Working near pit lakes – health and safety considerations

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Abstract

Pit lakes and their surrounding environment represent significant occupational health and safety (OH&S) risks to workers, whether they are on an operational or a relinquished (abandoned) mine site. Employers of staff working near pit lakes have a legal obligation to protect the health and safety of our employees and organisations and project leaders will benefit from improved OH&S reducing costs and increasing productivity.

The most significant acute OH&S risks around pit lakes relate to drowning. Other significant risks are heavy lifting of boats and other equipment, and off-road travel to site. Environmental exposures to extreme hot or cold may also occur where mining sites are located in extreme climates such as tropical, desert or cold-temperate regions. Diving in pit lakes is a particular hazard that should be avoided where possible by using engineering alternatives such as remote sampling devices. Protective personal equipment (PPE) should be a combination of standard field environmental protective clothing, e.g. sun hat and strong footwear, and mine site PPE requirements such as hard hat and long pants/shirt sleeves.

Chronic OH&S risks include inappropriate and sustained physical exertions and health effects from contaminated pit lake water such as elevated metals and metalloids. However, standard water quality contact issues such as pathogenic contamination may be more significant.

A risk-based approach is recommended to address risks, as an intrinsic component of near pit lake work planning and prior to entering the pit lake environment. This should be understood by all pit lake workers and regularly updated by learnings and other experiences.

1 Why health and safety?

Businesses and individuals have moral obligations to health and safety (OH&S); however, attention to OH&S is not just about being socially responsible. It also makes good business sense and OH&S should be regarded as just as important as the achievement of any other key project objective. Good health and safety practices can also help to enhance perception of their organisation as a socially responsible group. Good OH&S practices can:

- reduce absences and increase the productivity of workers
- increase motivation and the commitment of staff
- reduce project costs, such as insurance premiums, and decrease project disruption.

There are also legal and financial responsibilities which most countries have as laws and regulations. If businesses get OH&S wrong, the costs of accidents and ill-health can be substantial. For the individual, there are the costs of care, loss of earnings and loss of quality of life.

For large mining companies, OH&S incidents can therefore lead to significant disruption of productivity, claims for damages, government enquiries and inspections, loss of from communities and workers goodwill and loss of staff confidence in management. For small organisations such as research institutions and small consultancies, occupational accidents can have a major financial impact and delay or even prevent project outcomes being realised.

2 Risk management

The identification, assessment and management of risk are fundamental to effective health and safety and is a critical part of the decision making and planning process. It is important to understand the difference between hazard and risk.

Table 1 Hazard and risk definition

Hazard	A source or situation with a potential for harm in terms of human injury or ill-health, damage to property, damage to the environment, or a combination of these, e.g. deep lake water.
Risk	The combination of the likelihood of an occurrence of a hazardous event or exposure(s) and the severity of injury or ill health that can be caused by the event or exposure(s), e.g. deep lake water and a chance of falling in.

Standards and legislation regarding risk management vary depending on the country or state. However the methodology and principles of risk management remains constant regardless of location.

The guiding principles of risk management are:

- Hazards are identified and considered in the decision making process for projects, purchases and significant changes.
- Risks are assessed using tools and methods appropriate to the nature and scale of the task.
- Stakeholders are consulted when assessing risk and determining control measures.
- Risk controls are communicated to employees and contractors.
- Risks are reviewed following implementation and when significant changes occur.

2.1 Responsibilities

Everyone has a responsibility to take care of their own safety and that of others. However, effective risk management requires clear responsibilities to be determined at the outset. An example of safety responsibilities for a pity lake project may look like this:

- Staff are aware of a risk management framework and equipment used on the project.
- Risk management is implemented into the decision-making process.
- Risks associated with the project have been identified and adequately controlled.
- Staff on the project are aware of risk controls required.
- Staff have the tools and understanding to apply risk management principles during the project.
- A review of the adequacy of risk management process is undertaken at the project's conclusion.
- Conversely, staff should ensure they raise concerns in relation to safety issues with their manager and that they comply with the risk controls in place for the project.

2.2 Hazard identification

The first stage in risk management is to identify the hazards involved in the work to be undertaken.

Identifying hazards early in the process assists in clarifying responsibilities and or controlling or even eliminating the hazards throughout the lifecycle of the project. Identifying hazards may also avoid significant design changes late in the project and prevent injuries to direct employees and contractors working around the lake.

An effective risk management tool is the utilisation of a facilitated Hazard Identification Workshop (HAZID) at the beginning of the project to identify or review any general or specific health and safety hazards.

The objective of a HAZID workshop is to share and document project health, safety and environment risks and to ensure that measures are mitigating the risk. Consultation is a central feature of risk management because involving the people who do the work in identifying hazards and deciding how to control risks is the most effective way to manage health, safety and environmental risks. To obtain the most value from a HAZID workshop a health and safety representative from the pit lake project workers, contractors and mine company representatives should attend.

Representatives at the workshop should have detailed knowledge of the tasks, health and safety issues and risk controls relating to the work they will be undertaking. The attendees should also be at a level to influence preparation and execution of project activities within their own company. Experience shows that the most effective starting point for a HAZID workshop is to break the project into the main activities such as:

- travel to site
- project work
- discipline areas (e.g. hydrological, environmental)
- work environment, i.e. issues that are common across the work environment such as, hazardous fauna and environmental, e.g. heat, etc.

Once the main activities are identified the next step is to identify what hazards are likely to be present in each activity, what would cause those hazards to be realised, the consequences if they were realised and what controls are already in place to mitigate the hazards (Figure 1). If the risk rating remains high even with the current controls in place then further controls should be identified and, once these are in place, the risk reassessed. The resultant hazard is then risk assessed using a risk matrix.

							Risk Ranking				Residual Risk		
Item	Activity	HAZARD	Event	Cause	Consequences	Controls/ Mitigation	Likelihood	Consequence	Risk Rating	Further Treatment/ Controls/ Strategies	Likelihood	Consequence	Risk Rating

Figure 1 A HAZID worksheet to help identify and then control project risks

2.3 Risk assessment

Risk assessment should evaluate both the likelihood of a specific hazard being realised and the reasonable potential consequence that would result. Risk should be assessed through the use of a Risk Matrix. An example of a standard 5 x 5 risk matrix is shown in Figure 2.

Likelihood		Consequence				
		Catastrophic 5	Major 4	Significant 3	Minor 2	Insignificant 1
Almost certain	5	25 (VH)	20	15	10	5
Likely	4	20	16 (H)	12	8	4
Possible	3	15	12	9 (M)	6	3
Unlikely	2	10	8	6	4 (L)	2
Rare	1	5	4	3	2	1 (VL)

Figure 2 A typical 5 x 5 risk assessment matrix

Different organisations may use different risk matrices; some may use a 6 x 6 matrix or reverse the numerical ranking so that a value of 1 represents a Very High rather than Very Low risk. The format of the risk matrix is less important than ensuring that when assessing the risks all parties are working from the same agreed matrix format. To assist with determining the likelihood and consequence levels definitions are provided for each value (Tables 2 and 3).

Table 2 Likelihood descriptors

Likelihood	Rating	Description
Almost certain	5	Incident will occur in every circumstance (e.g. every time).
Likely	4	Incident will probably occur (e.g. 1 in 10 times).
Possible	3	Incident may occur at sometime (e.g. 1 in 100 times).
Unlikely	2	Incident is not expected to occur, but is conceivable (e.g. 1 in 1,000 times).
Rare	1	Incident would only occur in exceptional circumstances (e.g. 1 in 10,000 times).

Table 3 Consequence descriptors

Consequence	Rating	Description
Catastrophic	5	Death, large scale, long term environmental impact with detrimental effect, very high financial loss.
Major	4	Extensive injuries, loss of production capacity, environmental impact with potential long-term impact, high financial loss.
Significant	3	Medical treatment required, short-term environmental impact requiring assistance to manage, moderate financial loss.
Minor	2	First aid treatment, environmental impact can be managed with existing procedures and equipment, limited financial loss.
Insignificant	1	No injuries, low financial loss, minimal environmental impact.

As with risk matrices, the descriptions for likelihood and consequence will be different for each organisation. For example, what may only be considered a low financial loss for a large mining company may represent a much higher consequence for a small consultancy.

2.3.1 Risk assessment tools

A variety of tools are available for assessing risk dependant on the activity and level of risk. Regardless of the tool used the process for assessing the risk must remain consistent throughout the project, i.e. risk ratings are always referred back to the same matrix and likelihood and consequence descriptors.

2.3.1.1 Health, safety and environmental plans (HSE)

A HSE plan is developed from the results of the HAZID Workshop. The HSE plan details the hazards and risk associated with a specific project and the control measures in place to mitigate these. A HSE plan is a working document that must be accessible at the work site and is subject to continual review and updating to reflect changes to the project which may impact on safety.

2.3.1.2 Safe work procedures (SWP)

Sometimes referred to as standard work procedures, an SWP is a supporting document that details the minimum acceptable controls to manage potential hazards present in a standard operation. SWP may be generic to a task, i.e. water sampling in a pit lake, and so will not address the hazards specific to different sites or the use of different equipment.

2.3.1.3 Risk assessment form

The risk assessment form is used when a single issue is being assessed (e.g. fatigue) or a new piece of equipment is being purchased. Multiple hazards relating to the issue or piece of equipment can be recorded on the form. For example, hazards associated with use, storage, transport and disposal of new equipment.

2.3.1.4 Job safety analysis (JSA)

Also known as a job hazard analysis, work method statement or job safety and environment analysis, a JSA is a tool to guide a person or small group through an exercise in hazard identification and control in relation to a specific task. A JSA is the process of breaking a task down into steps and identifying the hazards associated with each step. This allows for the task to be critically examined prior to commencement to identify the hazards of the job and to identify ways to eliminate or control the risks. A JSA can be developed for a standalone task or to manage risks associated with an onsite safety issue not identified in the HSE plan. A JSA must be signed as read and understood by the personnel involved in the task and usually have an expiry date after which they must be re-drafted. The expiry is to ensure that a JSA remains current and takes into account any changes relating to the task or site. As JSA are specific to the task and location they are the ideal supporting documents to the more generic SWP.

2.4 Control and mitigation

Once the hazards have been identified and the risks from those hazards ranked, it is time to consider the appropriate level of controls to mitigate the risks. The hierarchy of controls approach should be used when determining the most effective controls to be implemented (Figure 3 and Table 4).

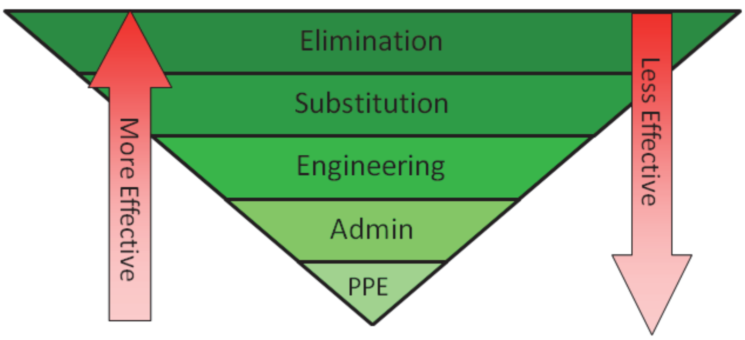

Figure 3 The hierarchy of controls for managing project risks

Table 4 Actions in order of priority to reduce risks

Action	Description
Elimination	Remove the hazard completely.
Substitution	Substitute the hazard with something less hazardous.
Engineering	Modify/guard the process to prevent people contacting the hazard.
Administrative	Implement processes, procedures, training, etc., to assist people in working with the hazard.
Personal Protective Equipment	Provide equipment and clothing to protect people should they contact the hazard.

Wherever possible a hazard should be eliminated. If that is not possible it should be controlled at its source through the use of an engineering control. Some hazards may require a combination of controls, i.e. engineering, administrative and PPE. The amount of time and resources put into controlling a hazard should reflect the risk which the hazard presents (Table 5).

Table 5 Guidance for implementing controls

Risk magnitude	Management requirement
Very Low Risk (VL)	No additional controls necessary. Continue to monitor risk.
Low Risk (L)	Consider additional controls to further reduce risk.
Moderate Risk (M)	Controls must be implemented to control risk.
High Risk (H)	Risk unacceptable. Do not proceed without additional controls. A minimum of engineering controls required.
Very High Risk (VH)	Risk unacceptable. Do not proceed without additional controls. A minimum of substitution or elimination controls is required.

3 Fieldwork safety

This section will briefly examine the hazards which are present in most operations undertaken in the field. Some of the hazards are applicable to sites in most parts of the world (vehicles, emergency response) while others may be more applicable to sites in Australia (snakes).

3.1 Fitness for duty

An employer's duty of care requires that reasonable steps be taken to provide a workplace free of hazards and to ensure that individuals are fit for work. Fit for work means that an individual is in a satisfactory physical, mental and emotional state to perform assigned tasks competently and in a manner which does not compromise or threaten the safety and health of themselves or others.

An individual may be unfit for work for a variety of reasons including the adverse effects of fatigue, stress, alcohol or other drugs and a range of physical and mental health issues. The consumption of alcohol or unauthorised drug intake should be strictly forbidden during work operations. Screening for alcohol and other drugs may be undertaken in accordance with the relevant Standards.

Personnel may also be required to undertake pre-mobilisation medical fitness tests and on-going medical surveillance during a project. Personnel returning to work following injury or illness may require additional medical examination at an approved medical centre to be confirmed as fit for duty.

3.2 Climate considerations

A combination of heat and humidity greatly increases the risk of heat-related illness. A combination of heat, humidity and wind speed allows a calculation of thermal comfort, sometimes called apparent temperature.

3.2.1 Hot and dry climates

Working in the heat can significantly increase of illness and also fatigue, which in turn can exacerbate a range of risks associated with the work. If the work does not involve significant movement, arrange for a portable shade structure to be erected to provide protection from the heat. Where possible, schedule physically demanding work in cooler parts of day and take regular breaks in a cool or shady area. This may be in the air-conditioned cab of the field vehicle.

Drink water regularly. You may need up to 8 L/person. Minimise intake of caffeine and soft drinks. Be aware of the heating effects of protective clothing such as coveralls, gloves and hard hats as these can reduce your body's ability to dissipate heat. Monitor for signs of heat stress and levels of fatigue. Consider protective gloves to handle equipment that retains heat from the environment (e.g. metal equipment).

Notify your project leader if you have a condition or are taking medication that affects your ability to work in the heat. Conditions that increase the risk of include: asthma, influenza, gastro, diabetes, pregnancy, heart conditions and epilepsy.

3.2.2 Hot and humid climates

There is an increased risk of heat-related illness when:

- the air temperature is between 31–35°C and the relative humidity is greater than 30%; or
- the air temperature is greater than 36°C and the relative humidity is greater than 25%; or
- the air temperature is greater than 37°C regardless of the humidity.

In these situations the following additional controls are required:

- Personnel working in the area should be acclimatised to the conditions.
- Rest breaks should be taken every hour as a minimum.
- An additional 4 L of water/person/day should be provided and personnel should drink 150 mL every 15 minutes during activity.
- Broad brimmed hats and loose fitting long sleeves and pants will protect from the sun’s heat and UV exposure (Figure 4).

Figure 4 PPE can consist of a number of items: protection against impact, cuts and abrasions; protection from AMD waters; protection from the sun; and buoyancy aid in case of immersion in the lake (Photo courtesy of C.D. McCullough)

3.2.3 Cold climates

Working in wet and cold environments can make handling items more difficult due to a lack of blood flow to the fingers. The use of gloves can also impact on manual dexterity. Wind chill can also significantly affect the apparent temperature particularly in conditions of high humidity as water conducts heat away from the body 25 times faster than dry air. Control measures for cold climates include:

- wear jackets, hoods, beanies and other clothing as required
- take regular breaks in warm areas, such as the cab of the vehicle
- monitor for signs of cold stress
- eat regularly and stay hydrated.

A number of factors may increase your susceptibility to the effects of a cold environment, including:

- previous cold-related injury
- predisposing health conditions:
  - fatigue, poor physical condition, old age
  - poor nutrition
  - medication
  - alcohol and caffeine.

3.3 Vehicles

There may be a number of types of vehicles on an operational mine site including heavy machinery (trucks, excavators, drill rigs) and light vehicles (project related, public vehicles and recreational vehicles). All vehicles represent a significant risk to the operator as well as personnel working in the vicinity. Controls for vehicles may include completion of any mine site pre-mobilisation inspections and adherence to site specifications/standards. There may also be site requirements for restricted roads and safe distances from moving plant such as haul trucks. The requirements for vehicles operated on site may include the following items in addition to the standard safety equipment in a domestic vehicle:

- roll over protection structure (ROPS)
- revolving flashing beacon
- bull bar
- cargo barrier
- first aid kit capable of treating minor injuries
- fire extinguisher
- breakdown kit (torch, warning triangle/cone and reflective vests)
- reversing alarm
- uhf radio, or satellite phone in more remote areas
- whip aerial and flag
- engineered/rated recovery points.

Personnel who are required to operate vehicles on a project should be adequately trained and possess the necessary skills to ensure the safe operation of the equipment. This may include specialist training in the vehicle itself and/or the terrain over which the vehicle is to operate, i.e. four-wheel driving training and/or training for driving off-road.

Figure 5 Where driving terrain is unknown or unpredictable, a walking leader can help find the best route forward trial (Photo courtesy of C.D. McCullough)

3.4 Emergency response and communication

In the event of emergency, the work activities should be stopped and the area made safe. If it is not possible to make the area safe, personnel should move to designated muster points and follow emergency procedures. The muster points should be designated prior to the start of work and there should be two muster points nominated for each work area.

A vital component of emergency management is effective communications. In the event of a crisis some or all of the following groups may need to be addressed:

- mine site contact staff
- other project staff
- family members of employees
- contractors
- members of the public
- regulatory authorities, i.e. police or environmental agencies.

Project emergency communications are likely to be conducted through a two-way UHF radio system and a dedicated emergency channel and backup channel should be agreed. Back up methods of communication may include:

- mobile phones
- satellite phones
- text messaging
- email.

Emergency response actions should form part of the projects HSE plan and should address as a minimum:

Table 6 Emergency response planning

Emergency	Suggested Actions
Medical	• Identify local medical facilities and support services. • Identify evacuation routes and methods. • Ensure First Aid is available in project vehicles or as personal issue. • Ensure filed personnel are trained to Senior First Aid level.
Fire	• Identify local fire support services. • Identify alarm signals, evacuation routes and muster points. • Ensure portable fire extinguishers are in project vehicles or available on site near the work area. • Ensure field personnel are trained in basic fire fighting.
Adverse weather	• Identify weather monitoring sources and delegate responsibility to monitor. • Identify evacuation routes and muster points. • Ensure field staff are aware, as applicable, of actions to take in the event of: ○ lightning ○ heavy rain ○ flood/tsunami ○ cyclones/hurricanes ○ strong winds.

Consideration should be given to the provision of post-emergency event support for personnel involved in a serious traumatic incident – either directly or indirectly.

3.5 Flora and fauna

Hazards may exist from local flora and fauna. Bites from fauna can cause health issues beyond the initial wound, i.e. leptospirosis from infected animal urine or Lyme disease from tick bites. Other bites may require special first aid treatment, i.e. compression bandages for snake bite. Similarly the toxic effects from flora can range from irritable dermatitis to poising causing minor health effects such as vomiting, or even death.

3.6 Manual handling

Muscle/ligament strains and back injuries due to poor manual handling practices are common in most occupations. Most legislation regarding manual handling, the most common cause of strain and back injuries, has moved away from the traditional prescriptive approach of specifying maximum lifting weights, etc. Instead, legislation now favours a hazard evaluation process to determine whether the specific individual is capable of conducting particular manual tasks.

The following risk control measures are suggested as only a few of many methods to reduce muscle strains and back injuries from manual handling. Do not attempt to move heavy or awkward items such as boats alone. Notify your supervisor and have heavy items moved with the aid of others. Drive as close as safe to the lake before unloading boats and use engineering solutions whenever possible to avoid directly lifting a heavy object, e.g. light trailers retractable wheels on boats.

- Do not make sudden, awkward, reaching or twisting moves while bending down. Your upper bodies contain significant weight; people have ruptured discs while bending over to pick up a paper clip.

- When lifting, crouch down, hold the object close to your body and keep your back straight.
- Do not spread your feet beyond the width of your shoulders, and use your leg muscles as much as possible to lift. When setting an object down, reverse the lifting procedure. Keep your back straight and lower with your leg muscles. Do not shift your feet or twist your back when lifting or lowering.

Figure 6 Loading and unloading from transport vehicles and carrying boats across rough and broken terrain is probably one of the greatest manual handling risks workers around pit lakes face (Photo courtesy of C.D. McCullough)

3.7 Hazardous materials

The storage and use of hazardous materials and substances presents both a personal injury and an environmental risk. Hydrocarbons and chemicals must be transported, handled, stored and disposed of correctly and in accordance with the relevant legislation.

Controls for hazardous materials should include:

- Reviewing storage and handling facilities for engine fuel and potentially hazardous chemicals such as sample preservative acid and ethanol before travelling to site.
- Include the minimum requirements for the handling and storage of chemicals and hydrocarbons in the safety induction.
- Keep a copy of the material safety data sheets (MSDS) where the hazardous materials are to be used and/or stored such as in laboratories.

As a general rule the product proposed should be the least hazardous to effectively perform the task for which it is being used and the quantity brought to site should be the minimum necessary to complete the job. For example, transport of dilute acid for metal preservative or ethanol instead of formalin for biological specimens.

4 Working safely near pit lakes

4.1 Access/egress

Due to the nature of their formation from previous mining operations, pit lakes tend to have steep sides and access can present a significant hazard in itself. To increase the risk the edges of the pit may be formed from unstable, slippery, soft or crumbly material.

Obvious hazards to consider are slips, trips and falls whilst negotiating the slopes as well as movement of the slopes themselves, potentially leading to earth-slips or landslides. Even a minor earth-slip may dislodge rocks which could pose a risk to other personnel on the slope or working in the pit lake. Use of a rope or firmly anchored ladder may assist with access and egress.

Care should be taken to limit the impact on vegetation by using approved tracks and also by defining exclusion zones around sensitive vegetation. Sensitive vegetation includes riparian (waterway) vegetation, habitat for endangered species and cultural heritage areas. Some of these areas are under protection orders of the local Environmental Protection Agency.

Prior to entering a pit lake consideration should be given to how you would manage a medical evacuation from the pit if required. Unless you have visited the site previously it is unlikely that an effective strategy could have been developed at the project HSE plan stage. A JSA or risk assessment should be conducted on site to address the location specific hazards to evacuation that are present in the pit and surrounding site.

4.1.1 Public access

Some pit lakes may be accessible by the general public and/or other workers on the site. On sites where public access is possible consideration must be taken to ensure that the project's operations do not present a risk to other people. People are naturally curious and controls should be considered with this in mind. Controls may include signs warning of the hazards, physical barriers around the work area, closure of access roads, site security and/or controlled entry. Similarly any equipment which is to be left on site should be secured to prevent theft, vandalism or unauthorised use, i.e. children using the project's boat to play on the pit lake.

4.2 Working around water

4.2.1 Water quality

The water within pit lakes may present a number of hazards due to poor water quality or other contamination. Dangerous gases such as carbon dioxide and hydrogen sulphide may be concentrated in the catchment or may be released in the event of a partial or complete lake turnover. Released gases may be heavier than air and form a lethal layer of CO_2-rich, H_2S-rich or O_2-poor air just above the lake surface. Use of direct-reading gas monitors and/or personal monitoring badges should be considered for establishing and on-going monitoring of the air quality in the work area.

In addition to the standard PPE for field work (high-visibility long trousers and shirts, safety helmets, boots and glasses) consideration should be given to personal respirators, chemical resistant gloves/aprons and safety goggles and/or face masks.

Prolonged contact with contaminated pit lake water may cause skin disorders like dermatitis and highly acidic waters can cause accelerated corrosion of equipment including aluminium boats. Given the chronic and acute effects which can be caused by pit lake water quality consideration should be given to implementing regular health surveillance screening for personnel involved in the field work.

4.2.2 Working near water

By nature the area surrounding natural and man-made watercourses is likely to be slippery and presents numerous trip hazards. Water and algae or similar substances significantly increases the risk of slipping. While obstacles such as exposed tree roots, eroded gullies etc present an obvious trip hazard.

While working in pit lakes there is an ever-present risk of falling into the water. This can be reduced by considering the work being performed and establishing the most stable place to perform it from and minimising the time spent by the water side. Carry only equipment needed to complete each task. If bags or belts are used to carry equipment, these should be designed to allow for quick release.

Processes to retrieve a person from the water shall be considered prior to commencing work. This includes the use of a personal floatation device (PDF) should the depth of the water be more than 1 m at the work location. When assessing which type of PDF to use consideration should be given to inflatable styles which are less likely to interfere with the manual dexterity and range of movement required to conduct the work. Inflatable PDF can be purchased which either inflates manually or automatically on contact with water. When working in cold weather a fall into water could also expose personnel to cold stress and hypothermia. Spare dry clothes and a means to dry off should be carried in such weather.

4.2.3 Working on water

Sampling activities may require the use of small boats. When selecting the type of boat to use consider the task being undertaken, the weight of passengers and equipment and the location in which the work is to be performed. An aluminium boat will be lighter and easier to launch and recover than a fibreglass boat.

A flat-bottomed 'punt' type of boat will provide greater stability than a traditional 'V' shaped hull which is important as sampling activities are likely to require leaning over the side of the boat. Stability will be further aided by remaining seated, careful weight distribution and clear communication before changing position. Unexpected collapse of the pit sides into the lake can also create a wave large enough to swamp a small boat and personnel should wear a PDF at all times and be confident swimmers.

The use of a boat for a project is likely to come under the classification of commercial usage. An operator of a commercial vessel must be able to demonstrate they comply with the relevant State or Federal legislation. Commercial vessels within Australia and New Zealand will generally be classified according to the number of passengers they can legally carry and the location or area of operation (e.g. offshore, smooth water). It is important to ensure the vessel has the appropriate classification prior to engaging it. Other vessels such as kayaks and small dinghies are sometimes exempt from legislative requirements such as licensing. Some provinces and states require the operator of even a small recreational vessel to hold a current marine skipper's ticket. Compliance with the local legislation relating to working from a boat should be established prior to undertaking fieldwork.

Maritime safety legislation stipulates the minimum safety and emergency equipment to be readily available on all vessels. This equipment will differ depending on the classification of the vessel. If the boat does not come under the classification of a commercial vessel consideration should be given to carrying the following safety equipment as a minimum:

- personal flotation device for each person on the vessel
- bailing equipment
- oars or paddles in addition to primary power plant
- basic tool kit suitable for the primary power plant
- anchor
- spare bungs
- first aid kit
- fire extinguisher appropriate for the type of vessel.

A watertight container with signalling equipment (flares; smoke, hand-held and/or parachute) may be required for large and/or particularly remote lakes.

Figure 7 **Life jackets should be worn when working with pit lakes; including boating and working around steep lake margins (Photo courtesy of C.D. McCullough)**

4.3 Diving operations

Due to the inherently increased risk when working underwater, diving operations should be avoided whenever possible. Elimination of the need for diving may include using remotely operated submersible equipment such as corers for sediment sampling. Where visual evaluation is required consideration should be given to the use of submersible still or video cameras.

Where diving operations are required drivers must be appropriately qualified. In some states a commercial diver qualification may be required whereas in others a recreational driving ticket may be acceptable. The client may also have minimum standards for driver qualifications on their site. Diving operations should never be undertaken alone and divers should always dive as a pair with the support of an experienced surface team. Prior to diving commencing a dive plan must be prepared and approved. As a minimum the drive plan should cover the following:

- Roles and responsibilities of the dive and above surface support team.
- Communication methods and signals (driver to surface/diver to diver/public awareness).
- Information about the dive site (access/egress, expected weather conditions, type of dive – boat/shore/drift).
- Intended depth and duration of dive (including repetitive dives/required safety stops/decompression breaks).
- Type and inspection of diving equipment (surface supply/re-breather/open circuit regulator/oxygen versus exotic gas mix).
- Minimum level of air at surface, i.e. 50 psi left in tank.
- Intended work to be undertaken.
- Emergency procedures (alternative exit points/local emergency services/nearest decompression facility and means of transport to same).

Some project operations may require a decompression chamber on site which will increase diving operations logistical complexity and cost. However, all diving operations, even those conducted regularly in the same pit lake, are different and should always be considered and managed as a high risk activity.