Guideline for implementing a land-based taonga risk and vulnerability assessment in the context of freshwater environments: Māori Rock Art

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Ngā Kete o te Wānanga: Mātauranga, Science and Freshwater Management Project
In partnership with the Ngāi Tahu Rock Art Trust

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1 Introduction

Tāngata whenua values including land-based freshwater taonga and wāhi tūpuna[1] can be significantly impacted by freshwater management decision making - but are rarely considered in current planning processes. This is largely due to the absence of appropriate risk assessment frameworks and methods that must necessarily partner Māori values and knowledge (mātauranga Māori) with science.

A sensitivity-based risk assessment framework is proposed[2] for the protection of land-based taonga (e.g., Kā Tuhituhi O Nehera - rock art, wāhi tapu, pā, urupā) resulting from potential adverse impacts of modifications to associated freshwater environments. The framework is a methodological process designed to facilitate a partnering of science and mātauranga Māori by considering both cultural and scientific attributes. This will help rūnanga, planning authorities, resource consent applicants and other organisations evaluate taonga sensitivity within the context of freshwater decision-making, limit setting processes and resource consent applications

The guideline focusses upon a particular kind of land-based taonga – Kā Tuhituhi O Nehera (rock art), but it is intended that the methods can be transferred to other land-based tāngata whenua values.

A land-based taonga sensitivity and risk assessment could be triggered in five distinct ways:

- As part of an assessment of effects that accompanies a resource consent application under the Resource Management Act 1991;
- As part of an assessments of effects that accompanies an application to disturb or destroy a site pursuant to the provisions of the Heritage New Zealand Pouhere Taonga Act 2014;
- As part of a scenario analysis within a formal planning process that is being undertaken by a resource management agency, such as a regional council undertaking a limit setting process, or a district council reviewing the provisions of a district plan;
- During development of a property / site management plan, which could include preparation of a farm management plan; or
- During hapū and iwi planning processes.

This guideline contains two principal stages for implementing a land-based taonga sensitivity and risk assessment in the context of freshwater environments:

[1] Glossary: wāhi tūpuna - place of significant ancestral connection and value; taonga – a highly valued object or natural resource; tāngata whenua – people of the land, those who belong to and have an authority over a particular place..

[2] Gyopari, M. and Tipa, G. 2017. Maori rock are and associated freshwater taonga protection: A sensitivity-based knowledge convergence approach. Report by the Nga Kete o te Wananga: Mātauranga, Science and Freshwater management MBIE-funded project for the Maori Rock Art Trust. 2017.

- Identification and recognition of the presence of land-based taonga so that it can be included in planning process requires a specialised methodology based upon scientific assessment and mātauranga Māori. Chapter 2 summarises the sensitivity zoning methodology developed for the identification and inclusion of rock art sites in the planning process. This methodology could be adapted for recognising different land-based taonga.

- The second stage of the framework is contained in Chapter 3 which provides guidance and methods for undertaking a wāhi tūpuna hydrological risk assessment – using rock art as a specific example.

2 Identification and recognition of Māori rock art using a sensitivity zoning methodology

Māori rock art sites in New Zealand are intrinsically fragile and are threatened, often seriously and irrevocably, by adjacent land use activities. Water use activities in the vicinity of rock art can adversely affect both surface condition of vulnerable rock art pigments as well as nearby freshwater ecosystems which are an integral component of the cultural landscape (wāhi tūpuna).

Rock art sites are almost always associated with freshwater ecosystems (through provision of water, food and transport, in addition to being intimately associated with cultural and spiritual practices). The preservation and management of rock art sites – including their freshwater taonga – requires a good understanding of their sensitivity or vulnerability to activities or planning decisions that modify and disturb local hydrological and hydrogeological environments. For example, as a result of irrigation practices, diversion of waterways, drainage, water and effluent storage, groundwater abstraction and sub-surface contaminant flows.

A way of communicating the presence of rock art, and thereby flagging a need to take them into consideration when engaging in resource management planning processes, is through the delineation of sensitivity zones.

Three tiers of rock art sensitivity zone are proposed[2]:

1. Geological sensitivity zone: based on the mapping of outcropping limestone areas where rock art is exclusively located;
2. Hydrological effects sensitivity zone: based upon a calculated distance for avoiding the effects of activities such as irrigation, water abstraction and construction activities on the rock art site;
3. Wāhi tūpuna zone: these are maps which define the extent of the immediate cultural landscape and specific freshwater ecosystems intimately associated with a rock art shelter or group of rock art sites.

The first two zones are based upon scientific evaluation, whilst the Wāhi tūpuna zone is identified and mapped by tāngata whenua using mātauranga Māori. The delineation and layering of the zones is designed to facilitate a coherent and structured convergence of different knowledges – of biophysical science and mātauranga Māori.

The geological sensitivity zone is premised on the recognition that rock art in South Canterbury and North Otago is, without exception, associated with outcropping limestone. The use of mapped limestone outcrops (with 100m buffer to account for mapping resolution) is therefore proposed as a *broad-scale indicator* that there is a *high probability* that rock art will be present in the mapped area. This zone (shown in Figure 1 on a regional scale) provides a simple primary 'alert' to planning authorities and applicants that rock art is likely to be present.

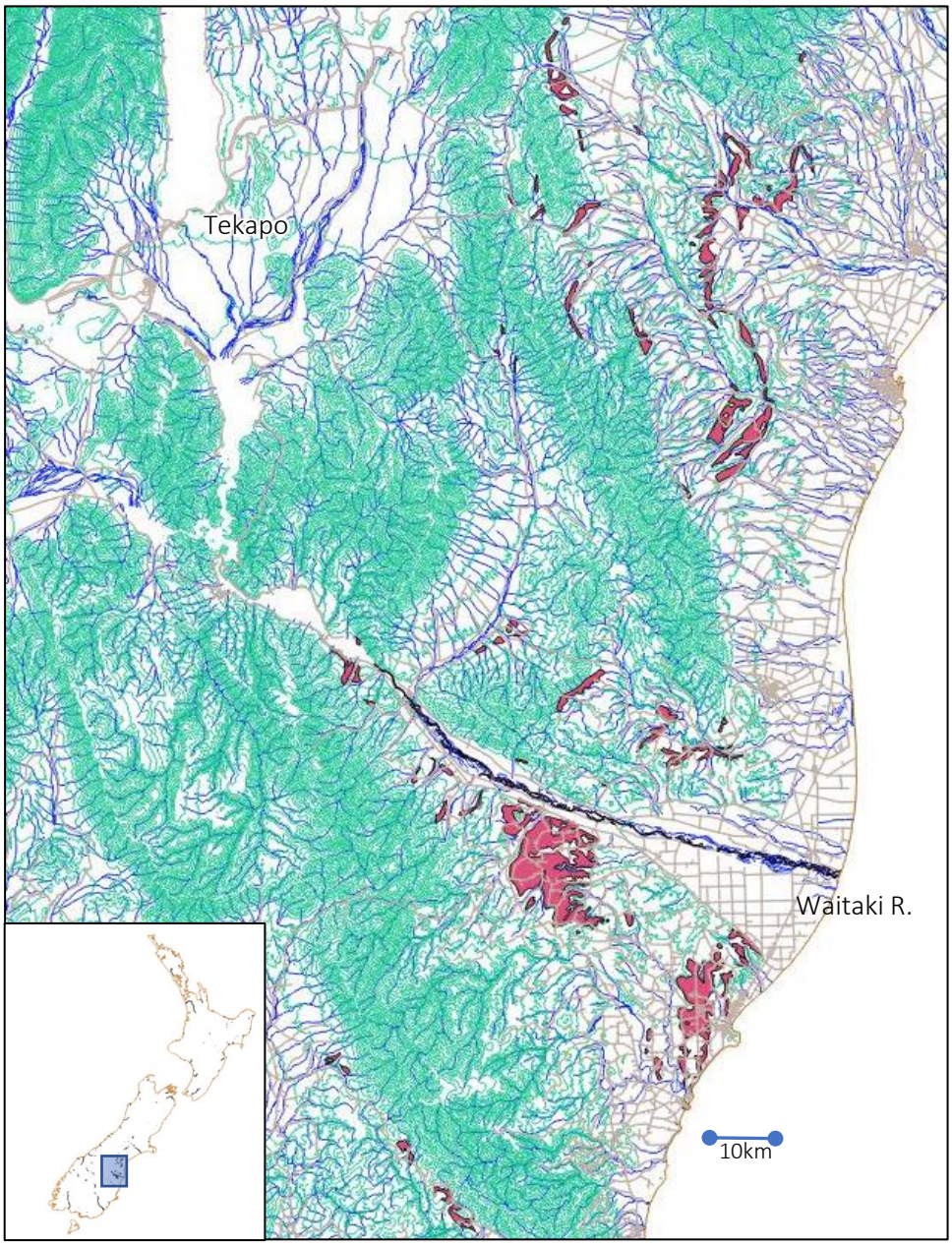

Figure 1: Distribution of limestone in the Ōpihi and Lower Waitaki catchments (dark red shaded areas) corresponding to the location of Māori rock art. Data source: GNS 1:250,000 geological map (Aoraki).

The **hydrological sensitivity zone** is an inner zone of fixed radius around each rock art site based upon calculation of the potential impact of hydrological and hydrogeological impacts associated with irrigation and groundwater abstraction. A fixed inner hydrological sensitivity zone of 300m is recommended (see Gyopari & Tipa 2017[Error! Bookmark not defined.] for a detailed description of the rationale behind the zone dimension).

The **wāhi tūpuna zone** is defined by the Heritage New Zealand Pouhere Taonga Act 2014 as a place important to Māori of ancestral significance and associated cultural and traditional values. Wāhi tūpuna mapping recognises other taonga, in addition to rock art, that contribute to the cultural landscape. Such taonga in a freshwater context may include wetlands, springs and streams. The wāhi tūpuna zone must be mapped by the Rūnanga, Ngāi Tahu Māori Rock Art Trust (or nominees). When a resource consent application is received, or when a planning authority requires it to inform other processes, the wāhi tūpuna zone will be

defined taking into account the nature of the site and the type, location and scale of the proposed activities or other aspects related to the use of the map.

It is important to note that these sensitivity zones are not intended to exclude activities, but rather they provide a planning support tool to ensure than any land or water-related activities are duly assessed to ensure that they do not compromise culturally important sites of considerable national significance

Because it is common for several rock art sites to be present in close proximity, the zones around each of them results will be superimposed and overlap. Figure 2 shows an example of overlapping hydrological and geological sensitivity zones around a group of rock are sites on the Opihi River in South Canterbury.

Figure 2: Example application of a rock art sensitivity zone map. Merged geological (limestone outcrop – shown in red) and hydrological (300m buffer – shown in blue) rock art sensitivity zones for a selected area on the Opihi River. Note: rock art site locations (small dots) are approximate only for the purposes of presenting this example. The map does not show the wāhi tūpuna zone.

Note on provision of rock art locations to planning authorities

The specific rock art locations will not be publicly available to ensure the security of the sites. However, the Ngāi Tahu Māori Rock Art Trust will provide GIS layers for the overlapping geological and hydrological rock sensitivity zones to planning authorities. The Trust will prepare the maps, check them for accuracy and update them as needed and will ensure that all necessary permissions and conditions for map use are in place.

The maps can be used to identify whether a proposed activity is likely to potentially impinge upon rock art. They will be valuable in terms of informing planning authorities during the design of freshwater management policy of the need to consider rock art in particular areas.

The maps provided to planning authorities will not include the wāhi tūpuna zone – which is to be mapped only when required. Therefore, planners need also to be cognisant of the wider freshwater environments in the vicinity of the geological and hydrological sensitivity zones.

3 Guidance framework for undertaking a rock art and wāhi tūpuna hydrological risk assessment

The following process illustrates a recommended process of implementing a rock art and wāhi tūpuna effects assessment process.

When a planning authority is required to make a policy decision or receives consent application which has potential to effect freshwater environments (groundwater and surface water including wetlands, springs, small streams and large rivers), the following stepped process should be implemented:

Step 1 - Consult sensitivity maps and Ngāi Tahu Māori Rock Art Trust
Potential areas of influence of a proposed activity location are overlain on the 'rock art sensitivity' GIS layer (i.e. merged geological and hydrological zones). Adjacent freshwater environments outside the rock art sensitivity zones also need to be considered when assessing potential effects. It is recommended that any freshwater environments with at least 500m of the hydrological sensitivity zones be initially identified. Note – the wāhi tupuna zone may not be available at this stage.

Step 2 - Define wāhi tūpuna zone
Papatipu Rūnanga, and / or Ngāi Tahu Rock Art Trust, or nominee to define the wāhi tūpuna zone.

Step 3 – Undertake risk analysis.
Ngāi Tahu Māori Rock Art Trust in consultation with planning authority undertakes a 'vulnerability screening'.

Step 4 – Investigation requirements
If medium, high or extreme risks are identified in Step 4, scope investigations needed to be carried out by applicants, councils to confirm risk and scale of impact. The Ngāi Tahu Māori Rock Art Trust, planning authority and applicant to agree upon a terms of reference for detailed effects and mitigation investigations.

Step 5 – Design/recommend mitigation and monitoring
If appropriate, mitigation actions and monitoring proposals are jointly agreed

Step 6 – Assess vulnerability of the rock art site and wāhi tūpuna to risks presented by land and water management decisions following adoption of the mitigation/ monitoring measures.

3.1 Step 1: Consultation of geological and hydrological rock art sensitivity GIS layer

The consenting authority will consult the rock art geological and hydrogeological sensitivity zones GIS layer to identify whether a proposed activity/application lies within them or is considered in close enough proximity to warrant further assessment.

The following activities occurring in any rock sensitivity zone are considered to present a potential risk to rock art and/or the associated wāhi tūpuna freshwater environment:

- Application of water or wastewater to land above or below a rock art site (through irrigation or other means, such as soakage whether intentional or unintentional);
- The abstraction or diversion of groundwater or surface water;
- The disposal of waste, wastewater or other hazardous materials on or beneath the land surface;
- The excavation of quarries, pits, reservoirs, ponds or other structures that cause intercept groundwater, dam surface water or store wastewater;
- The diversion of drainage channels or construction of new water conveyance structures;
- The drainage, modification or contamination of wetlands, springs, streams or lakes/ponds;
- Any other activity that may impact surface water or groundwater environments within the sensitivity zones.

In addition, major construction activities outside the sensitivity zones in the general vicinity of rock art (within c. 1km) represent a potential risk. These include, but are not limited to:

- Large scale groundwater abstraction (>100L/sec);
- Large scale excavations;
- Construction of major infrastructure including but not limited to water conveyance systems, roads and storage structures.

3.2 Step 2: Wāhi tūpuna mapping

Should any of the activities described above be located within are near to the rock art sensitivity zones, the Papatipu Rūnanga and Ngāi Tahu Māori Rock Art Trust are to be notified

who will determine if it is necessary to map a wāhi tūpuna zone. The relevant wāhi tūpuna mapping team will engage in mapping the zone and identify freshwater ecosystems and other factors associated with the rock art cultural landscape which they would like to be considered in the consent application.

Agreement to be reached between the Ngāi Tahu Maori Rock Art Trust, Rūnanga, consenting authority and applicant around values and attributes of relevant freshwater ecosystems. A 'terms of reference' may be collectively developed between the Applicant, consenting authority, and applicant for an assessment of effects to be undertaken with respect to the rock art site and/or the wāhi tūpuna landscape.

3.3 Step 3: Rock art risk analysis framework

The framework follows a conventional risk assessment framework and is based on the assumption that *risk* is a concept that is easy to convey given it links different knowledges.

The framework has several integrated aspects:

- Identify important elements / attributes of a rock art site that could be impacted – e.g. rock face, vegetation, type of art, condition, place in wāhi tupuna etc;
- Identify activities that could impact rock art/wāhi tūpuna
- Screen potential impacts of land and water management activities;
- Assess the level of risk represented by the impacts. Risk = severity x likelihood.

To first address aspects 1, 2 and 3, a matrix has been designed which screens the potential impacts of land and water management decisions on rock art sites. This is shown in Table 1 which identifies the principal attributes of concern and describes the potential impacts of activities which alter the local hydrological and physical environment.

Table 1: Matrix for screening the potential impacts of land and water management decisions on rock art sites

	MATRIX 1 – IMPACT OF ACTIVITIES ON ATTRIBUTES OF ROCK ART SITE				
Environmental Effects of Activities	**Overall rock face condition & stability**	**Rock art panel integrity**	**Safety/access**	**Wāhi tūpuna freshwater environments (springs, streams, wetlands)**	**Disturbance of other tangata whenua values (e.g. wāhi tapu, pa, urupa ….)**
Activities that locally raise the water table (e.g. irrigation, pond, canal, road construction or alteration, activities that result in structures that may impede or dam groundwater flow etc).	On top of rock art site: raised water table ('mounding') and increased soil moisture causes increased weight loading – risk of instability and large-scale failure/rock-fall. Migration of moisture to rock face from above or below (including from wicking and capillary rise from water table and drainage from above through the rock mass) causes changes in rock face stability and mechanical weathering processes. Changes in moisture content cause increased chemical and mechanical erosion.	Raised water table at base of art site, or increased recharge/drainage from above, causes changes in moisture content and possible development of (or changes to) a seepage face. Wicking/capillary action from higher water table may damage pigments, cause salt encrustation and chemical degradation. Increased risk of stormwater ponding at base of rock face results in changes rock face moisture content and microclimate. Migration of contaminants (i.e. nitrates, phosphates) to rock art panel and precipitation – obscuring and degrading art.	Increased risk of rock fall. Risk of changes in rock face condition and stability raises significant safety and access concerns. Increased risk of flooding and ponding during heavy rainfall events. Increased risk of unstable/unsafe public access routes.	Migration of contaminants adversely affects freshwater ecosystem health. Changes in natural hydrological functioning disrupts and damages wetland/spring ecosystem health. Migration of contaminants results in contamination of drinking water bores. Freshwater ecosystems are enhanced/restored by increased flows and raised levels.	Tāngata whenua values disturbed by raised water table and altered hydrological environment.
Activities that locally lower the water table (e.g. groundwater abstraction; drainage channels and structures, dewatered excavations, etc)	Drying of saturated zone above rock art site results in seasonal desiccation and permits rapid migration of runoff via fracture pathways to rock art face.	Changes in moisture conditions at rock face affects rock panel condition.	None	Freshwater ecosystem health impacted by extreme or atypical drying or depleted water levels and flows. Depletion effects on streams, springs, wetlands, main rivers.	Tāngata whenua values degraded by altered hydrological environment and negatively impacted freshwater environments.

Activities that changes vegetation cover (e.g. tree clearance or planting, forestry, native bush clearance, change in land use/vegetation cover)	Removal of vegetation (trees) – causes rotting root structure thereby creating enhanced pathways for drainage; increase risk of freeze/thaw mechanical weathering and risk of large-scale rock face failure; rotting of root systems causes slope instability. Planting of trees resulting in roots penetrating and widening rock fractures resulting in changed drainage and weakened slope/rock face.	Changes in recharge through overlying soil zone alters moisture conditions of rock panels. Changes in water chemistry/rates through rock outcrop causes damage to rock art panels. Changes in microclimate due to altered surrounding vegetation cover affects rock art panels.	Growing root systems cause rock face instability; rotting root structures may enhance mechanical weathering and rock face or slope stability.	Significant changes in vegetation cover (exotic species) alters the hydrodynamics of freshwater ecosystems; affects runoff; groundwater recharge; evapotranspiration causes water table to drop; invasion of root systems into sensitive freshwater environments	Tāngata whenua values disturbed by changes in vegetation cover and altered hydrological environments.
Activities that cause atmospheric contamination (e.g. irrigation spray drift; effluent spray drift; dust from construction and quarrying sites)	None	Significant changes in atmospheric moisture and dust negatively impacts rock art pigments rock surface condition (weathering, encrustation, moss/algal/biological degradation). Contaminants in spray drift negatively impact rock art.	Contaminants in spray drift and dust pose a health risk to visitors.	Air-borne particulates and spray drift containing nutrients contaminates freshwater ecosystems.	Tāngata whenua values are impacted by contamination of water resources.
Activities that alter, divert, dam or store surface water or wastewater, or dispose of waste (e.g. diversion of waterways, construction of irrigation canals and drainage ditches; water and effluent storage ponds; dams; waste pits)	Increased loading above rock art shelter from storage ponds/reservoirs increases risk of slope/face instability/rock fall. Leakage through unlined channels/ponds/ reservoirs enhances drainage through soil towards rock art site; may raise water table; causes increase saturation and loading and affects rock of slope/face stability.	Leakage through unlined channels/ ponds/reservoirs above rock art enhances drainage through soil towards rock art site – increased moisture and contaminants adversely impacts rock art. Leakage from unlined channels/ ponds/reservoirs below rock art causes raised water table and changes in rock face moisture/causes ponding.	Change and slope or rock face stability poses safety/access concerns. Increase risk of ponding during heavy rainfall events poses access and safety risk. Contaminants in drainage/leakage poses health risk.	Migration of contaminants causes adverse effects on freshwater ecosystems. Drinking water bores are contaminated.	Tāngata whenua values are impacted by changes hydrological environments and/or contamination of water resources.

Activities that cause significant vibration (e.g. construction of infrastructure, excavation, quarrying)	Risk of instability and rock fall.	Rock art panels physically damaged.	Rock fall risk increases.	None	None

Identification of the level of risk or opportunity presented by the screened potential impacts (aspect 4) is calculated using a risk classification which combines the assessment of consequences of the change with the likelihood of impact (which can be positive or negative). There are five classes of risk consequence - catastrophic, severe, major, moderate, minor. Table 2 provides risk matrices for negative impacts (2A) and positive impacts (2B).

Table 2A: Risk matrix used to calculate the level of negative impact

Likelihood	Negative consequences				
	Minor	Moderate	Major	Severe	Catastrophic
Rare	Low	Low	Low	Low	Low
Unlikely	Low	Low	Medium	Medium	Medium
Possible	Low	Medium	Medium	High	High
Likely	Low	Medium	High	High	Extreme
Almost certain	Low	Medium	High	Extreme	Extreme

Table 2B: Risk matrix used to calculate the level of positive impact

Likelihood	Positive consequences				
	Minor	Moderate	Major	Extreme	Phenomenal
Rare	Low	Low	Low	Low	Low
Unlikely	Low	Low	Medium	Medium	Medium
Possible	Low	Medium	Medium	High	High
Likely	Low	Medium	High	High	Extreme
Almost certain	Low	Medium	High	Extreme	Extreme

The final step of the risk assessment is achieved by combining the risk classification in Table 2 with the potential impact assessment contained in Table 1. Table 3 shows an example risk analysis for a specific rock art site.

Table 3: Example risk analysis for a specific site by combining the matrices in Tables 1 and 2

Component of rock art site	Activity of concern	Potential impact	Likelihood of Impact	Consequence	Risk (using the matrix in Table 2 and 3)
Overall rock face condition & stability	Irrigation on top of rock art bluff	Raised water table ('mounding') and increased soil moisture causes increased weight loading – risk of instability and large-scale failure/rock-fall.	Almost certain	Severe	Extreme
Rock art panel integrity	Irrigation on top of rock art bluff	Increased recharge/ drainage from above, causes changes in moisture content and possible development of (or changes to) a seepage face.	Almost certain	Severe	Extreme
Safety/access	Irrigation at base of rock art bluff	Increased risk of rock fall. Risk of changes in rock face condition and stability poses safety and access concerns.	Possible	Severe	High
Wāhi tūpuna freshwater environments	Groundwater abstraction in wāhi tūpuna	Freshwater ecosystem health impacted by extreme or atypical drying or depleted water levels and flows.	Possible	Moderate	Medium
Disturbance of other tāngata whenua values	Groundwater abstraction in wāhi tūpuna	Tāngata whenua values degraded by altered hydrological environment and negatively impacted freshwater environments	Likely	Major	High

3.4 Step 4: Investigation requirements

Contingent upon the outcomes of the step 3 risk assessment, the applicant, nominated specialists or regional council may be required to undertake investigations to further evaluate the impacts of proposed activities or planning decisions on rock art and wāhi tūpuna.

The scope of investigation and a terms of reference will be negotiated between the Papatipu Rūnanga, Ngāi Tahu Māori Rock Art Trust, Regional Council and applicant.

Accepted scientific and engineering methodologies are to be employed for assessing potential effects of activities. The Applicant and specialists will be required to work closely with the Ngāi Tahu Māori Rock Art Trust and wāhi tūpuna mapping team and share understandings.

3.4.1 Recommended rock art effects assessment methods

The background report accompanying this document[2] discusses the potential impacts of losses from irrigation practices on rock art through the possible raising of groundwater levels or the altered diversion of unsaturated zone irrigation return flows to the rock art panels.

A rock art impact assessment should be based upon Tables 1-3 and follow the agreed terms of reference. A full statement of uncertainties and assumptions must accompany the assessment which must nevertheless carry an acceptable degree of confidence that a nationally significant historical and cultural site will not be adversely affected by the proposed activity or planning decision. Evaluation of effects of the proposed activity on: rock face condition and stability, rock art panel integrity, safety and access to the rock art site, effects on associated freshwater environments (wāhi tūpuna), effects on tāngata whenua values (see Table 1).

The recommended scope of investigations relating to some specific activities is provided below. Note the scope is for general guidance and should not be limiting. Assessment of other activities not listed should follow the same overall methodology aimed at investigating the impacts of the activity on the local hydrological and hydrogeological environments and the potential effects on rock art and wāhi tūpuna freshwater environments.

Activities that can locally raise water table and/or increase water infiltration (e.g. irrigation / drainage modification, dam/pond construction, structures that dam groundwater flow).

Affects assessments should include provision of the following as minimum (but not be limited to):

- Activity location/area, description of nature of proposed activity (e.g. irrigation)
- Water (irrigation) application rate, water demand and efficiency during a range of climatic and soil conditions;
- Calculated seepage/leakage rates to groundwater from ponds, dams, channels
- Source of water (irrigation);
- Quantification of losses of applied irrigation water (or seepage losses) through the base of the soil horizon and the quality of the draining water (or seepage losses from ponds, dams, channels);
- Underlying geology and nature of the unsaturated zone (i.e. whether conditions are favourable for lateral interflow to the rock art panels);
- Magnitude of potential water table mounding and how or whether this will impact the rock art face;
- Potential groundwater and unsaturated zone flow paths, travel times and flow rates for infiltrating water;
- Potential for dissolved contaminants to reach the rock art surface, and potential for encrustation of salts;
- Whether the increased saturated weight of the soil horizon directly above a rock art overhang may result in an increased risk of structural instability and potential collapse;
- Whether a seepage face might develop or expand on the rock art surface (either from above or below);

- How uncertainties in the assessment can be mitigated through monitoring and remedial action.
- The potential for spray drift from the irrigated areas towards rock art, potential contaminants in the spray drift, any health risks.

The assessment will require a reasonable level of knowledge of the soil hydraulic properties as well as the unsaturated and saturated hydrogeological conditions. It is expected that in many assessments that some form of simplified soil moisture modelling and geotechnical analysis will be required to assess potential enhanced recharge through the soil zone and potential for rock face instability and excess seepage.

Groundwater abstraction/drainage/lowering of water table

The dropping of groundwater levels, although probably not of significant concern to rock art panel integrity, has potential to adversely impact nearby culturally significant freshwater ecosystems such as wetlands, lakes, springs and streams which are part of the rock art shelter's cultural landscape. Groundwater abstraction from bores below rock art shelters (usually from adjacent river terraces) is the largest potential cause of water table drawdown. The drawdown can cause springs and wetlands (taonga) to become dry when pumping is occurring and will also impact on the flow in nearby rivers.

Assessment of the impacts of groundwater abstraction should follow standard best-practice hydrogeological methods (such as analytical calculation, numerical modelling) and be fully documented. Assumptions and analysis limitations should be explicit and, where appropriate, an assessment of parameter and an uncertainty/sensitivity analysis should be presented.

Microclimate modification, spray drift, dust, vibration and any other environmental effects.

Rock art and associated taonga is potentially sensitive to other environmental effects – such as irrigation spray drift, significant microclimate modification, dust, vibration, and any other activity which may impinge on the site. Due consideration should be given to these in any assessment using recognised methods.

3.5 Step 5: Mitigation and monitoring

Following identification of the risks to rock art, mitigation actions may be required to reduce or avoid the risks. Mitigation actions may include maintaining a specified buffer between any activity or structure and the rock art site/wāhi tūpuna or adapting the operation and design of activities or structures to minimise or avoid risks.

In addition to any other mitigating or avoidance requirements, the following general minimum restrictions are recommended:

If a proposed activity is located within any of the sensitivity and wāhi tūpuna zones:

- A minimum irrigation set-back or buffer of 100m (between margin of spray irrigation application and rock face/bluff hosting the rock art, or wāhi tūpuna

freshwater ecosystem) is to be maintained. Where risks to rock face damage by moisture ingress are evaluated as high or extreme, a larger buffer may be recommended.

- Within a 300m radius of the rock art site, ensure that any irrigation practices are efficient and are closely managed using soil moisture monitoring instruments to minimise any excess drainage through the soil zone.

The rock art risk and effects assessment may result in a need to establish a monitoring programme to measure potential effects of hydrological, hydrogeological, climatic ad other environmental conditions. For example, it may be necessary to install soil moisture monitoring instruments to ensure efficient application of irrigation or monitor shallow groundwater levels. Monitoring of rock face moisture content (thermal imagery) and salt deposition may be required in special circumstances where the risk is conserved to be high or extreme.

The monitoring programme should be developed in association with the Rock Art Trust, planning authorities and land owner. Consideration should also be given to establishing an adequate monitoring baseline record prior to the commencement of a rock art -sensitive activity.

3.6 Step 6: Vulnerability assessment

'Vulnerability' combines the assessed risk with the capacity to avoid or mitigate the risk

The vulnerability of the site needs to be reviewed following risk and effects investigations and the design of mitigation or risk avoidance actions. The vulnerability review is calculated using a matrix (shown in Table 4) which combines the assessment of risk (from Table 2 – revised following the investigation activities – Step 4) with the capacity to address or mitigate the identified risk(s). This results in a three-fold categorisation of vulnerability:

Low: Can avoid or mitigate with major disruption and significant additional costs being incurred.

Medium: Can avoid or mitigate with moderate disruption and moderate additional costs being incurred.

High: Can avoid or mitigate with minimal disruption and minor costs additional being incurred.

Table 4: Assessment of vulnerability

Potential impact risk	Ability to mitigate or avoid impact		
	Low	Medium	High
Extreme	High	High	Moderate
High	High	High	Moderate
Medium	Moderate	Moderate	Low
Low	Low	Low	Low

Combining the risk identification (Table 1), risk assessment (Table 2) and vulnerability review (Table 3) assessments, an example summary analysis of a proposed activity is provided in Table 5.

Table 5: Example summary of risk and vulnerability assessment

Concerns	Rock Art Trust outcomes	Mitigations	Responsibilities - who will undertake the mitigations and who will monitor/audit	Risk	Adaptive Capacity	Vulnerability
Irrigation causes raised water table ('mounding') and increased soil moisture causes increased weight loading – risk of instability and large-scale failure/rock-fall. Irrigation causes increased recharge/drainage from above, causes changes in moisture content and possible development of (or changes to) a seepage face.	To ensure the rock art bluff is stable and poses no safety and access risks to visitors. To ensure rock art is not damaged by infiltrating water derived from irrigation returns Mineral encrustation processes are not exacerbated.	• Irrigation set back distance of 250m from the rock face. • Soil moisture monitoring undertaken to ensure efficient water application and minimise returns to groundwater within 500m of the rock face. • Monitor rock face stability (visually) and rock face moisture changes using thermal imagery.	• Applicant to ensure buffer is maintained. • Applicant to monitoring soil moisture and ensure irrigation efficiency • RAT to monitor face stability, moisture and slat encrustation.	Extreme	High	Moderate