5.0 OVERALL APPROACH TO ROOT CAUSE ANALYSIS

5.1 OVERALL APPROACH

In order to conduct this forensic investigation and root cause analysis in a systematic manner consistent with the state of practice of root cause analysis, we have adopted the terminology and a modified version of the methodology utilized by the US Department of Energy as stated in their Root Cause Analysis Guidance Document (DOE, 1992).

The basic reason for investigating and reporting the causes of negative events is to enable the identification of corrective actions adequate to prevent recurrence, and thereby, protect the health and safety of the public, the workers, and the environment. In the case of the breach of the Upper Reservoir Dike, a primary purpose of this root cause analysis is to develop design parameters for a possible rebuild of the Upper Reservoir Dike if a decision is reached to do so. The rebuild would likely be an entire rebuild, rather than remediating the remnant Dike. DOE's suggested Phase III (Corrective Actions), Phase IV (Inform) other than this Report and Phase V (Follow-up) are not addressed in this report. Consequently, the root cause investigation reported here consists of two Phases defined by DOE as follows:

Phase I - Data Collection: It is important to begin the data collection phase of root cause analysis immediately following the occurrence identification to ensure that data are not lost. (Without compromising safety or recovery, data should be collected even during an occurrence.) The information that should be collected consists of conditions before, during, and after the occurrence; personnel involvement (including actions taken); environmental factors; and other information having relevance to the occurrence.

Phase II - Assessment: Any root cause analysis method may be used that includes the following steps:

1. Identify the problem.

2. Determine the significance of the problem.

3. Identify the causes (conditions or actions) immediately preceding and surrounding the problem.

4. Identify the reasons why the causes in the preceding step existed, working back to the root cause (the fundamental reason which, if corrected, will prevent recurrence of these and similar occurrences throughout the facility).

DOE guidance describes six common methodologies for conducting root cause analysis. We have adopted the Barrier Analysis Methodology, which is a systematic process that can be used to identify physical, administrative, and procedural barriers or controls that should have prevented the occurrence.

5.2 DEFINITIONS AS APPLIED TO THIS ROOT CAUSE ANALYSIS

The DOE Guidance utilizes certain definitions in the root cause analysis, some of which are adopted and utilized here:

Facility: Any equipment, structure, system, process, or activity that fulfills a specific purpose. In our case, the Facility is the Upper Reservoir.

Event: A real-time occurrence (e.g., pipe break, valve failure, loss of power). In our case, the Event is defined as follows:

"The uncontrolled, rapid release of water from the Upper Reservoir"

Cause (Causal Factor): A condition or an event that results in or contributes to an Event. In DOE Facilities, this could be anything from noise in an instrument channel, a pipe break, an operator error, or a weakness or deficiency in management or administration. In our case, Causal factors range from instrument failure to structural failures, all as discussed in context later in this Report.

Root Cause as used in this Report: The cause that directly resulted in the Event. In the parlance of this Report, this is the Root Cause of the ***"the uncontrolled, rapid release of water from the Upper Reservoir."***

Contributing Cause: A cause that contributed to an event but, by itself, would not have caused the event. For example, in the case of a leak, a contributing cause could be lack of adequate operator training in leak detection and response, resulting in a more severe event than would

have otherwise occurred. We also use the terms Primary, Secondary, and Tertiary Contributing Causes to reflect our view of the degree that the Contributing Cause had on the Event, with a Tertiary Contributing Cause being the weakest contributor.

5.3 GENERIC OVERVIEW OF THE EVENT INVESTIGATION

The objective of investigating and reporting the cause of events is to enable the identification of corrective actions adequate to prevent recurrence, and thereby, protect the health and safety of the public, the workers, and the environment. Programs and facilities can then be improved and managed more efficiently and safely.

The investigation process is used to gain an understanding of the event, its causes, and what corrective actions are necessary to prevent recurrence. The line of reasoning in the investigation process is:

1. **Outline what happened step by step**.

2. **Begin with the event occurrence and define the problem**. In our case we have defined the event as ***"The uncontrolled, rapid release of water from the Upper Reservoir."***

3. **Determine what program element was supposed to have prevented this event?** Was it lacking or did it fail?

4. **Investigate the reasons why this situation was permitted to exist**.

This line of reasoning will explain why the event was not prevented and what corrective actions will be most effective. This reasoning should be kept in mind during the entire root cause process.

5.4 GENERIC COMMENTS ON DATA COLLECTION

It is important to begin the data collection phase of the root cause process immediately following event identification to ensure that data are not lost. The information that should be collected consists of conditions before, during, and after the event; personnel involvement; environmental factors; and other information having relevance to the condition or problem. For serious cases, photographing the area of the occurrence from several views may be useful in analyzing information developed during the investigation.

Every effort should be made to preserve physical evidence such as failed components, ruptured gaskets, burned leads, blown fuses, spilled fluids, partially completed work orders and procedures. Event participants and other knowledgeable individuals should be identified.

Once all the data associated with this event have been collected, the data should be verified to ensure accuracy. The investigation may be enhanced if some physical evidence is retained. Establishing a quarantine area, or the tagging and segregation of pieces and material, should be performed for failed equipment or components.

The basic need is to determine the direct, contributing and root causes so that effective corrective actions can be taken that will prevent recurrence. Some areas to be considered when determining what information is needed include:

- Activities related to the event.
- Hardware (equipment) or software (programmatic-type issues) associated with the occurrence.
- Recent administrative program or equipment changes.
- Physical environment or circumstances.

Some methods of gathering information include:

- Conducting interviews/collecting statements - Interviews must be fact finding and not fault finding. Preparing questions before the interview is essential to ensure that all necessary information is obtained.

- Interviews should be conducted, preferably in person, with those people who are most familiar with the problem. Although preparing for the interview is important, it should not delay prompt contact with participants and witnesses. The first interview may consist solely of hearing their narrative. A second, more-detailed interview can be arranged, if needed. The interviewer should always consider the interviewee's objectivity and frame of reference.

- Reviewing records: Review of relevant documents or portions of documents and reference their use in support of the root cause analysis.

- Acquiring related information: Some additional information that an evaluator should consider when analyzing the causes include:

  – Evaluating the need for laboratory tests, such as destructive/nondestructive failure analysis.

  – Viewing physical layout of system, component, or work area; developing layout sketches of the area; and taking photographs to better understand the condition.

  – Determining if operating experience information exists for similar events at other facilities.

  – Reviewing equipment supplier and manufacturer records to determine if correspondence has been received addressing this problem.

5.5 GENERIC COMMENTS ON DATA ASSESSMENT

The assessment phase includes analyzing the data to identify the causal factors, possibly summarizing the findings, and categorizing the findings by the cause categories. For example, cause categories might include some or all of the following:

- Equipment/Material Problem/Procedure Problem,
- Personnel Error,
- Design Problem,
- Training Deficiency,

- Management Problem, and
- External Phenomena.

These categories address the problems that could arise during operations prior to the event. Those elements necessary to perform any task are equipment/material, procedures (instructions), and personnel. Design and training determine the quality and effectiveness of equipment and personnel. These five elements must be managed, and therefore, management is also a necessary element. Whenever there is an event, one of these five elements was inadequate to prevent the occurrence. External phenomena beyond operational control serve as a sixth cause category. Note that a direct (root) cause or contributing cause can occur any place in the causal factor chain; that is, a root cause can be an operator error while a management problem can be a contributing cause, depending on the nature of the event.

5.6 BARRIER ANALYSIS

DOE provides a list of various methods for performing root cause analysis. Many of these methods are specialized and apply to specific situations or objectives. We have chosen to use the Barrier Analysis Method at Taum Sauk because, the Barriers are easily identified and fit well with the way in which Dikes and Dams are designed and constructed.

Generally speaking, Barrier Analysis is a systematic process that can be used to identify physical, administrative, and procedural barriers or controls that should have prevented the event. This technique should be used to determine why these barriers or controls failed and what is needed to prevent recurrence.

We use the term barrier as something, be it a physical component, an instrument, a management policy, an operations manual, etc., that otherwise prevents an event. At Taum Sauk, we include all of those barriers that existed prior to the event that were established to prevent an **"*uncontrolled, rapid release of water from the Upper Reservoir*."** Therefore, the following eight (8) questions were addressed for each Barrier.

1. Did the Barrier perform its intended function under normal operating conditions?

2. Did the Barrier perform its intended function under the upset or faulted condition?

3. Did the Barrier mitigate the Event severity?

4. Was the Barrier design adequate?

5. Did the Barrier design contemplate the occurrence of the Event?

6. Was the Barrier construction adequate?

7. Was the Barrier adequately maintained?

8. Was the Barrier inspected prior to Event?