/score cell indicates the number of participants that used that score for that criteria. Within a need, the criteria are sorted from the highest to the lowest mean score.

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
1.Need a better understanding of multi-phase transport of C14 at the SDA.									
Criterion 2 (0.95)	12	1	1	64	H(4.57)	H	1.16	14	4.34
Criterion 5 (2.29)	12	1	1	64	H(4.57)	H	1.16	14	10.47
Criterion 3 (0.26)	10	2	2	58	H(4.14)	H	1.51	14	1.08
Criterion 4 (1.06)	8	5	1	56	H(4.00)	H	1.30	14	4.24
Criterion 6 (0.80)	8	3	3	52	M(3.71)	H	1.68	14	2.97
Criterion 1 (0.65)								0	
2.Need more data and better analysis of C14 concentration trends in all media at the SDA.									
Criterion 4 (1.06)	9	5		60	H(4.29)	H	0.99	14	4.54
Criterion 2 (0.95)	9	4	1	58	H(4.14)	H	1.29	14	3.94
Criterion 5 (2.29)	9	4	1	58	H(4.14)	H	1.29	14	9.49
Criterion 6 (0.80)	6	3	5	44	M(3.14)	H	1.83	14	2.51
Criterion 3 (0.26)	3	3	8	32	M(2.29)	L	1.68	14	0.59
Criterion 1 (0.65)								0	
3.Need a better understanding of the origin of the C14 detected between WAGS 3,2, &7.									
Criterion 2 (0.95)	5	8	1	50	M(3.57)	M	1.22	14	3.39
Criterion 4 (1.06)	4	9	1	48	M(3.43)	M	1.16	14	3.63
Criterion 5 (2.29)	4	5	5	40	M(2.86)	??	1.66	14	6.54
Criterion 6 (0.80)	2	5	7	32	M(2.29)	L	1.49	14	1.83
Criterion 3 (0.26)	1	2	11	22	L(1.57)	L	1.22	14	0.41
Criterion 1 (0.65)								0	
4.Need to better understand the effect OCVZ vapor extraction system on interbed moisture contents and C14 transport.									
Criterion 5 (2.29)	7	4	2	49	M(3.77)	H	1.54	13	8.63
Criterion 4 (1.06)	6	5	2	47	M(3.62)	H	1.50	13	3.83
Criterion 2 (0.95)	5	6	2	45	M(3.46)	M	1.45	13	3.29

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 6 (0.80)	4	5	4	39	M(3.00)	M	1.63	13	2.40
Criterion 3 (0.26)	1	7	5	31	M(2.38)	M	1.26	13	0.62
Criterion 1 (0.65)								0	

Need scores by criteria

This table shows the distribution of scores (H, M, L) across the needs for each of the six criteria. The number in each cell of the matrix indicates the number of participants who placed the criteria at that position on the list.

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
2.Criterion 2								
Need a better understanding of multi-phase transport of C14 at the SDA.	12	1	1	64	H(4.57)	H	1.16	14
Need more data and better analysis of C14 concentration trends in all media at the SDA.	9	4	1	58	H(4.14)	H	1.29	14
Need a better understanding of the origin of the C14 detected between WAGS 3,2, &7.	5	8	1	50	M(3.57)	M	1.22	14
Need to better understand the effect OCVZ vapor extraction system on interbed moisture contents and C14 transport.	5	6	2	45	M(3.46)	M	1.45	13
3.Criterion 3								
Need a better understanding of multi-phase transport of C14 at the SDA.	10	2	2	58	H(4.14)	H	1.51	14
Need to better understand the effect OCVZ vapor extraction system on interbed moisture contents and C14 transport.	1	7	5	31	M(2.38)	M	1.26	13
Need more data and better analysis of C14 concentration trends in all media at the SDA.	3	3	8	32	M(2.29)	L	1.68	14
Need a better understanding of the origin of the C14 detected between WAGS 3,2, &7.	1	2	11	22	L(1.57)	L	1.22	14
4.Criterion 4								
Need more data and better analysis of C14 concentration trends in all media at the SDA.	9	5		60	H(4.29)	H	0.99	14
Need a better understanding of multi-phase transport of C14 at the SDA.	8	5	1	56	H(4.00)	H	1.30	14
Need to better understand the effect OCVZ vapor extraction system on interbed moisture contents and C14 transport.	6	5	2	47	M(3.62)	H	1.50	13

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need a better understanding of the origin of the C14 detected between WAGS 3,2, &7.	4	9	1	48	M(3.43)	M	1.16	14
5.Criterion 5								
Need a better understanding of multi-phase transport of C14 at the SDA.	12	1	1	64	H(4.57)	H	1.16	14
Need more data and better analysis of C14 concentration trends in all media at the SDA.	9	4	1	58	H(4.14)	H	1.29	14
Need to better understand the effect OCVZ vapor extraction system on interbed moisture contents and C14 transport.	7	4	2	49	M(3.77)	H	1.54	13
Need a better understanding of the origin of the C14 detected between WAGS 3,2, &7.	4	5	5	40	M(2.86)	??	1.66	14
6.Criterion 6								
Need a better understanding of multi-phase transport of C14 at the SDA.	8	3	3	52	M(3.71)	H	1.68	14
Need more data and better analysis of C14 concentration trends in all media at the SDA.	6	3	5	44	M(3.14)	H	1.83	14
Need to better understand the effect OCVZ vapor extraction system on interbed moisture contents and C14 transport.	4	5	4	39	M(3.00)	M	1.63	13
Need a better understanding of the origin of the C14 detected between WAGS 3,2, &7.	2	5	7	32	M(2.29)	L	1.49	14

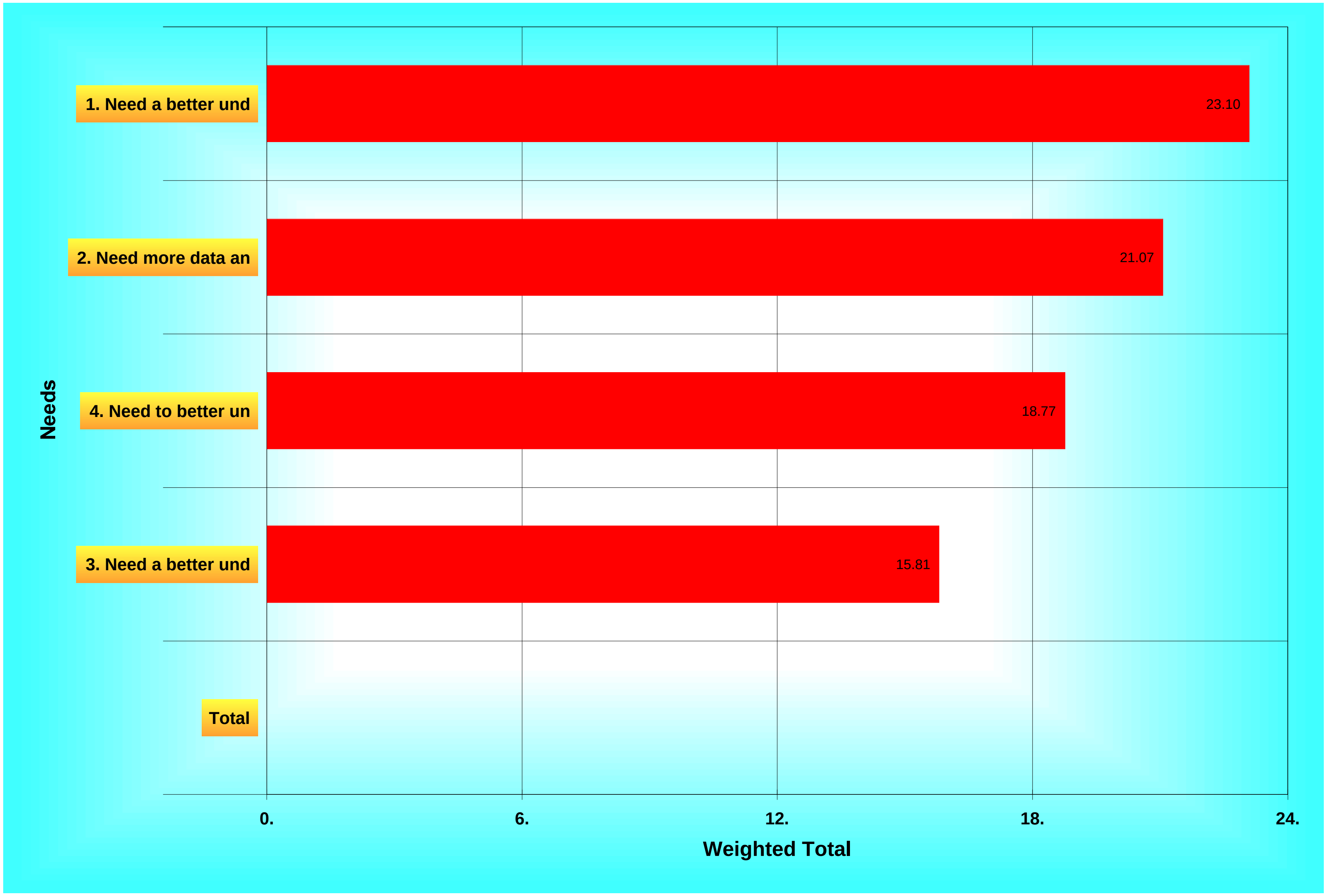

Figure 13. Weighted total scores of C14 needs without criterion 1.

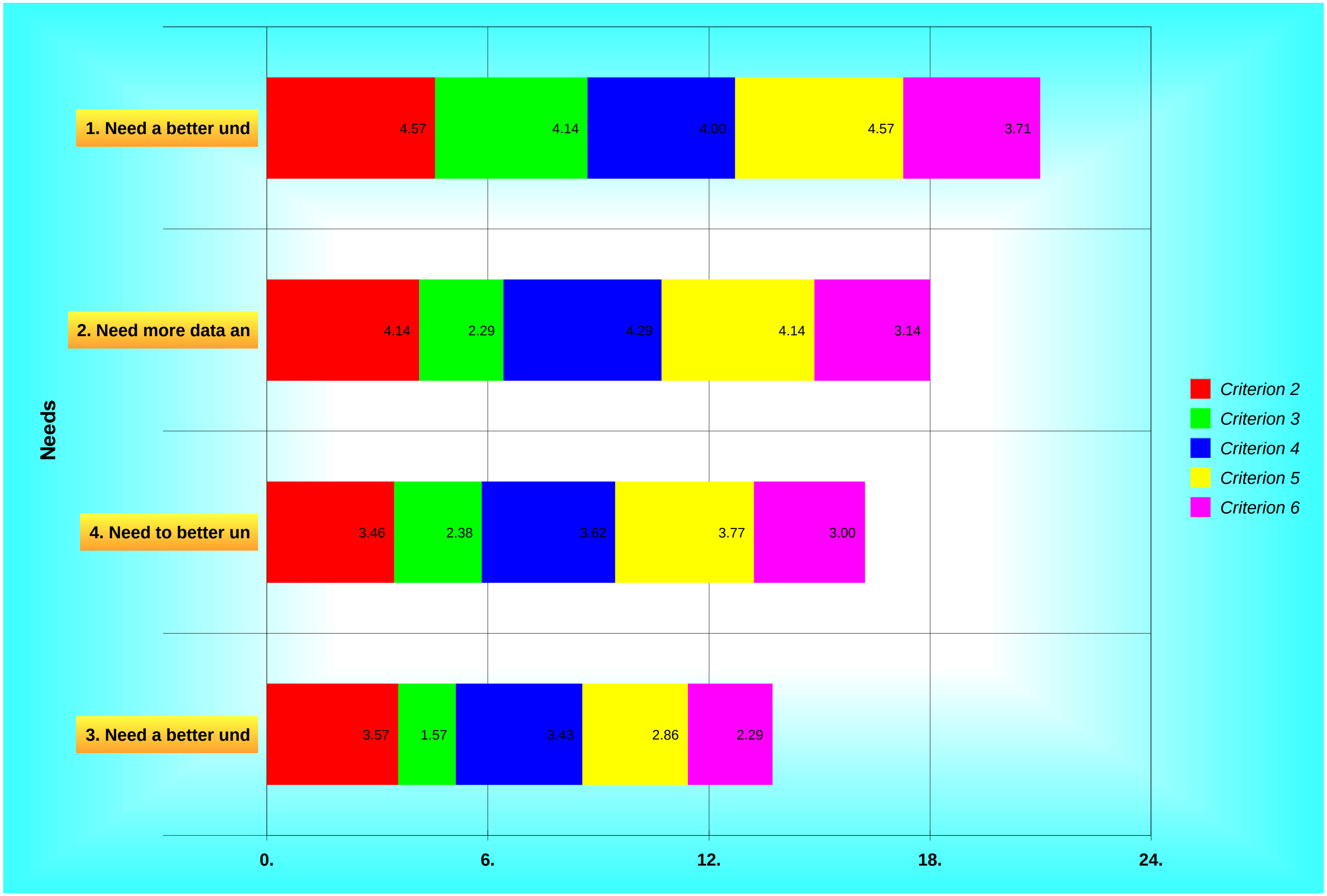

Figure 14. Unweighted criteria scores of C14 needs without criterion 1.

Modeling Needs Group

Discussion and comments on the modeling needs

1. Need to develop a 3D modeling code that can be performed quickly.
    - (WAGs 3)(Uncertainties 4, 12, 19, 24){#97}
    - Need to Enhance speed of running TETRAD.{#98}
        - ✓ (WAGs 3)(Uncertainties ?){#99}
    - Hopefully not at the expense at accuracy {#249}
    - Much can be done with 2D models, which are inherently much faster. These are presently underutilized. {#252}
    - While codes may provide a rapid way to run a model, care must be taken that the model is well posed in relation to the conceptual model. {#254}
    - Agree with hopefully not at expense of accuracy {#255}
    - Calculation accuracy is not a big problem, especially compared to uncertainty from inadequacy of the conceptual model the code is based on. {#260}
2. Need to develop statistical methods for applying point data over large areas.
    - (WAGs Site-wide)(Uncertainties 4, 16, 19){#103}
    - This is really a scaling issue {#250}
    - Whatever statistical methods are developed, they must be technically defensible (not in the legal sense) and must be compatible with conceptual model elements. {#251}
    - GIS software? {#259}
    - Important to get bang for the buck. {#261}
3. Need to develop better scientific modeling of moisture movement based on data from the type B probes.
    - (WAGs 7)(Uncertainties 3, 4, 8, 15, 19){#105}
4. Need to optimize sequential codes to parallel processing to speed run times.
    - (WAGs Site-wide)(Uncertainties 4, 10, ?){#107}
    - The ability to speed run times must not overwhelm the need to do good basic hydrology in setting up a numerical model. {#257}
5. Need to develop 3-D data presentation methodologies.
    - (WAGs 3)(Uncertainties 4, 12, 19){#109}
    - This should already be available in commercial software. {#253}
6. Need to develop better reactive transport codes.
    - (WAGs 7)(Uncertainties 1, 5, 15, 17, 23){#111}
7. Need to develop codes for integrating multiple types of data sets.
    - (WAGs 3, 7, Site-wide)(Uncertainties 4, 5, 16, 17, 19, 25){#115}
    - GIS again can be used to answer some not at high level {#262}
8. Need to Perform an evaluation of alternative conceptual flow models.
    - (WAGs Site-wide)(Uncertainties 4, 6){#119}
    - Extremely important. The equivalent-porous-media models are incapable of telling us much of what we need to know, especially about fast flow paths. {#256}
9. Need to evaluate plume models with regard to the I129 predictions from WAG 3.
    - (WAGs 3)(Uncertainties 2, 4, 6, 8, 10, 19){#121}
    - Model not calibrated to I-129. Source term uncertain. {#258}

Unclear need, more information is needed for clarity

1. Need integration of parameter estimation codes.
    - (WAGs 3)(Uncertainties 4, 23){#101}
2. Need to resolve model/observational issues in WAG 7 RI/FS.
    - (WAGs 7)(Uncertainties ?){#113}
3. Need to determine relationship of moisture content and matrix flow in unsaturated flow models.
    - (WAGs Site-wide)(Uncertainties 4, 10, 14, 16, 19){#117}

Modeling needs rated against the criteria

This table shows the average scores for each of the criteria within a need. The color of the cell indicates the level of consensus of the scores within that cell. A green cell indicates a high level of consensus and a red cell indicates a low level of consensus. The blue cells were not rated by the participants during the meeting.

A consensus threshold value was set to help focus the group on those cells that had the most disagreement in the scores in the limited time available for discussion. It was not intended to imply that the group was in agreement on the score in that cell. The threshold level for consensus was set at 0.50. Typically, the threshold is set at 0.6 for discussion. The lower than normal threshold is indicative of the different perspectives of the participants.

Needs	Criterion						Total	Mean	STD	Weighted Total
	1	2	3	4	5	6				
Weight	0.65	0.95	0.26	1.06	2.29	0.80				
1.Need to develop a 3D modeling code that can be performed quickly.		M(2.54)	H(4.33)	M(3.15)	M(2.23)	M(2.00)	14.26	M(2.85)	0.93	13.59
2.Need to develop statistical methods for applying point data over large areas.		M(2.85)	M(3.50)	M(3.46)	L(1.92)	L(1.67)	13.40	M(2.68)	0.85	13.02
3.Need to develop better scientific modeling of moisture movement based on data from the type B probes.		M(3.31)	M(2.17)	M(3.33)	M(3.31)	M(2.33)	14.45	M(2.89)	0.59	16.68
4.Need to optimize sequential codes to parallel processing to speed run times.		M(2.33)	M(3.18)	M(3.18)	M(2.00)	L(1.36)	12.06	M(2.41)	0.78	12.09
5.Need to develop 3-D data presentation methodologies.		M(2.69)	M(3.50)	M(3.46)	L(1.92)	L(1.33)	12.91	M(2.58)	0.95	12.61
6.Need to develop better reactive transport codes.		M(2.85)	H(4.00)	M(3.17)	M(2.54)	M(2.00)	14.55	M(2.91)	0.75	14.51
7.Need to develop codes for integrating multiple types of data sets.		M(3.15)	M(3.67)	M(3.46)	M(2.23)	L(1.83)	14.35	M(2.87)	0.80	14.19
8.Need to perform an evaluation of alternative conceptual flow models.		M(3.46)	H(4.00)	M(3.46)	M(3.31)	M(2.17)	16.40	M(3.28)	0.68	17.31
9.Need to evaluate plume models with regard to the I129 predictions from WAG 3.		M(3.33)	L(1.55)	M(3.92)	M(3.31)	M(2.27)	14.38	M(2.88)	0.95	17.12

Criteria scores by need

This table shows the distribution of scores (H, M, L) across the six criteria for each of the needs. The number within a criteria/score cell indicates the number of participants that used that score for that criteria. Within a need, the criteria are sorted from the highest to the lowest mean score.

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
1.Need to develop a 3D modeling code that can be performed quickly.									
Criterion 3 (0.26)	8	4		52	H(4.33)	H	0.98	12	1.13
Criterion 4 (1.06)	4	6	3	41	M(3.15)	M	1.52	13	3.34
Criterion 2 (0.95)	3	4	6	33	M(2.54)	L	1.66	13	2.41
Criterion 5 (2.29)	3	2	8	29	M(2.23)	L	1.74	13	5.11
Criterion 6 (0.80)	2	2	8	24	M(2.00)	L	1.60	12	1.60
Criterion 1 (0.65)								0	
2.Need to develop statistical methods for applying point data over large areas.									
Criterion 3 (0.26)	6	3	3	42	M(3.50)	H	1.73	12	0.91
Criterion 4 (1.06)	6	4	3	45	M(3.46)	H	1.66	13	3.67
Criterion 2 (0.95)	4	4	5	37	M(2.85)	L	1.72	13	2.70
Criterion 5 (2.29)	1	4	8	25	L(1.92)	L	1.32	13	4.40
Criterion 6 (0.80)	1	2	9	20	L(1.67)	L	1.30	12	1.33
Criterion 1 (0.65)								0	
3.Need to develop better scientific modeling of moisture movement based on data from the type B probes.									
Criterion 4 (1.06)	4	6	2	40	M(3.33)	M	1.44	12	3.53
Criterion 2 (0.95)	5	5	3	43	M(3.31)	??	1.60	13	3.14
Criterion 5 (2.29)	5	5	3	43	M(3.31)	??	1.60	13	7.57
Criterion 6 (0.80)	1	6	5	28	M(2.33)	M	1.30	12	1.87
Criterion 3 (0.26)	2	3	7	26	M(2.17)	L	1.59	12	0.56
Criterion 1 (0.65)								0	

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
4.Need to dptimize sequential codes to parallel processing to speed run times.									
Criterion 3 (0.26)	4	4	3	35	M(3.18)	??	1.66	11	0.83
Criterion 4 (1.06)	4	4	3	35	M(3.18)	??	1.66	11	3.37
Criterion 2 (0.95)	1	6	5	28	M(2.33)	M	1.30	12	2.22
Criterion 5 (2.29)	1	4	7	24	M(2.00)	L	1.35	12	4.58
Criterion 6 (0.80)		2	9	15	L(1.36)	L	0.81	11	1.09
Criterion 1 (0.65)								0	
5.Need to develop 3-D data presentation methodologies.									
Criterion 3 (0.26)	6	3	3	42	M(3.50)	H	1.73	12	0.91
Criterion 4 (1.06)	6	4	3	45	M(3.46)	H	1.66	13	3.67
Criterion 2 (0.95)	3	5	5	35	M(2.69)	??	1.60	13	2.56
Criterion 5 (2.29)		6	7	25	L(1.92)	L	1.04	13	4.40
Criterion 6 (0.80)		2	10	16	L(1.33)	L	0.78	12	1.07
Criterion 1 (0.65)								0	
6.Need to develop better reactive transport codes.									
Criterion 3 (0.26)	6	6		48	H(4.00)	??	1.04	12	1.04
Criterion 4 (1.06)	2	9	1	38	M(3.17)	M	1.03	12	3.36
Criterion 2 (0.95)	2	8	3	37	M(2.85)	M	1.28	13	2.70
Criterion 5 (2.29)	2	6	5	33	M(2.54)	M	1.45	13	5.81
Criterion 6 (0.80)	2	2	8	24	M(2.00)	L	1.60	12	1.60
Criterion 1 (0.65)								0	
7.Need to develop codes for integrating multiple types of data sets.									
Criterion 3 (0.26)	5	6	1	44	M(3.67)	M	1.30	12	0.95
Criterion 4 (1.06)	5	6	2	45	M(3.46)	M	1.45	13	3.67
Criterion 2 (0.95)	2	10	1	41	M(3.15)	M	0.99	13	3.00

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 5 (2.29)	1	6	6	29	M(2.23)	??	1.30	13	5.11
Criterion 6 (0.80)	1	3	8	22	L(1.83)	L	1.34	12	1.47
Criterion 1 (0.65)								0	
8.Need to perform an evaluation of alternative conceptual flow models.									
Criterion 3 (0.26)	8	2	2	48	H(4.00)	H	1.60	12	1.04
Criterion 2 (0.95)	6	4	3	45	M(3.46)	H	1.66	13	3.29
Criterion 4 (1.06)	7	2	4	45	M(3.46)	H	1.85	13	3.67
Criterion 5 (2.29)	5	5	3	43	M(3.31)	??	1.60	13	7.57
Criterion 6 (0.80)	3	1	8	26	M(2.17)	L	1.80	12	1.73
Criterion 1 (0.65)								0	
9.Need to evaluate plume models with regard to the I129 predictions from WAG 3.									
Criterion 4 (1.06)	7	5	1	51	M(3.92)	H	1.32	13	4.16
Criterion 2 (0.95)	4	6	2	40	M(3.33)	M	1.44	12	3.17
Criterion 5 (2.29)	5	5	3	43	M(3.31)	??	1.60	13	7.57
Criterion 6 (0.80)	2	3	6	25	M(2.27)	L	1.62	11	1.82
Criterion 3 (0.26)	1	1	9	17	L(1.55)	L	1.29	11	0.40
Criterion 1 (0.65)								0	

Need scores by criteria

This table shows the distribution of scores (H, M, L) across the needs for each of the six criteria. The number in each cell of the matrix indicates the number of participants who placed the criteria at that position on the list.

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
2.Criterion 2								
Need to perform an evaluation of alternative conceptual flow models.	6	4	3	45	M(3.46)	H	1.66	13

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need to evaluate plume models with regard to the I129 predictions from WAG 3.	4	6	2	40	M(3.33)	M	1.44	12
Need to develop better scientific modeling of moisture movement based on data from the type B probes.	5	5	3	43	M(3.31)	??	1.60	13
Need to develop codes for integrating multiple types of data sets.	2	10	1	41	M(3.15)	M	0.99	13
Need to develop better reactive transport codes.	2	8	3	37	M(2.85)	M	1.28	13
Need to develop statistical methods for applying point data over large areas.	4	4	5	37	M(2.85)	L	1.72	13
Need to develop 3-D data presentation methodologies.	3	5	5	35	M(2.69)	??	1.60	13
Need to develop a 3D modeling code that can be performed quickly.	3	4	6	33	M(2.54)	L	1.66	13
Need to optimize sequential codes to parallel processing to speed run times.	1	6	5	28	M(2.33)	M	1.30	12
3.Criterion 3								
Need to develop a 3D modeling code that can be performed quickly.	8	4		52	H(4.33)	H	0.98	12
Need to develop better reactive transport codes.	6	6		48	H(4.00)	??	1.04	12
Need to perform an evaluation of alternative conceptual flow models.	8	2	2	48	H(4.00)	H	1.60	12
Need to develop codes for integrating multiple types of data sets.	5	6	1	44	M(3.67)	M	1.30	12
Need to develop statistical methods for applying point data over large areas.	6	3	3	42	M(3.50)	H	1.73	12
Need to develop 3-D data presentation methodologies.	6	3	3	42	M(3.50)	H	1.73	12
Need to optimize sequential codes to parallel processing to speed run times.	4	4	3	35	M(3.18)	??	1.66	11
Need to develop better scientific modeling of moisture movement based on data from the type B probes.	2	3	7	26	M(2.17)	L	1.59	12
Need to evaluate plume models with regard to the I129 predictions from WAG 3.	1	1	9	17	L(1.55)	L	1.29	11
4.Criterion 4								
Need to evaluate plume models with regard to the I129 predictions from WAG 3.	7	5	1	51	M(3.92)	H	1.32	13
Need to develop codes for integrating multiple types of data sets.	5	6	2	45	M(3.46)	M	1.45	13
Need to develop statistical methods for applying point data over large areas.	6	4	3	45	M(3.46)	H	1.66	13
Need to develop 3-D data presentation methodologies.	6	4	3	45	M(3.46)	H	1.66	13
Need to perform an evaluation of alternative conceptual flow models.	7	2	4	45	M(3.46)	H	1.85	13
Need to develop better scientific modeling of moisture movement based on data from the type B probes.	4	6	2	40	M(3.33)	M	1.44	12
Need to optimize sequential codes to parallel processing to speed run times.	4	4	3	35	M(3.18)	??	1.66	11

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
Need to develop better reactive transport codes.	2	9	1	38	M(3.17)	M	1.03	12
Need to develop a 3D modeling code that can be performed quickly.	4	6	3	41	M(3.15)	M	1.52	13
5.Criterion 5								
Need to develop better scientific modeling of moisture movement based on data from the type B probes.	5	5	3	43	M(3.31)	??	1.60	13
Need to perform an evaluation of alternative conceptual flow models.	5	5	3	43	M(3.31)	??	1.60	13
Need to evaluate plume models with regard to the I129 predictions from WAG 3.	5	5	3	43	M(3.31)	??	1.60	13
Need to develop better reactive transport codes.	2	6	5	33	M(2.54)	M	1.45	13
Need to develop codes for integrating multiple types of data sets.	1	6	6	29	M(2.23)	??	1.30	13
Need to develop a 3D modeling code that can be performed quickly.	3	2	8	29	M(2.23)	L	1.74	13
Need to optimize sequential codes to parallel processing to speed run times.	1	4	7	24	M(2.00)	L	1.35	12
Need to develop 3-D data presentation methodologies.		6	7	25	L(1.92)	L	1.04	13
Need to develop statistical methods for applying point data over large areas.	1	4	8	25	L(1.92)	L	1.32	13
6.Criterion 6								
Need to develop better scientific modeling of moisture movement based on data from the type B probes.	1	6	5	28	M(2.33)	M	1.30	12
Need to evaluate plume models with regard to the I129 predictions from WAG 3.	2	3	6	25	M(2.27)	L	1.62	11
Need to perform an evaluation of alternative conceptual flow models.	3	1	8	26	M(2.17)	L	1.80	12
Need to develop a 3D modeling code that can be performed quickly.	2	2	8	24	M(2.00)	L	1.60	12
Need to develop better reactive transport codes.	2	2	8	24	M(2.00)	L	1.60	12
Need to develop codes for integrating multiple types of data sets.	1	3	8	22	L(1.83)	L	1.34	12
Need to develop statistical methods for applying point data over large areas.	1	2	9	20	L(1.67)	L	1.30	12
Need to optimize sequential codes to parallel processing to speed run times.		2	9	15	L(1.36)	L	0.81	11
Need to develop 3-D data presentation methodologies.		2	10	16	L(1.33)	L	0.78	12

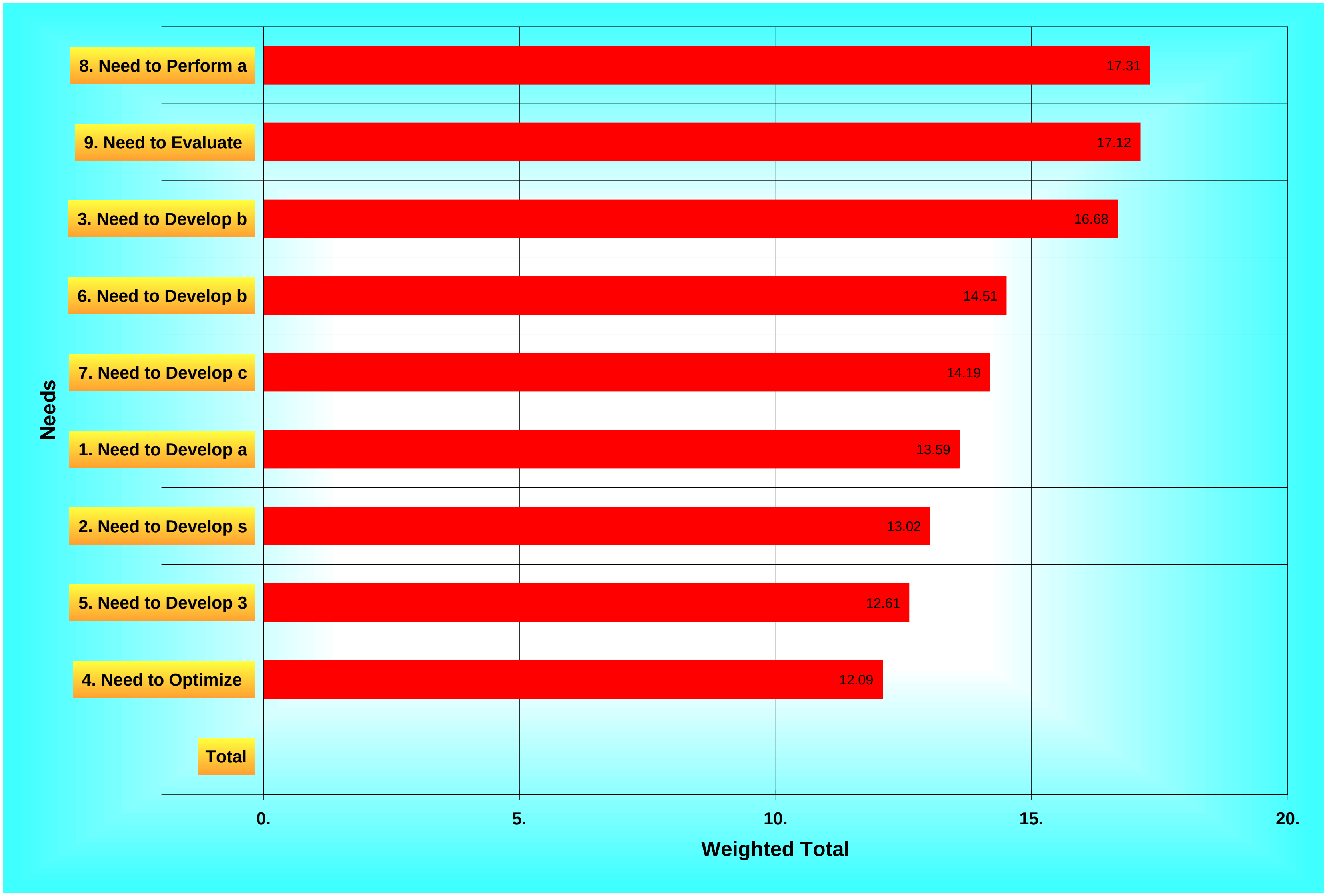

Figure 15. Weighted total scores of modeling needs without criterion 1.

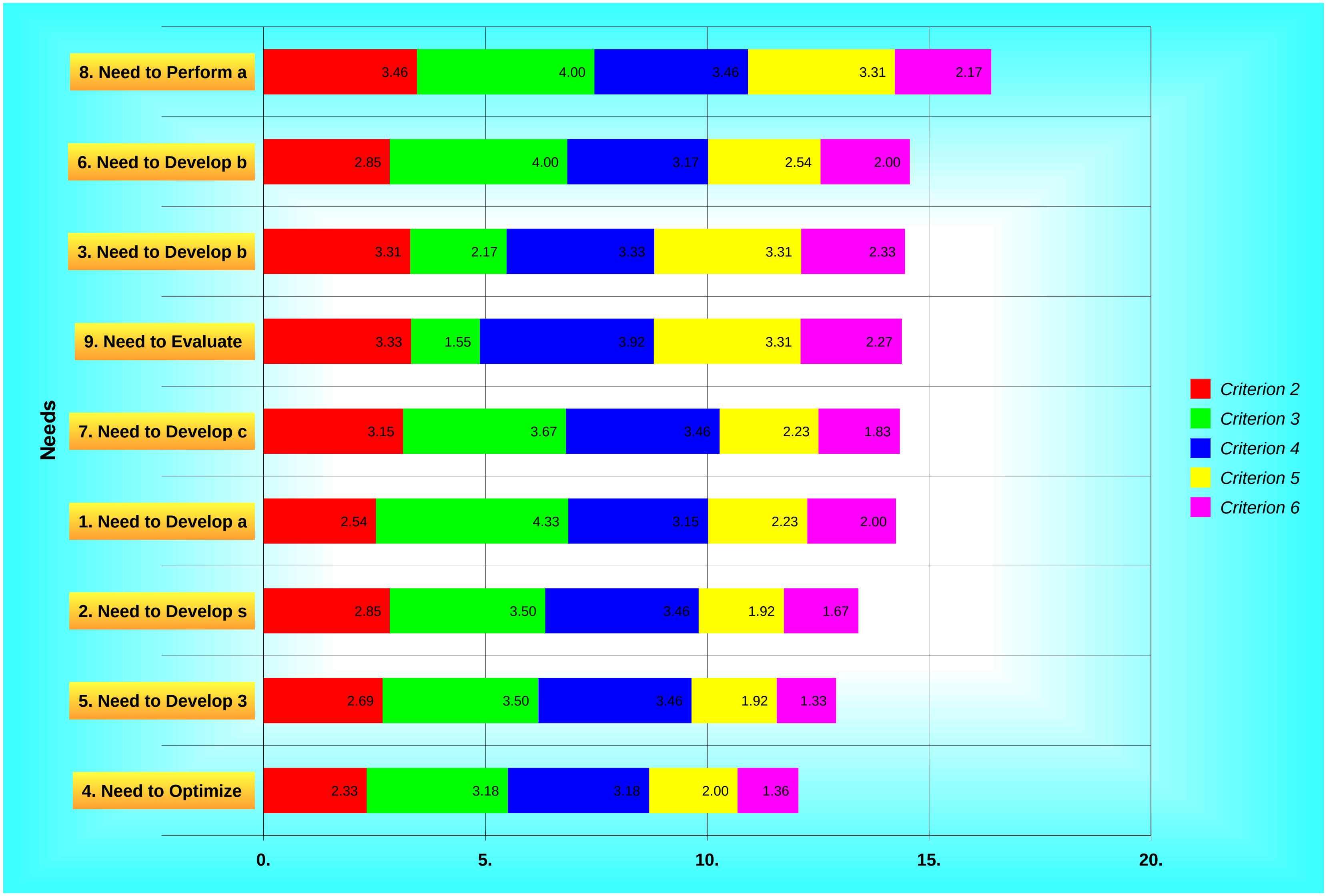

Figure 16. Unweighted criteria scores of modeling needs without criterion 1.

Kd Values Needs Group

Discussion and comments on the Kd values needs

1. Need to develop appropriate Kd values for COCs other than Pu.
   - (WAGs 3, 7, Site-wide)(Uncertainties 1, 14, 18){#47}
   - Need to Develop more "site specific" Kd values for calculating risk.{#50}
     - ✓ (WAGs 9)(Uncertainties 1, 3, 7, 19){#51}
   - Kds are inappropriate for the vast majority of COC transport problems and are greatly overused. {#253}
2. Need to evaluate other methods for representing adsorption besides the use of Kd Values for COCs other than Pu.
   - (WAGs 3, 7, Site-wide)(Uncertainties 1, 14){#49}
   - Important to investigate alternatives that are likely to be more realistic than the Kd approach. {#254}
   - This is how to model the physical processes. {#259}
3. Need to determine what form the standpoint of geochemistry is influencing transport and retardation.
   - General issue. Important. {#256}
   - Need to better understand the interbed ion exchange. (this came from the characterization group). {#257}
   - This is understanding the physical processes. {#258}

Kd values needs rated against the criteria

This table shows the average scores for each of the criteria within a need. The color of the cell indicates the level of consensus of the scores within that cell. A green cell indicates a high level of consensus and a red cell indicates a low level of consensus. The blue cells were not rated by the participants during the meeting.

A consensus threshold value was set to help focus the group on those cells that had the most disagreement in the scores in the limited time available for discussion. It was not intended to imply that the group was in agreement on the score in that cell. The threshold level for consensus was set at 0.50. Typically, the threshold is set at 0.6 for discussion. The lower than normal threshold is indicative of the different perspectives of the participants.

Needs	Criterion 1	2	3	4	5	6	Total	Mean	STD	Weighted Total
Weight	0.65	0.95	0.26	1.06	2.29	0.80				
1.Need to develop appropriate Kd values for COCs other than Pu.		M(2.38)	M(2.00)	M(3.46)	M(2.38)	L(1.83)	12.06	M(2.41)	0.63	13.38
2.Need to evaluate other methods for representing adsorption besides the use of Kd Values for COCs other than Pu.		H(4.23)	H(4.00)	M(3.62)	H(4.23)	M(3.17)	19.24	M(3.85)	0.46	21.11
3.Need to determine what form the standpoint of geochemistry is influencing transport and retardation.		H(4.54)	M(3.33)	M(3.92)	H(4.54)	M(3.00)	19.33	M(3.87)	0.70	22.13

Criteria scores by need

This table shows the distribution of scores (H, M, L) across the six criteria for each of the needs. The number within a criteria/score cell indicates the number of participants that used that score for that criteria. Within a need, the criteria are sorted from the highest to the lowest mean score.

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
1.Need to develop appropriate Kd values for COCs other than Pu.									
Criterion 4 (1.06)	6	4	3	45	M(3.46)	H	1.66	13	3.67

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 2 (0.95)	2	5	6	31	M(2.38)	L	1.50	13	2.27
Criterion 5 (2.29)	3	3	7	31	M(2.38)	L	1.71	13	5.46
Criterion 3 (0.26)	2	2	8	24	M(2.00)	L	1.60	12	0.52
Criterion 6 (0.80)	1	3	8	22	L(1.83)	L	1.34	12	1.47
Criterion 1 (0.65)								0	
2.Need to evaluate other methods for representing adsorption besides the use of Kd Values for COCs other than Pu.									
Criterion 2 (0.95)	8	5		55	H(4.23)	H	1.01	13	4.02
Criterion 5 (2.29)	9	3	1	55	H(4.23)	H	1.30	13	9.69
Criterion 3 (0.26)	7	4	1	48	H(4.00)	H	1.35	12	1.04
Criterion 4 (1.06)	5	7	1	47	M(3.62)	M	1.26	13	3.83
Criterion 6 (0.80)	4	5	3	38	M(3.17)	M	1.59	12	2.53
Criterion 1 (0.65)								0	
3.Need to determine what form the standpoint of geochemistry is influencing transport and retardation.									
Criterion 2 (0.95)	10	3		59	H(4.54)	H	0.88	13	4.31
Criterion 5 (2.29)	10	3		59	H(4.54)	H	0.88	13	10.39
Criterion 4 (1.06)	7	5	1	51	M(3.92)	H	1.32	13	4.16
Criterion 3 (0.26)	4	6	2	40	M(3.33)	M	1.44	12	0.87
Criterion 6 (0.80)	4	4	4	36	M(3.00)	??	1.71	12	2.40
Criterion 1 (0.65)								0	

Need scores by criteria

This table shows the distribution of scores (H, M, L) across the needs for each of the six criteria. The number in each cell of the matrix indicates the number of participants who placed the criteria at that position on the list.

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
2.Criterion 2								
Need to determine what form the standpoint of geochemistry is influencing transport and retardation.	10	3		59	H(4.54)	H	0.88	13
Need to evaluate other methods for representing adsorption besides the use of Kd Values for COCs other than Pu.	8	5		55	H(4.23)	H	1.01	13
Need to develop appropriate Kd values for COCs other than Pu.	2	5	6	31	M(2.38)	L	1.50	13
3.Criterion 3								
Need to evaluate other methods for representing adsorption besides the use of Kd Values for COCs other than Pu.	7	4	1	48	H(4.00)	H	1.35	12
Need to determine what form the standpoint of geochemistry is influencing transport and retardation.	4	6	2	40	M(3.33)	M	1.44	12
Need to develop appropriate Kd values for COCs other than Pu.	2	2	8	24	M(2.00)	L	1.60	12
4.Criterion 4								
Need to determine what form the standpoint of geochemistry is influencing transport and retardation.	7	5	1	51	M(3.92)	H	1.32	13
Need to evaluate other methods for representing adsorption besides the use of Kd Values for COCs other than Pu.	5	7	1	47	M(3.62)	M	1.26	13
Need to develop appropriate Kd values for COCs other than Pu.	6	4	3	45	M(3.46)	H	1.66	13
5.Criterion 5								
Need to determine what form the standpoint of geochemistry is influencing transport and retardation.	10	3		59	H(4.54)	H	0.88	13
Need to evaluate other methods for representing adsorption besides the use of Kd Values for COCs other than Pu.	9	3	1	55	H(4.23)	H	1.30	13
Need to develop appropriate Kd values for COCs other than Pu.	3	3	7	31	M(2.38)	L	1.71	13
6.Criterion 6								
Need to evaluate other methods for representing adsorption besides the use of Kd Values for COCs other than Pu.	4	5	3	38	M(3.17)	M	1.59	12
Need to determine what form the standpoint of geochemistry is influencing transport and retardation.	4	4	4	36	M(3.00)	??	1.71	12
Need to develop appropriate Kd values for COCs other than Pu.	1	3	8	22	L(1.83)	L	1.34	12

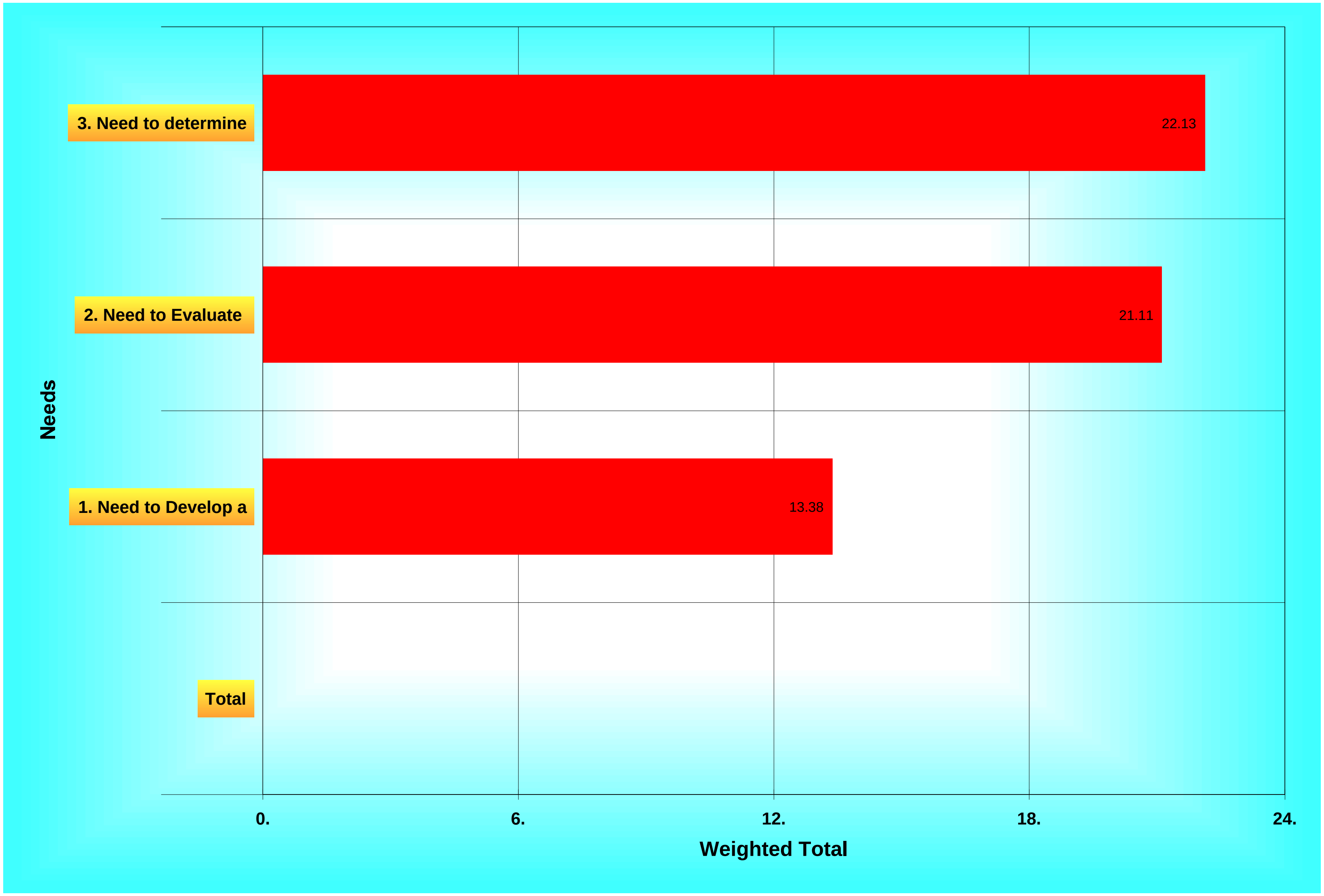

Figure 17. Weighted total scores of Kd values needs without criterion 1.

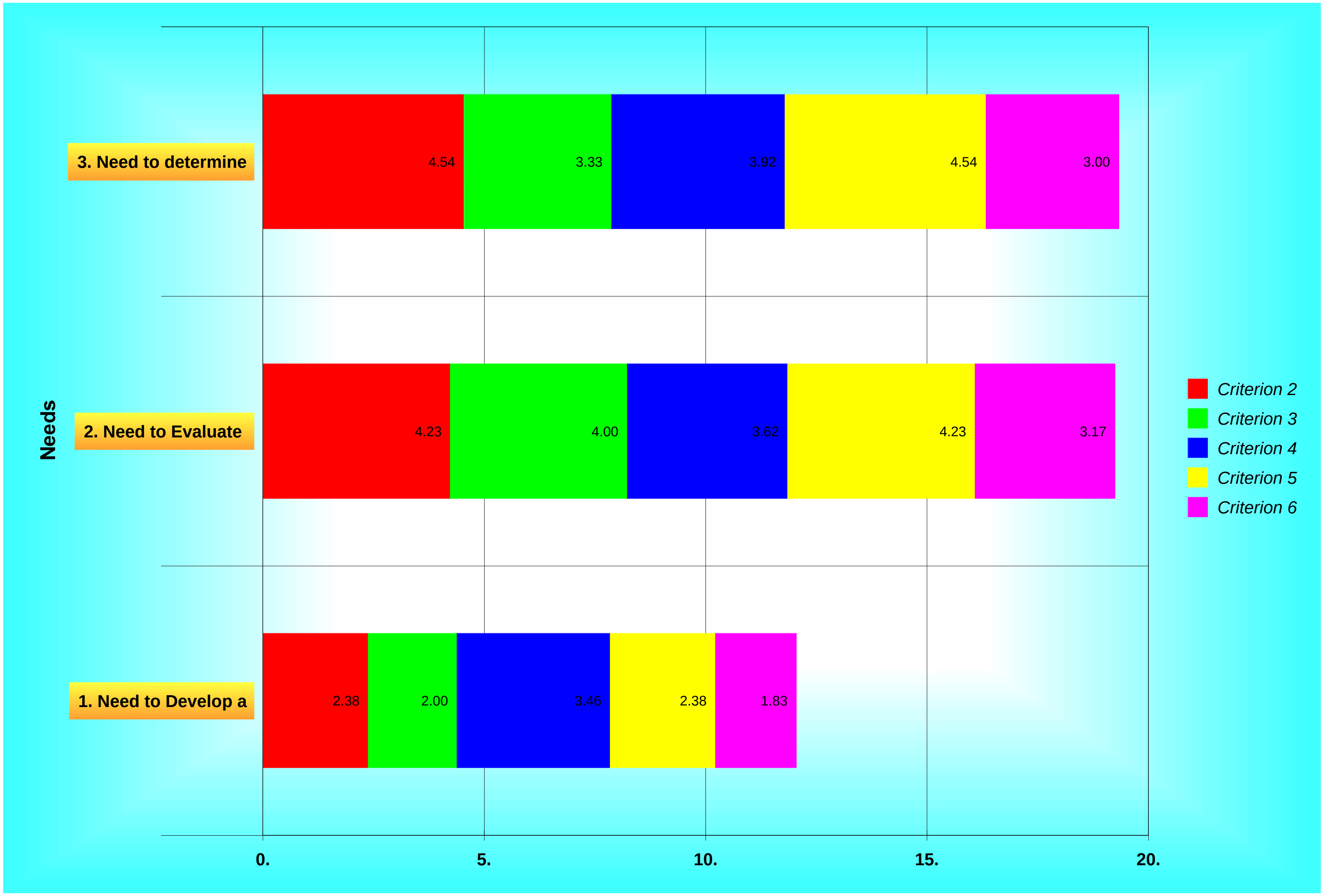

Figure 18. Unweighted criteria scores of Kd values needs without criterion 1.

Leak detection Needs Group

Discussion and comments on the leak detection needs

1. Need development of sensors to detect & identify source of leakage (e.g. into vaults at INTEC tank farm).

- (WAGs 3)(Uncertainties 3, 5, 9, 10, 15){#229}
- Need Development of early warning leak detection systems.{#234}
  - ✓ (WAGs Site-wide)(Uncertainties 3, 5, 9, 10, 15, 19){#235}

2. Need development of methods to determine source of high concentrations of contaminants around 603 basin.

- (WAGs 3)(Uncertainties 3, 5, 8, 9, 10, 15, 17){#231}

3. Need development of forensic (identify the source) methods to detect any leakage from waste calcine facility monolith as part of determining what is causing contamination of perched water at INTEC.

- (WAGs 3)(Uncertainties 1, 3, 5, 9, 10, 13, 15){#233}

Leak detection needs rated against the criteria

This table shows the average scores for each of the criteria within a need. The color of the cell indicates the level of consensus of the scores within that cell. A green cell indicates a high level of consensus and a red cell indicates a low level of consensus. The blue cells were not rated by the participants during the meeting.

A consensus threshold value was set to help focus the group on those cells that had the most disagreement in the scores in the limited time available for discussion. It was not intended to imply that the group was in agreement on the score in that cell. The threshold level for consensus was set at 0.50. Typically, the threshold is set at 0.6 for discussion. The lower than normal threshold is indicative of the different perspectives of the participants.

Needs	Criterion 1	2	3	4	5	6	Total	Mean	Weighted Total
Weight	0.65	0.95	0.26	1.06	2.29	0.80			
1.Need development of sensors to detect & identify source of leakage (e.g. into vaults at INTEC tank farm).		M(3.62)	M(3.17)	M(3.77)	M(3.46)	M(2.64)	16.65	M(3.33)	18.29
2.Need development of methods to determine source of high concentrations of contaminants around 603 basin.		M(3.15)	L(1.50)	M(3.31)	M(3.46)	M(2.64)	14.06	M(2.81)	16.93
3.Need development of forensic (identify the source) methods to detect any leakage from waste calcine facility monolith as part of determining what is causing contamination of perched water at INTEC.		M(3.46)	M(2.50)	M(3.31)	M(3.77)	M(2.82)	15.86	M(3.17)	18.33

Criteria scores by need

This table shows the distribution of scores (H, M, L) across the six criteria for each of the needs. The number within a criteria/score cell indicates the number of participants that used that score for that criteria. Within a need, the criteria are sorted from the highest to the lowest mean score.

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
1.Need development of sensors to detect & identify source of leakage (e.g. into vaults at INTEC tank farm).									

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 4 (1.06)	6	6	1	49	M(3.77)	??	1.30	13	4.00
Criterion 2 (0.95)	6	5	2	47	M(3.62)	H	1.50	13	3.43
Criterion 5 (2.29)	6	4	3	45	M(3.46)	H	1.66	13	7.93
Criterion 3 (0.26)	5	3	4	38	M(3.17)	H	1.80	12	0.82
Criterion 6 (0.80)	2	5	4	29	M(2.64)	M	1.50	11	2.11
Criterion 1 (0.65)								0	
2.Need development of methods to determine source of high concentrations of contaminants around 603 basin.									
Criterion 5 (2.29)	6	4	3	45	M(3.46)	H	1.66	13	7.93
Criterion 4 (1.06)	4	7	2	43	M(3.31)	M	1.38	13	3.51
Criterion 2 (0.95)	4	6	3	41	M(3.15)	M	1.52	13	3.00
Criterion 6 (0.80)	3	3	5	29	M(2.64)	L	1.75	11	2.11
Criterion 3 (0.26)		3	9	18	L(1.50)	L	0.90	12	0.39
Criterion 1 (0.65)								0	
3.Need development of forensic (identify the source) methods to detect any leakage from waste calcine facility monolith as part of determining what is causing contamination of perched water at INTEC.									
Criterion 5 (2.29)	7	4	2	49	M(3.77)	H	1.54	13	8.63
Criterion 2 (0.95)	6	4	3	45	M(3.46)	H	1.66	13	3.29
Criterion 4 (1.06)	4	7	2	43	M(3.31)	M	1.38	13	3.51
Criterion 6 (0.80)	4	2	5	31	M(2.82)	L	1.89	11	2.25
Criterion 3 (0.26)	3	3	6	30	M(2.50)	L	1.73	12	0.65
Criterion 1 (0.65)								0	

Need scores by criteria

This table shows the distribution of scores (H, M, L) across the needs for each of the six criteria. The number in each cell of the matrix indicates the number of participants who placed the criteria at that position on the list.

Needs	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
2.Criterion 2								
Need development of sensors to detect & identify source of leakage (e.g. into vaults at INTEC tank farm).	6	5	2	47	M(3.62)	H	1.50	13
Need development of forensic (identify the source) methods to detect any leakage from waste calcine facility monolith as part of determining what is causing contamination of perched water at INTEC.	6	4	3	45	M(3.46)	H	1.66	13
Need development of methods to determine source of high concentrations of contaminants around 603 basin.	4	6	3	41	M(3.15)	M	1.52	13
3.Criterion 3								
Need development of sensors to detect & identify source of leakage (e.g. into vaults at INTEC tank farm).	5	3	4	38	M(3.17)	H	1.80	12
Need development of forensic (identify the source) methods to detect any leakage from waste calcine facility monolith as part of determining what is causing contamination of perched water at INTEC.	3	3	6	30	M(2.50)	L	1.73	12
Need development of methods to determine source of high concentrations of contaminants around 603 basin.		3	9	18	L(1.50)	L	0.90	12
4.Criterion 4								
Need development of sensors to detect & identify source of leakage (e.g. into vaults at INTEC tank farm).	6	6	1	49	M(3.77)	??	1.30	13
Need development of methods to determine source of high concentrations of contaminants around 603 basin.	4	7	2	43	M(3.31)	M	1.38	13
Need development of forensic (identify the source) methods to detect any leakage from waste calcine facility monolith as part of determining what is causing contamination of perched water at INTEC.	4	7	2	43	M(3.31)	M	1.38	13
5.Criterion 5								
Need development of forensic (identify the source) methods to detect any leakage from waste calcine facility monolith as part of determining what is causing contamination of perched water at INTEC.	7	4	2	49	M(3.77)	H	1.54	13
Need development of sensors to detect & identify source of leakage (e.g. into vaults at INTEC tank farm).	6	4	3	45	M(3.46)	H	1.66	13
Need development of methods to determine source of high concentrations of contaminants around 603 basin.	6	4	3	45	M(3.46)	H	1.66	13
6.Criterion 6								
Need development of forensic (identify the source) methods to detect any leakage from waste calcine facility monolith as part of determining what is causing contamination of perched water at INTEC.	4	2	5	31	M(2.82)	L	1.89	11
Need development of sensors to detect & identify source of leakage (e.g. into vaults at INTEC tank farm).	2	5	4	29	M(2.64)	M	1.50	11
Need development of methods to determine source of high concentrations of contaminants around 603 basin.	3	3	5	29	M(2.64)	L	1.75	11

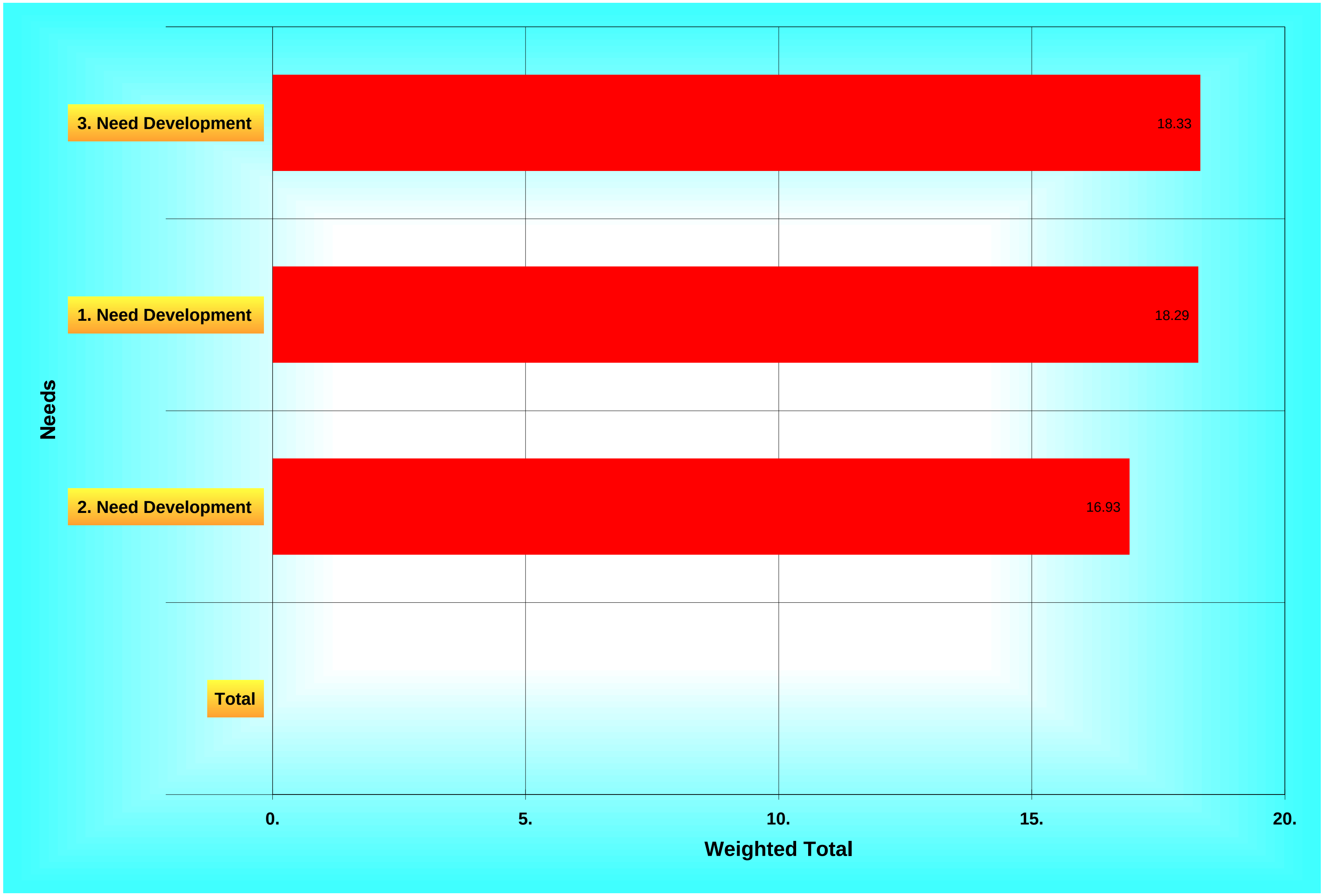

Figure 19. Weighted total scores of leak detection needs without criterion 1.

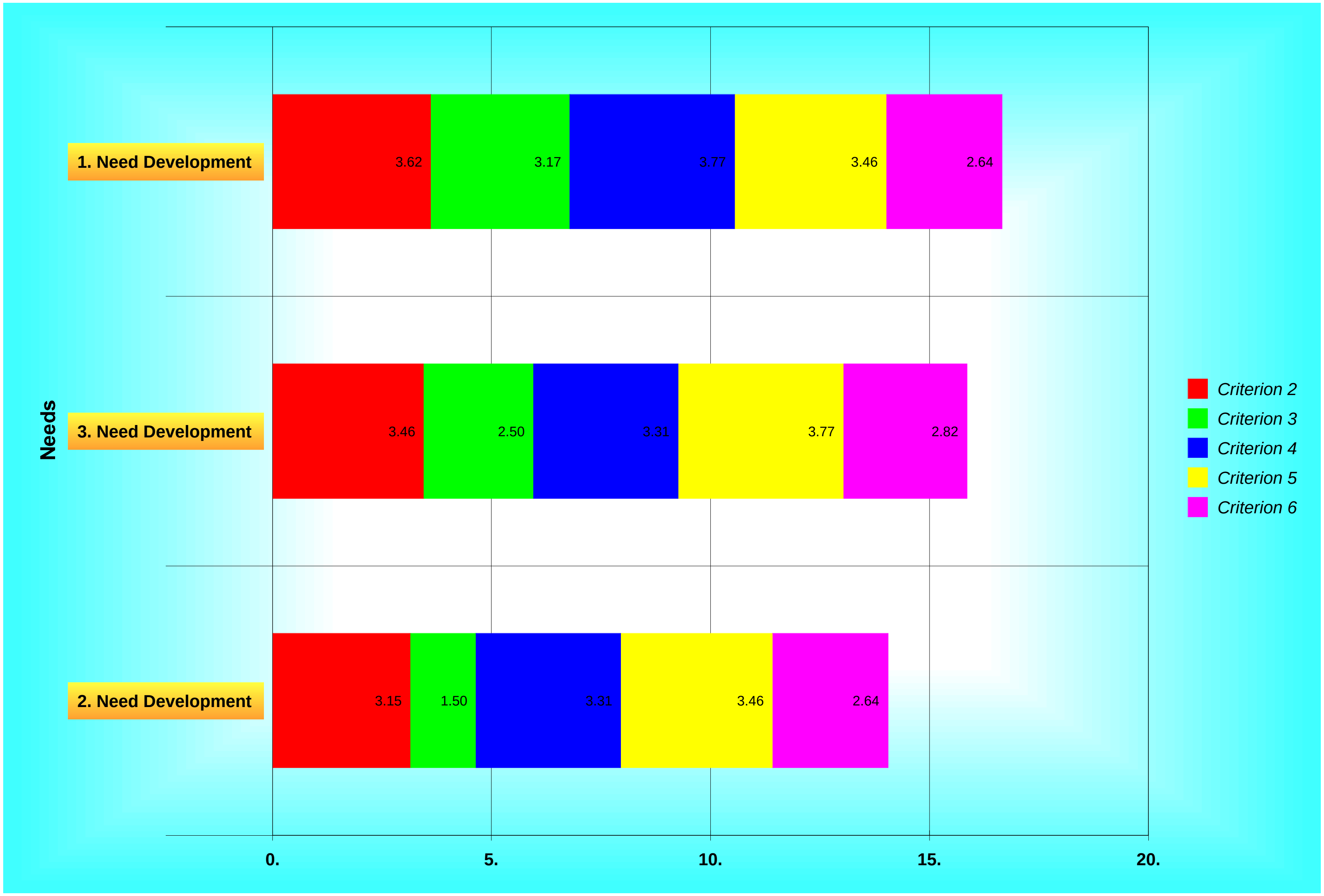

Figure 20. Unweighted criteria scores of leak detection needs without criterion 1.

Data Base Needs Group

Data base needs rated against the criteria

This table shows the average scores for each of the criteria within a need. The color of the cell indicates the level of consensus of the scores within that cell. A green cell indicates a high level of consensus and a red cell indicates a low level of consensus. The blue cells were not rated by the participants during the meeting.

A consensus threshold value was set to help focus the group on those cells that had the most disagreement in the scores in the limited time available for discussion. It was not intended to imply that the group was in agreement on the score in that cell. The threshold level for consensus was set at 0.50. Typically, the threshold is set at 0.6 for discussion. The lower than normal threshold is indicative of the different perspectives of the participants.

Need	Criterion						Total	Mean	STD	Weighted Total
	1	2	3	4	5	6				
Weight	0.65	0.95	0.26	1.06	2.29	0.80				
1.Need to develop a better data base and information management to integrate different data sources.		H(4.54)	M(2.69)	H(4.69)	M(3.92)	M(3.00)	18.85	M(3.77)	0.90	21.37

Criteria scores by need

This table shows the distribution of scores (H, M, L) across the six criteria for each of the needs. The number within a criteria/score cell indicates the number of participants that used that score for that criteria. Within a need, the criteria are sorted from the highest to the lowest mean score.

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
1.Need to develop a better data base and information management to integrate different data sources.									
Criterion 4 (1.06)	11	2		61	H(4.69)	H	0.75	13	4.97
Criterion 2 (0.95)	10	3		59	H(4.54)	H	0.88	13	4.31
Criterion 5 (2.29)	7	5	1	51	M(3.92)	H	1.32	13	8.98

Criteria	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n	Weighted Total
Criterion 6 (0.80)	5	3	5	39	M(3.00)	??	1.83	13	2.40
Criterion 3 (0.26)	4	3	6	35	M(2.69)	L	1.80	13	0.70
Criterion 1 (0.65)								0	

Need scores by criteria

This table shows the distribution of scores (H, M, L) across the needs for each of the six criteria. The number in each cell of the matrix indicates the number of participants who placed the criteria at that position on the list.

Need	H(5)	M(3)	L(1)	Total	Mean	Mode	STD	n
2.Criterion 2								
Need to develop a better data base and information management to integrate different data sources.	10	3		59	H(4.54)	H	0.88	13
3.Criterion 3								
Need to develop a better data base and information management to integrate different data sources.	4	3	6	35	M(2.69)	L	1.80	13
4.Criterion 4								
Need to develop a better data base and information management to integrate different data sources.	11	2		61	H(4.69)	H	0.75	13
5.Criterion 5								
Need to develop a better data base and information management to integrate different data sources.	7	5	1	51	M(3.92)	H	1.32	13
6.Criterion 6								
Need to develop a better data base and information management to integrate different data sources.	5	3	5	39	M(3.00)	??	1.83	13

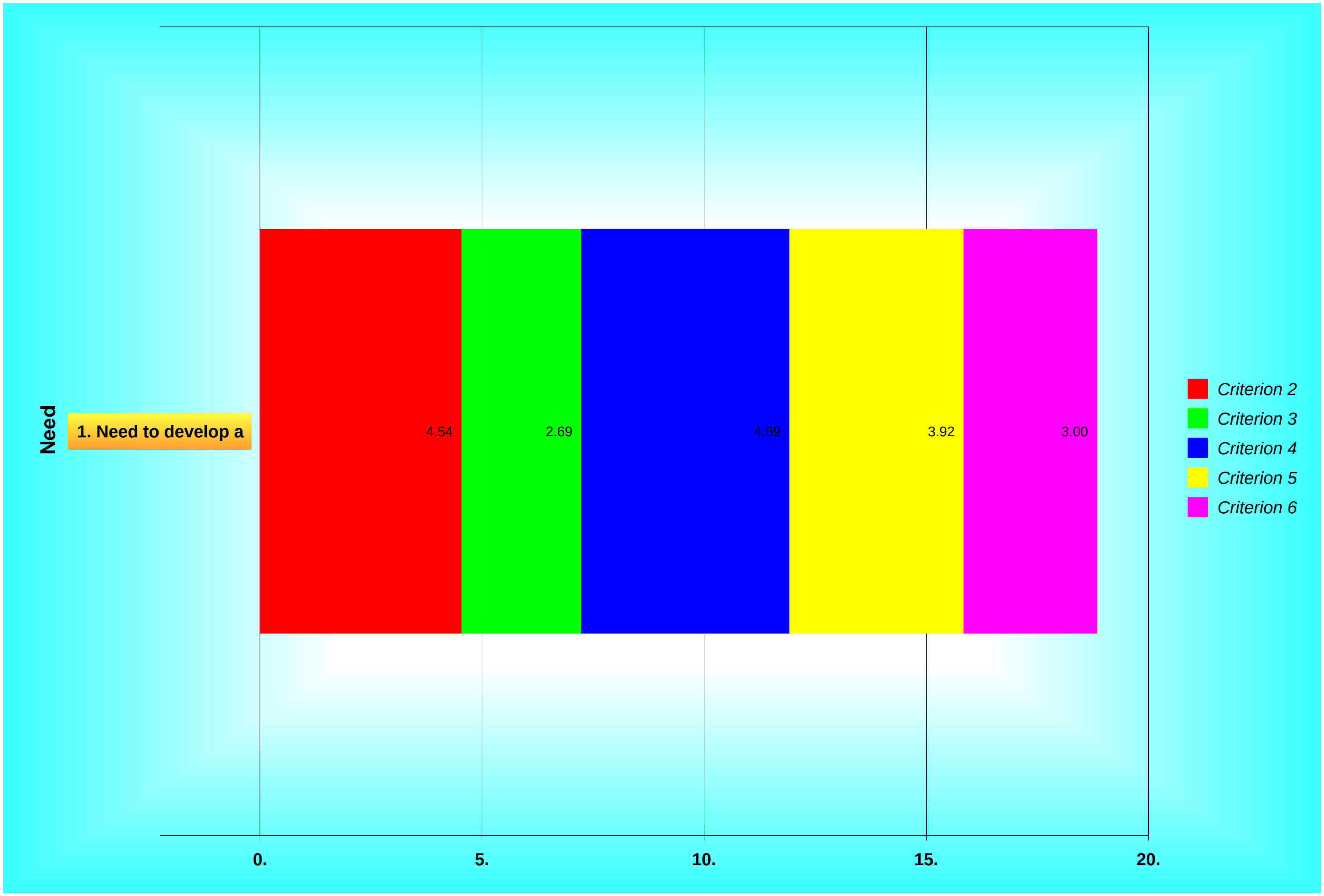

Figure 21. Unweighted criteria scores of data base needs without criterion 1.

Appendix E – Roadmap Wall Chart

The draft INEEL Vadose Zone Roadmap wall chart is a consolidated portrayal of INEEL cleanup activities and uncertainties related to the vadose zone and the groundwater. The left side of the chart depicts major milestones for cleanup and waste management programs across the site based on the draft 2012 Accelerated Clean-Up Plan. The right side of the chart provides details on uncertainties related to the milestones.