

# 6 Surveillance

## 6.1 Introduction

Surveillance is the continual examination of the physical condition and operation of a dam. Surveillance programs should be capable of detecting problems or unsafe conditions at an early stage so that corrective measures can be taken and dam safety is not compromised. To obtain a historical context for defects, surveillance should commence as early in the life of the dam as possible to detect the development of any problem or unsafe trends and to provide full background information on a dam's performance.

A dam safety management program begins with the initial investigation of the dam foundation and continues through its design, construction and operation. While many problems may occur and need to be overcome during these phases, there is always a risk that not all problems have manifested themselves or been detected by the time the dam has reached its operational phase.

Any unusual behaviour, regardless of how seemingly insignificant, should be identified and recorded because this may be the forewarning of a newly developed unsafe condition.

The causes and processes of dam failure are varied and the knowledge gained from previous dam failures has contributed to the advancement of specialised knowledge essential to the prevention of further failures. Case histories of dam incidents reveal many remarkable similarities in antecedent conditions and processes of deterioration.

Each dam should have its own surveillance program. The scope of a surveillance program should be appropriate to the size of the dam and storage, the population at risk and other consequences of dam failure, the level of risk at the dam, and the value of the dam to the owner.

A surveillance program should include:

- monitoring of instrumentation
- collection of information or data relating to dam performance (eg investigation, design and construction reports)
- evaluation and interpretation of the data
- a range of inspections, from routine inspections by operational staff through to comprehensive inspections by engineers.

Each of these is considered in more detail in the following sections.

Experienced dams engineers should be consulted on the nature and extent of suitable surveillance programs. Generally, larger more complex structures with novel design features require more detailed and comprehensive surveillance programs. These should be instigated during the design and construction phases and in response to emergent problems.

## 6.2 Monitoring

Monitoring is the collection, presentation and evaluation of information from measuring devices installed at or near dams. Monitoring is needed:

- to detect deterioration in performance of the dam
- to detect trends or behaviour to establish compliance with design expectations (If the trends

indicate non-compliance with design expectations, remedial action should be initiated.)

- to rectify dam design issues which could not be resolved to high reliability during the design and construction stages (Such issues can only be addressed with a monitoring strategy, which can substantiate design expectations by establishing a correlation with actual behaviour. Some behaviour responds slowly over many years while some may not become evident for many years.)

The designer, review engineer, or inspection engineer should identify the issues that need to be monitored and incorporate appropriate instrumentation into the dam. For instance, for a farm dam, it may be concluded that there is no need for any instrumentation. Forms of monitoring include:

- deformation surveys
- water level measurements (including rainfall)
- seepage and pore pressure measurements
- measurements to confirm design parameters
- foundation pressure management
- stresses in embankments or structural components
- spillway performance and condition
- monitoring of deficiencies (eg cracking or erosion)
- seismic monitoring
- level of surveillance data.

The preferred frequency of monitoring varies over time. Factors influencing the frequency of monitoring include:

- the consequences of a dam failure
- the nature of the behaviour being monitored
- the stage of maturity of the dam (eg monitoring should be more intense during the construction and initial filling stages than during the operational phase)
- the existence of any problems or events (eg special events, such as record floods and earthquakes, will require more intense monitoring).

Dam owners should ensure that dam monitoring programs are reliably executed and that all instrumentation is maintained in a reliable condition and provides accurate readings throughout the life of the dam. Instrumentation available varies according to complexity, robustness and cost. Regardless of the instruments used, the dam owner must be able to ensure that the appropriate standard of monitoring is achieved.

The designer of the dam should determine the monitoring program, instrumentation used and frequency of observations initially in the design and construction phase. Dam owners should have a dams engineer review the appropriateness of the monitoring program, the instrumentation used and the frequency of observation as part of each comprehensive dam safety inspection. Instrumentation may need to be retrofitted if potential problems are identified.

There may be potential for remote monitoring and automation of data collection. However, malfunctions of remote monitoring and automatic data gathering during times of extreme weather conditions suggest that careful consideration be given to the reliability of such systems, especially when some form of operational control relies upon the monitoring. Owners should ensure that backup facilities are available for checking remote monitoring and accessing operational data for the dam during critical periods.

As the design and installation of instrumentation systems is a specialised area of dams engineering, dam owners should engage engineers experienced in this field.

The inclusion of accelerometers in dams in cooperation with wider seismic networks (state or national)

should be considered. This is important in seismically active areas or for large dams where reservoir induced seismicity could occur. Interpretation of data and maintenance of systems should be undertaken by a seismologist.

### 6.3 Data collection and management

Dam owners are responsible for the collection, storage and presentation of all data associated with the operation and maintenance of a dam. There are two types of data:

- Static data does not change with time. Such data will normally be stored in the data books, dam safety reviews and reports. Static data usually encompasses all design and construction investigations, including the Designers Operating Criteria. Much of this information is found in the Design Report and As-Constructed documentation.

As much of the static data will never be changed, it may be reduced and stored on microfilm or some electronic storage medium. Sufficient, easily accessible information should be kept on hand in Data Books to provide information for any situations which could arise.

- Dynamic data changes with time. It includes data derived from dam safety surveillance, monitoring, operations and maintenance activities. This data is accumulated in the Dam Safety Inspection and Surveillance Reports. Much of the dynamic data is suitable for computer storage and presentation, particularly that arising from monitoring.

For data collection and management purposes, dam owners should be aware of:

- the strengths and limitations of computer storage and retrieval systems (eg ease of access for retrieval of information)
- issues associated with compatibility of computer systems.

Dam owners should ensure that the system used to collect and process the data has facilities to detect the occurrence of “obviously different” data, which can be caused by:

- data recording and transfer errors
- instrumentation malfunction
- abnormal behaviour of the dam.

These situations should be investigated immediately. If the change is attributed to abnormal behaviour, the owner should initiate further investigations to explain the abnormality and ensure that it is not indicative of a worsening dam safety situation. These abnormalities can be a trigger for remedial action.

### 6.4 Surveillance evaluation

Not all dam deficiencies can be detected by visual inspections. There are many cases where an analysis of surveillance data has detected problems not evident by other means. Surveillance evaluation is an assessment of the safety of a dam in terms of its condition and operation based on data obtained from dam safety inspections and monitoring.

Data is accumulated during the course of surveillance, monitoring and operation of a dam. For ease of understanding, it may be beneficial to reduce this data into graphical form. Dam owners should ensure this data is evaluated on a regular basis to monitor the continued safety of each dam. Data evaluation should be assigned to an experienced dams engineer who should make recommendations based upon their interpretations.

Some examples of how areas of dam performance are considered in a surveillance evaluation include:



- assessment of the available pressure, movement and seepage monitoring data by analysis of the impact (if any) of all monitoring results
- assessment of the seepage from the storage (A plan should be provided showing position, quantity and quality of seepage.)
- the recent movement survey for the dam
- the foundation and embankment pressures being experienced by the dam. A plan showing the position and purpose of the individual piezometers should be provided.

Surveillance evaluation is conducted as part of a periodic dam safety inspection (at five yearly intervals), although evaluation may be undertaken at more frequent intervals or at times of concern.

Following evaluation, a Surveillance Report should be prepared. Experienced dam engineers familiar with the entire history of the dam should prepare this report. The Surveillance Report should:

- review all dam safety inspections and surveillance data for a dam
- identify any anomalous trends
- make recommendations on any actions required to ensure the continued safety of the dam
- summarise and extend previous reports to provide a clear picture of long-term trends.

Anomalies and concerning trends identified in the Surveillance Report should be considered as deficiencies. It is the responsibility of the dam owner to ensure that appropriate remedial actions are taken and documented. Further guidance on surveillance evaluation can be found in Appendix 3.

## 6.5 Dam safety inspections

One of the most important activities in a dam surveillance program is the frequent and regular dam safety inspection for abnormalities in conditions and deterioration of the dam.

Dam safety inspections are conducted to determine the status of the dam and its features relative to its structural and operational safety. Different types of dam safety inspections should be undertaken for different purposes:

### 6.5.1 Routine inspections

Purpose:	To identify physical deficiencies of the dam.
Reporting:	There is no standard report for these inspections as they can vary from a short weekly check for a small farm dam to a twice daily dam check using a checklist.
Undertaken by:	The dam owner or field and operating personnel as part of their normal duties at the dam.
Discussion:	Routine Inspections are best carried out by someone involved in the day to day running of the dam. Much of the inspection and observation should be incorporated in the daily work routine of such officers. The Standing Operating Procedures (SOP) should outline the requirements regarding: <ul style="list-style-type: none"> <li>• the timing and frequency of the inspections</li> <li>• who should be involved (In some cases electrical expertise may be needed to inspect some elements of dams.)</li> <li>• the reporting requirements.</li> </ul>

### 6.5.2 Periodic inspections

- Purpose:** Generally carried out by a dams engineer with the purpose of identifying physical deficiencies of the dam by visual examination and review of surveillance data against prevailing knowledge.
- Reporting:** The report should fully document the status of the dam and all defects or unsafe conditions and outline a strategy for taking remedial action (including preliminary costing and, if several defects or conditions are found, prioritisation of actions).
- Undertaken by:** An experienced dams engineer who is a Registered Professional Engineer (RPEQ).
- Discussion:** The inspection should assess all physical aspects of the dam. A periodic inspection requires preparation of checklists, preparation of mechanical equipment, and preparation of access (confined and difficult areas). These inspections are generally carried out on a five yearly basis. However many dam owners may opt to undertake a less extensive periodic inspection more regularly (eg annually). This inspection may exclude aspects of five yearly inspections such as:
- a test operation of all equipment
  - evaluation of all surveillance data
  - major function checks and maintenance inspections. For example:
    - flip bucket dewatering
    - conduit dewatering
    - diver inspection of intake works
    - conduit video inspection.

The timing of the inspection depends on the regional weather pattern. For example, if a distinct wet season exists inspections are best carried out immediately after the wet season, to allow remedial work to be planned and undertaken prior to the next wet season. Guidance on these inspections follows in Appendix 4.

### 6.5.3 Special inspections

- Purpose:** The examination of a particular physical feature or operational aspect of a dam for some special reason. For example, a special inspection may be carried out on a particular feature of a dam that has been identified as having a possible deficiency or has been subject to abnormal loading conditions.
- Reporting:** The report should fully document the status of the particular physical feature or operational aspect of a dam subject of the investigation as well as any other defects or unsafe conditions and outline a strategy for taking remedial action (including preliminary costing and, if several defects or conditions are found, prioritisation of actions).
- Undertaken by:** A specialist dams engineer.
- Discussion:** These inspections are often carried out with a degree of urgency. It requires some insight into the nature of the feature or defect being investigated to determine what specialist needs to be engaged to carry out the inspection. The inspection will address only issues that relate to the subject feature and is in addition to the regular and periodic inspections. Guidance on these inspections follows in Appendix 4.

#### 6.5.4 Comprehensive inspections

- Purpose:** A periodic inspection of the dam and a review of the owner's whole dam safety management program.
- Reporting:** The report should assess all aspects of the dam safety management program and fully document:
- deficiencies identified in the dam safety management program and its documentation
  - a strategy for overcoming the deficiencies (including prioritisation of actions if several deficiencies are identified).
- Guidance on these inspections follows in Appendix 4.
- Undertaken by:** An experienced dams engineer who is a RPEQ.
- Discussion:** This inspection should incorporate:
- a periodic inspection
  - an assessment of the appropriateness and adequacy, the effectiveness and application (including the owner's response to inspection report and Safety Review recommendations) of the dam safety management program and documentation for the dam including:
    - SOPs
    - DOMMs
    - Emergency Action Plan
    - Data Book
    - Design Report/Safety Review
    - Surveillance and inspection program and records.
- (This assessment should take into account applicable development permit conditions for the dam and the requirements outlined in this guideline.)

#### 6.5.5 Regulatory audits

- Purpose:** Independently, NR&M in its role as Regulator may audit dam safety management programs for referable dams in Queensland. These audits will generally examine compliance with development permit conditions dealing with dam safety and the outcomes of inspections and Safety Reviews. Such audits assist dam owners to compare their practices with industry standards.
- Undertaken by:** NR&M
- Reporting:** The report may indicate:
- deficiencies in the dam safety management program and its documentation
  - non-compliance with development permit conditions
  - proposed actions by NR&M and the dam owner
  - comments on the efficiency and the effectiveness of the dam safety management program.
- Discussion:** Generally the audit will be carried out on dams at random. Dams with a questionable management performance record are more likely to be audited. The outcome of these audits will assist NR&M to assess the effectiveness of their regulation program throughout the state.