LEGIONELLA RISK MANAGEMENT IN BUSINESS FIRMS

WITHIN THE EAST LONDON AND BORDER AREAS

OF THE EASTERN CAPE.

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At Nelson Mandela Metropolitan University.

Promoter: Mr. C. Ndlovu

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DECLARATION

“I, Christopher Mahwehwe, hereby declare that:

➢ The work in this research paper is my original work;

➢ All sources used or referred to have been documented and recognised; and

➢ This thesis has not been previously submitted in full or partial fulfilment of the requirements of an equivalent or higher qualification at any recognised educational institution.”

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CHRISTOPHER MAHWEHWE

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DATE
ABSTRACT

The pace at which change is occurring in the life of human beings, due to technological advancement, could be described as logarithmic. This fast-paced change is not just of consequence to the individual, but to countries, governments, companies, big and small systems like villages and sports clubs and the like, as well. This study case was inspired by the fact that what was a little-known threat yesterday, could suddenly become a crippling matter. It is, therefore, critical for individuals and businesses to consider risk not just in the usual context but with an open mind. This is especially true for systems in the Third World or developing nations where evolutionary stages of advancement and development are known to have been skipped due to forced or influenced adoption by the advanced or First World dictates. An example is the adoption of Carbon Emission Minimisation Pacts that have also been mooted for developing nations, even though their participation in causing the past Industrial Revolution pollution was minimal.

A small operation in the Eastern Cape may, today, see no need to attract an overseas customer, not realising that the local customer may enter a merger or be bought out by an international organisation which would demand international protocols on the local supplier. Such is the risk with Globalisation. Local businesses should embrace global competitive practices for sustainability in the global business arena that is surely upon the business place today and the short term. South African businesses are no longer protected by the country borders, or the government and political systems such as the apartheid-born sanctions and tariff regimes.

The objective of this study of Legionella bacteria risk management by business firms in the Eastern Cape (East London and Border Areas) is to obtain an insight into how they fare on one of the risks that, in Europe, is legislated and, in many parts of the First World, is regarded as fundamental. Beside the globalisation issues mentioned above, the South African workforce has been noted as highly affected by HIV and TB, which are symptomatic of people susceptible to Legionnaire’s Disease. The high cost and skills shortage in the South African industry demand great care in order to prevent further loss, due to sick absenteeism or the death of workers.
The study included a comprehensive literature review of issues around Legionella bacteria in industrial operations and how ill effects could be prevented and managed. A questionnaire was then drawn up and used to check for awareness, capability and ascertain what motivational factors could influence Legionella risk management by businesses in the geographical study area.

All businesses with facilities utilising water cooling towers, safety showers, waste water treatment plants, humidifier air conditioning and water fountains, were presented with the questionnaire. A 56% return was achieved and responses were processed and analysed using Microsoft Excel on a Windows XP computer package.

The findings showed that there was a poor awareness of Legionella bacteria and the risk they posed, a factor that may be used to explain the poor questionnaire returns. The capability assessment also showed a weak status. Legislation, proof of outbreak and fines were determined as effective would-be motivators for full Legionella risk management.

The study concluded with recommendations for awareness programmes by interested bodies like the Legionella Action Group, Department of Labour and companies providing Legionella consulting services.

While legislation and, therefore, fines, were not yet applied in South Africa, the drive for employee and community welfare should be adequate motivating factors for businesses to manage Legionella risk.

Foreign capital inflow into the South African economy was also a factor that should be considered by businesses that looked to expand and need to access these funds through mergers or acquisitions. These funds would require financial as well as technical audits that show adequate risk protection.
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Chapter 1

Problem Statement and Structuring of Study

1.1 Introduction

While business activities and efforts aim to progress the business organisation towards desired goals and objectives, forces or obstacles always exist and attempt to prevent gaining and ensuring momentum towards goal achievement. Risks are amongst such obstacles of which businesses must be aware and endure. These risks should be articulated and managed pro-actively to weaken and/or prevent ill effects but, better still, convert these obstacles into competitive strengths through deliberate management approaches and programmes. Risks to business are many and manifest in different ways. Examples of the nature of risks are:

- financial risks,
- human factor risks,
- equipment risks,
- systems risks, ……

Risks may also be looked at from a cause point of view, for example:

- environmental (‘PESTLE’) caused risks;
- marketplace-caused risks and
- internally-caused risks….

Yet another approach to risks could be the evaluation of the point or area of impact:

- productivity affecting risk,
- market share loss risk,
- financial goodwill risk,
- community harmony affecting risk.

Legionella risk is one that can affect human productivity, the organisation’s profitability, employee and community welfare. In some countries where this has
now been legislated, this risk impacts the law and, therefore, can result in court cases and judgements against the business.

Legionella species are an opportunistic and environmental health hazard for humans causing respiratory ailments that can be fatal. These include Legionellosis, Legionnaire’s Disease and Pontiac Fever. Over 30 different species of Legionella, in low levels, are widely present in the environment, in lakes, streams and ponds of water. At these low levels, chances of contracting Legionnaire’s Disease from a water source are very slight.

The problem arises when high concentrations of the organisms grow exponentially in water sources of temperatures between 20 to 50 degrees Celsius, where bacteria-contaminated aerosols can be produced and people can inhale this air. Water aerosols from cooling towers, evaporative condensers, evaporative coolers (swamp coolers), humidifiers, misters, showers, sinks and whirlpool baths can be contaminated with the organism, and, if inhaled by human beings, could cause the disease. These situations do exist in hospitals, food factories. Other examples include industrial operations, hotels and shopping malls with fountains, high-rise buildings and other manufacturing concerns with utilities that use water, for example, for air conditioning and machine cooling, showers for safety and bathing, fire hydrants and water for cleaning (CIP).

Pauline Coubrough and Bettina Genthe, in their Draft document for South African Guidelines (2003), indicated that, in South Africa, about 64% of cooling towers contained Legionella levels of 1000/L (and lower) while 35% showed levels of 1000 – 100 000/L and 1% had a level of >100 000/L. They opined that Legionellosis was a preventable and avoidable disease. The cost associated with an outbreak, in both human and financial terms, was far greater than the cost of prevention. Legionella levels should not be allowed to amplify to above 200 - 1000/L or the limit of detection.

The Legionella Action Group in South Africa indicated that, in parts of the developed world, this management was legislated while, in the developing world, including South Africa, it was not directly legislated. Businesses in South Africa, however, due
to globalisation, were exposed to conformance pressure in one or more of the following ways. Multinationals' standardised requirements for South African branch operations compelled the adoption of Legionella risk management. The markets or customers, especially in the Developed World, could demand this level of care from suppliers. The global trend to litigate against faltering businesses placed a high risk to local companies that did not conform to acceptable practices. Highly skilled and top professional potential applicants may not want to be associated with non-conforming organisations.

Unionism was highly developed and was used successfully in South Africa to obtain workers’ demands. This increased risk of work stoppage in situations of business “negligence”. An example of this pressure on South African businesses was highlighted when an aircraft manufacturing company was organising a training programme at a venue in Bredasdorp, Western Cape. Some delegates requested testing for Legionella, which was found positive, resulting in the venue losing the business (ImproChem Sales Records, 2004).

The European Hygienic Equipment Design Group (EHEDG) (August 2002) described Legionella Risk Management “as a systematic programme that organisations adopt to manage the threat to human health as a result of infection by these bacterial organisms called Legionella”. The programme included operation specific risk evaluation; drawing up of risk elimination or minimisation procedures; implementation and evaluation of the activities, including record keeping.

To the extent that, in South Africa, Legionella risk affected employees, customers, and the community at large, it was possible that legislation could, in the near future, be enforced due to global dynamics. Therefore, it was important to establish the status of the risk management in the Eastern Cape and, indeed, the rest of the country.

1.2 The Problem Statement

As highlighted in the Introduction, the problem noted in this study was that businesses which ran factories that used water for cooling, fire fighting, process
and decorative purposes, were at risk of human productivity loss, financial loss, goodwill and market share losses in cases of poor Legionella bacteria control. The South African climate, as well as temperatures at which water systems (e.g. cooling towers) ran, promoted the growth and proliferation of Legionella bacteria. The above factors were compounded by the high prevalence of Human Immuno-Virus (HIV) and Tuberculosis (TB) in the South African workforce which, together, presented a major risk factor for businesses and communities that relied on these factories for income. It should be noted that people with TB and or HIV Positive (immunity-compromised) individuals were more susceptible to Legionella bacteria-caused diseases than healthy individuals were.

A South African national HIV prevalence, incidence, behaviour and communication survey of 2008 conducted jointly by HSRC, MRC CADRE and NICD, put the prevalence estimate among South Africans of all age groups at 10.6%. A study done in 2000 by South Africa's second largest company, Sasol, also indicated that 15% of its local workforce was HIV positive. The Global TB Report of 16 March 2008 indicated that the country had the highest TB rate in the world at about 1%.

The immunity-compromised workforce was most susceptible to Legionnaire’s Disease as noted by the Legionella Action Group in South Africa. Productivity losses, due to employee absenteeism as a result of sickness and, possibly death, were real risks to business. The shortage of a skilled workforce was noted as one of the impediments to the country’s development goals. It was, therefore, critical that any skilled worker remained productive and available to factories in order to achieve these companies’ and, indeed, national goals.

A review of research activities known and sanctioned by the Legionella Action Group of South Africa indicated a focus on methods of sampling and analysis for the organism and the standardisation thereof. A research gap, therefore, existed in establishing how completely businesses were aware of Legionella risk and the level of willingness to commit resources in comprehensive risk management. This excluded piecemeal approaches generally involving annual sampling and testing for Legionella.
The aim, therefore, and the main problem of the study, was to establish the extent to which businesses in the East London and Border areas of the Eastern Cape, South Africa, scored on the following aspects:

- Awareness of Legionella and the risk these bacteria could cause to their employees, customers, and the community within which they operated. Did they comprehend, in financial and goodwill terms, the impact that poor management of these bacteria in their utility water systems could have on their costs, profitability and sustainability, especially in consideration of the inherent globalisation of business?
- What capability existed on the ground with respect to Legionella risk management practice? Capability, measured as “the synergistic power of capacity and ability employed on Legionella risk management” needed to be evaluated in this study. Capacity in terms of quantity of resources, and ability in terms of knowledge, systems and management, needed to be ascertained in evaluating Legionella risk management in the study area.
- What was the existing, and what would be the driving factors, for this risk management? The strength or weakness of driving factor/s determined what effort management would employ on an aspect of business management. The study needed to establish which factors actually played a role, and to what extent they could influence management, to adopt Legionella risk management practices.

1.3 Objectives of Study - Conceptual Model

1.3.1 Research Primary Objective

The primary objective of this study was to improve risk management in business firms through investigating their:

- Awareness of the risks posed by Legionella bacteria in the water systems employed at their operations.
- Control actions taken to prevent, minimise and/or manage outbreaks.
- Motivating or compelling factors that would ensure that this risk was adequately managed through deployment of effort and resources.
In other words, the study established the level of preventative actions taken, and also gauged the state of readiness of the organisations, to manage in the event that Legionella outbreak occurred in their water systems. It indicated which resources had been allocated, if any, to ensure that a Legionella outbreak was contained and did not have a lasting impact on the organisation and in the community.

While the research was a “point in time” study, it sought to provide insight into how local (Eastern Cape) organisations fared in response to global business trends, especially as Legionella risk management impacted in the medium- to long-term benefits or pitfalls, i.e. sustainability or non-sustainability of these organisations going into the global future.

1.3.2 Secondary Objectives

Two secondary objectives of the study related to (a) a market force, namely the customer, and (b) an environmental force, legislation. The researcher sought to establish the current impact of these factors as well as their potential, futuristic influence.

a) Customer Influence:
   General business talk refers to the “customer as king”. To that aim, the researcher wanted to link the relationship between the practice of Legionella risk management to customer demands, in order to assess the markets’ influence on this factor by the firms/study cases. Both local and export customers’ influence on local operations were surveyed to picture the extent to which they compelled these businesses to practice Legionella risk management.

b) Legislation Influence:
   The current South African legislation applicable to Legionella only specifies the bacteria as “a hazardous biological agent (HBA)” and the risk management is not very specific to these bacteria. The HBA regulation
enforces businesses to control these substances and organisms within acceptable/ non-hazardous levels within their operations and facilities in as far as they would be required to take responsibility in the event of ill-effects.

The research sought to establish the level of knowledge of the legislation factor. The quest for good environmental health and safety in South Africa, globalisation, the compilation of a White Paper on Legionella bacteria and risk management were all signs that a specific legal requirement would impact on business operations in various parts of the world. To that extent, the study investigated the possible impact that legislation that fines would have, if any, on the capability, i.e. quantity and quality of resources (spend), including time allocated to Legionella risk management.

1.3.3 Research Design Objectives

The following research design objectives were pursued for this study.

- Data Collection
  A questionnaire was sent to managers (General, Engineering or Safety, Health and Environmental Managers) of all major businesses with facilities/factories that used water utilities in the East London and Border Areas of the Eastern Cape. Qualifying utilities included cooling towers, safety showers, waste water treatment plants, humidifier air conditioning and water fountains. This case selection criterion ensured that all high-risk potential businesses or industries were included in the research, while excluding otherwise trivial cases that could possibly distort the validity of the findings.

- Data Analysis
  Data analysis in this positivistic study used quantifying approaches. Collis and Hussey (2003) listed the following positivistic methodologies:
  - Cross sectional studies – These were designed to simultaneously obtain information on variables in different contexts. An investigation was made of the associations between labour turnover and productivity.
  - Experimental studies - Experiments were carried out in either laboratories or natural settings. Causal relationships could be identified through this
approach when studies were carried out while one variable (independent) was manipulated. During this time, the dependent variable was observed.

- Longitudinal studies - When a variable or subject was studied over a period of time. This could be used to establish relative stability of phenomena over time.
- Survey - A sample or whole population was studied to make inferences about the population. Two types of survey were noted, namely, the descriptive and analytical surveys. The descriptive survey was concerned with identifying and counting the frequency of a specific population at either a point in time or at various times. The intention of the analytical survey was to determine if there were any relationships between different variables.

The review of these approaches, in consideration of the research needs and constraints, showed that the longitudinal study could highlight the trend over time. However, the period required for meaningful changes to occur was a limitation for the researcher, who needed to complete the study within one year. This study, therefore, took the survey approach where a questionnaire was used to establish the current situation and opinion concerning aspects of Legionella risk management.

- Findings and Deductions
  Due to varied interests by the different parties of this study, including the researcher's employer and their competitors in the water treatment market place, the subject/case companies and interested groups (e.g. the Legionella Action Group of South Africa and the Department of Labour), the findings were presented in such a manner that each of these parties could obtain value.

The research questions answered in this study were:
- “What is the specification of business firms that have water using utilities in the geographical area of study?”
- “What is the level of awareness of Legionella bacteria and the risk they pose in these business firms in the East London and Border areas?”
• "What level of Legionella risk management capability exists in these firms?”, and
• “What factors are driving, and would drive, these businesses to adopt and sustain Legionella risk management practices?”
1.4 Methodology

1.4.1 The Research Theory

The research, which aimed at looking at practices in order to come up with observable regularities and explanations of these regularities, was given by Alan Bryman and Emma Bell (2007) as an inductive approach. This, they indicated, differed from the deductive approach where theory guided the research.

The inductive approach was used to observe and explain regularities around the practice of Legionella risk management in the geographical area of study. In this research, observations or findings were used to make generalisations about the subject study. Below is a discussion of the different approaches given in literature that were used to demonstrate why the researcher selected the particular approach and instrument including the sampling techniques.

1.4.2 Research Paradigms:

The design of a research study begins with the selection of a topic and a paradigm. A paradigm is essentially a worldview, a whole framework of beliefs, values and methods within which research takes place. Bryman (1988a:4) explained a paradigm as “a cluster of beliefs and dictates which, for scientists in a particular discipline influence, should be studied, how the research should be done and how results should be interpreted”.

The researcher in this study believed that businesses were at risk from inadequately managing Legionella bacteria in their water systems. The reasons for this ranged from lack of awareness, lack of capacity and low motivational factors that need to be studied. Collen and Hussey (2003) identified two main research paradigms: positivism (quantitative) and phenomenological / interpretivism (qualitative) research.
➢ Quantitative Paradigm

Collen and Hussey (2003) explained that “a quantitative study is an inquiry into a social or human problem, based on testing a theory composed of variables, measured with numbers, and analyzed with statistical procedures, in order to determine whether the predictive generalizations of the theory hold true”. Wikipedia (2008) added that “quantitative research is the systematic, scientific, investigation of properties and phenomena and their relationships”. The objective of quantitative research was to develop and employ mathematical models, theories and/or hypotheses pertaining to natural phenomena. The process of measurement was central to quantitative research because it provided the fundamental connection between empirical observation and mathematical expression of quantitative relationships.

➢ Qualitative Paradigm

Collen and Hussey (2003) defined a qualitative paradigm study as “an inquiry process of understanding a social or human problem, based on building a complex, holistic picture, formed with words, reporting detailed views of informants, and conducted in a natural setting”. Wikipedia (2008) further explained that “unlike quantitative research, qualitative research relies on reasons behind various aspects of behaviour”.

Simply put, it investigated the why and how of decision-making, as compared to what, where, and when of quantitative research. Hence, the need was for smaller, but focused, samples rather than large random samples, which qualitative research categorised data into patterns as the primary basis for organizing and reporting results. Qualitative researchers typically relied on four methods for gathering information:
1. participation in the setting,
2. direct observation,
3. in-depth interviews, and
4. analysis of documents and materials.
In illustrating how each of the research paradigms were implemented in reality, Collis and Hussey (2003) associated surveys, cross-sectional experimental and longitudinal studies with the quantitative or positivistic paradigm, participative enquiry, case studies, grounded theory, ethnography, hermeneutics and action research as phenomenological or qualitative methodologies. Given the complexities associated with each research paradigm, Leedy and Ormrod (2005:96) identified a set of distinguishing characteristics between the two paradigms. These findings have been tabulated in Figure 1 in the Annexure.

- Motivation for Quantitative Paradigm:
  This proposed research study took on the quantitative or positivistic paradigm because:
  - The assessment parameters were objective and could be statistically noted. Parameters here included issues like subject companies’ employee count, locality of companies, how many were aware of Legionella the bacteria and/or Legionellosis the disease, and how many would be influenced by legislation and fines in their adoption of risk management practices.
  - The researcher was completely independent and impartial with what was being researched. The researcher’s feelings or disposition regarding what was being studied did not influence the reported outcome, but absolute measurement evaluation was done. In other words the researcher’s values and biases were of no consideration in the assessment.
  - The process of research was inductive, i.e. had cause and effect. The process design was static (not emerging) as categories could be isolated before the study was actually carried out.
  - Validity and reliability testing was possible to evaluate the accuracy and reliability of findings.
  - Use of quantitative instruments of measure could be made.
  - The sample size was large enough to provide statistical measurements required for quantitative study.
1.4.3 Sampling

De Vos (1998) defined research sampling as “the elements in the research population considered for the actual inclusion in the study, where a sample is defined as a sub-set of cases or elements selected for study from among people or objects within a defined population”. Various sampling methods were identified, ranging from probability sampling to non-probability methods.

1.4.3.1 Probability and Non-Probability Sampling:

Probability Sampling:
Each member of the population has an equal chance of being included in the sample. Non-probability methods, on the other hand, are techniques where the sample is specifically selected rather than chosen by chance or at random. Examples of probability sampling techniques are simple and systematic random sampling, stratified random sampling and multi-stage cluster sampling. For non-probability sampling, examples include convenience, snowball and quota sampling techniques.

Random Sampling:
All members of the target population have the same characteristics, and, therefore, all have an equal chance of being selected for the sample. Random sampling, thus, means that the researcher picks a sample from the population at random. This assumes that the sample is characteristic of the entire population. With this type of sampling, the sample selection is unbiased and representative of the entire population.

However, it is possible that certain parts of the population may be under- or over-represented. Not all members of the population may be equally accessible once selected for the sample, and it may not be possible to know each and every member of the population. Therefore, it was possible that these might have been excluded from the sample selection process. For
example, employees at company X, selecting winning raffle tickets from a hat, or households in a neighbourhood.

Stratified Sampling:
The target population is comprised of various members with different characteristics, and each grouping or strata within the population is identified. The sample is chosen at random, with representatives picked from each of the identified strata. The advantage is that the sample generally represents major groupings in the population. It is still, however, necessary to know each member of the population and strata although detailed information about the size and composition of each stratum may not always be available. It may also be more expensive than the typical random selection. For example, employees at company X can be grouped by gender, age, department, skills, etc., while households in a neighbourhood can be grouped by income, etc.

Quota Sampling:
This technique aims at producing a sample that reflects a population in terms of the relative proportions of individuals in different categories such as gender, socio-economic groups or industrial sector grouping. The individual subject is also selected by the interviewer based on the selection criteria.

1.4.3.2 The Research Sampling:

The population plan for the study as indicated in the objectives of the research was the economic geographical area of East London and Border Areas of the Eastern Cape. The south-western boundary of the study area was marked by the towns of Peddie and Fort Beaufort; the north at Aliwal North and the north-eastern boundary at Matatiele and Mount Ayliff.

This research used a quasi-judgemental and screening which selected all factories/business establishments with building facilities that operated cooling towers, safety showers, wastewater treatment plants, humidifier air conditioning and/or water fountains. All major shopping complexes were included in the survey. All questionnaires were hand-delivered by the
researcher, after having first established that the above subject criteria were met. The survey ensured that all subjects from the different industrial sectors (viz. food manufacturing, hoteliers and commercial properties, hospitals and health facilities, engineering manufacturing and chemical manufacturing) were considered.
1.4.4 The Measuring Instrument

Collis and Hussey (2005:151) listed the main data collection methods as “critical incident technique, diaries, focus groups, interviews, observation, protocol analysis and questionnaires”.

This study utilised an optional anonymity-based questionnaire to gather all the primary data that was used in this study. In any research, the selection of the type of questions to be asked are critical as the respondent’s frame of reference or background may affect their understanding, interpretation and response to the questions asked. “It is important that respondents should have enough information or expertise to answer the questions truthfully”, stipulated (Wikipedia, 2008).

To this end, structured closed questions were used to enable quantitative analysis and deductions. The questionnaire contained questions that characterised the respondent, investigated awareness of Legionella risk and management, established the existence of capability to undertake Legionella risk management and, finally, investigated the motivational factors, existing and/or potential, to pursue risk management by the subject organisations or businesses.

1.4.5 Data Analysis

Since quantitative data was gathered, the analysis had quantitative deductions, e.g. percentages of respondents that were aware of Legionella risk. Bar graphs and pie charts were used to show distribution of responses to the different aspects surveyed.
1.5 Research Questions

The research questions were developed in four main groups starting, with those that helped with characterisation and specifications of subject cases. These were followed by questions that exposed the state of awareness around the subject of Legionella in water utilities and the diseases that these bacteria caused. A third group of questions sought to gain information on the state of capacity and ability of the businesses in performing Legionella risk management. Finally, the questionnaire included questions which sought to establish the current internal, market and/or environmental motivational or driving factors on the practice of Legionella risk management. This fourth set of questions also focussed specifically on establishing what impact legislation, including fines, would have on the adoption and implementation of Legionella risk management in the case businesses. Below is an outline of the questioning in each group of questions.

1.5.1 Subject Characteristics:

This group of questions elicited, and provided, responses that enabled the understanding and picture of the subject businesses which were selected for the study. They also played a role in placing the results of the study in context. This allowed the researcher and the reader the latitude to generalise findings to similar industry and businesses. It further assisted in preventing the generalisation of findings to businesses that did not share commonality with actual study businesses.

➢ “Where are the subjects located within the study geographical area?”

The location of the subject business within the greater study geographical area needed to be established as this could shed some light as to why, if any, trends were to be notable. Remotely-located businesses could, for example, show poor response levels or long response times due to the difficulty of connecting to electronic communication means. The lack of exposure to highly urbanised and regulated environments could also influence the apathy with which the risk was attended.
“What industry sector and employee rating are they?”
The industrial sector into which a business fell tended to promote certain concerns while downplaying others. The food and beverage manufacturing, for example, might be extremely concerned with hygiene within their operations for product quality. However, the focus of the hotel and hospitality industry could be greater on presentation and customer experience. It was necessary for the researcher to know the industrial sector to which a subject business belonged, in order to evaluate and make conclusions on issues of motivation to manage Legionella risk. Industrial sectors that were more affected by globalisation could have tended to adopt risk management practices due to the high standards set in this global or international arena.

It was vital to characterise the subject businesses in respect of the number of employees, to enable the researcher to comment on whether large businesses were practicing Legionella risk management better than small businesses. This would also assist the reader in evaluating the gravity with which Legionella risk should be rated when considering the multitude of employees directly exposed to potential risk, let alone the general population around these businesses estimating from the employee-to-dependent average figures in Eastern Cape industrial centres.

“Are they local businesses or are they internationally linked?”
Ownership played a significant role in the mission and policy development of the business units owned, to that the extent of the research needed to establish some ownership or international linkage aspects that could be used to influence Legionella risk management attitude. The provincial, national, international or global linkages of the subject business operations were surveyed to project the influence of global policy on each business. The effects that global economic dictates could have played, and the extent to which Legionella risk management was undertaken, was also surveyed.
1.5.2 Awareness:

Just as ignorance of the law is not a defence in the legal system, lack of risk awareness is no protection against ill-effects of the risk. The research questions, therefore, needed to establish the levels of awareness around the subject of Legionella risk. Were business managers aware of the risks posed by Legionella bacteria to their businesses with regard to the following aspects?

Awareness of Legionella bacteria, the conditions under which they propagated and proliferated, as well as the results they could cause to their operations, were questioned. For example, were employers aware that a lathe machine cooling water could present those conditions and create aerosols to which their skilled employees, fitters and turners could be affected? Were they able to recover man-hour loss due to illness related to this risk?

The health of the community within which a business is run is important as it provides employees, customers and harmonious co-existence to the enterprise. Attracting young talent from this community is critical for success. Many of the Eastern Cape school graduates appear to be leaving for more profitable economic opportunities in other provinces. Providing a healthy and progressive industry in this province is, therefore, necessary to curb this “brain drain”. Programmes including Legionella risk management could assist with such goals. Were managers aware of the impact that Legionella risk had on the health and welfare of employees, customers, clients and the local community?

It certainly is costly and time consuming to develop and build a financially viable brand. This makes it imperative to guard against loss or damage of goodwill. The researcher also needed to establish the awareness level within the study area through selected subject businesses of the potential financial and goodwill losses. An outbreak of Legionella at a hotel establishment
would certainly make unfavourable news headlines and would, thus, have a negative impact on business profits and sustainability.

Other awareness dimensions that needed to be surveyed were the actual methods and procedures of controlling growth and proliferation of these bacteria. Furthermore, where growth and proliferation could not be brought under certain control, were methods of exposure management known?

1.5.3 Capability:

With awareness and motivation levels established, the next question was that of capability. Did companies have the necessary capability to manage the risk posed by these bacteria?

➢ Were businesses fully **knowledgeable on how to manage** the Legionella risk? This included carrying out complete facility or factory **risk assessments**, **implementing the control programmes** as well as maintaining all requisite documentation/records of actions. **Were follow-up processes** that included two-yearly risk checks and actions to take in case of an outbreak comprehended? Were these procedures recorded and budgets allocated?

➢ Were they allocating capacity in terms of personnel, prioritisation, finance, training and other essential resources?

1.5.4 Motivation Factors

Were businesses motivated to manage the risk posed by Legionella bacteria to their operations? Would the forces of environmental concern, employee welfare, company policies, market/customer demands, as well as legislation, compel managers to undertake Legionella risk management?

1.6 Terminology

**Legionella Bacteria** - Haward R Barnes, (2005): A Guide to Legionella and Legionnaire’s Disease explained Legionella as “a bacterium which, when
visualized with the aid of a microscope, appears rod-shaped”. It is Gram-negative (stains pink using Gram stain), motile with an average cell size of 0.6 μm width and 10 μm length. It is “aerobic”, meaning that it needs oxygen to survive, prefers neutral pH water bodies and its optimum temperature for growth is between 35-37 degrees Centigrade.

“Legionella” is the name given to the genus that contains at least 40 different species of which Legionella pneumophila (L. pneumophila) is the most well known. The guide noted that, at that stage, there were 16 recognized serogroups of L. pneumophila. Most of these were grouped together as L. pneumophila sg2-16 to distinguish them from the more common and pathogenic sg1 strain of L. pneumophila. All the serogroups of L. pneumophila were potentially capable of causing Legionellosis.

Legionella Risk Assessment - A survey and evaluation of the factories’ or facilities’ water utilities has to be undertaken by a competent person/s to evaluate design, positioning and management programmes. This included water sampling and testing for microbiological activity to determine the level of risk posed. The assessment should be used to draw up a management and implementation plan, as well as set priorities specifically intended for the plant assessed. Sampling and testing for Legionella bacteria is not specifically a Legionella risk assessment requirement, but could be used to evaluate risk management activities.

Legionella Risk Management – This is a comprehensive programme intended to protect an establishment against the risks posed by Legionella bacteria to a firm with, and using, water utilities. It involves risk assessment, preventative programme design, implementation and follow-up/control activities (Pauline Coubrough, (2003, 7-1), Guidelines for Legionella levels in water, A code of practice, (Water Research Commission Report No. TT174/02).

Utilities – Pieces of equipment or machinery used by firms to achieve required provisions for the operations. These included, but were not limited to, cooling towers, evaporative condensers, evaporative coolers (swamp coolers), humidifiers, misters, showers, sinks and whirlpool baths.
**Legionellosis and Legionnaire’s Disease** - Legionellosis is a collective term for the pneumonia-like illnesses caused by Legionella bacteria. These illnesses include Legionnaire’s Disease, Pontiac Fever and the Lochgoilhead fever conditions. Legionnaire’s Disease is the most serious and well-known one of these several illnesses caused by the Legionella bacterium. Legionnaire’s Disease is an infection of the lungs that is a form of pneumonia. Legionnaire’s Disease is caused by inhaling water in the form of an aerosol contaminated with rod-shaped bacteria named Legionella pneumophila.

Early symptoms of the illness are much like influenza. After a short period of time (in some cases a day or two), more severe pneumonia-like symptoms may appear. Not all individuals with Legionnaire’s Disease experience the same symptoms. Some individuals will only have influenza-like symptoms while, with others, the disease could be fatal. This is especially true in the case of elderly and immune-compromised individuals like HIV positive people, kidney disease sufferers, tuberculosis (TB) sufferers, heavy drinkers and smokers.

**Legionella Outbreak** - Pauline Coubrough and Bettina Genthe in Guidelines for Legionella levels in Water, “A code of practice,” defined Legionella outbreak as “when more than two people are infected and contract Legionnaire’s Disease from the same site, it is considered an outbreak”. Cooling water systems, potable water of both hot and cold water systems, as well as whirlpool systems, caused most of the outbreaks in the world.

**Published Guidelines for Legionella Control** - This document clearly outlined the specific scope and nature of risk assessment, monitoring and control and training required by industry to ensure compliance. It, therefore, provided a template upon which to design and implement site specific, risk-based remedial, control and monitoring programmes. In South Africa, there is no legislated code of practice and guidance document for the control of Legionella bacteria. Legislation, however, exists in other parts of the world including the United Kingdom (HSE 2000), Australia and New Zealand (SA/SNZ, 1998).
In South Africa, however, Legionella is categorised as an HBA (Hazardous Biological Agent) and legislated in the OHS (Occupational Health and Safety) Act of 1993. As a “Group 2, HBA”, the OHS Act number 85 of 1993 regulation ultimately demands that the business accept responsibility for the control of exposure of individuals to Legionella.

The need to provide adequate training and information, risk assessment, monitoring and record keeping is highlighted. The Legionella Action Group in South Africa meets regularly to develop recommendations for a legal framework to address the risk of Legionella in the country. A White Paper now exists covering this subject.

The Water Research Commission of South Africa has drafted a guideline document on Legionella, TT174/02 April 2003.

1.7 Outline of Study

Chapter 1
This Chapter covered the introduction of the research subject area including the statement of the problem. The chapter also put into context the conceptual model specifying the primary, secondary and research design objectives of the study.

Chapter 2
Chapter 2 was dedicated to a literature overview of the subject of study. Literature covered the nature of Legionella, the organism, the disease it caused (Legionnaire’s Disease) and infection pathway. Susceptible industrial utilities, risk management practices, environmental forces influencing risk management and some occurrences published in newspapers/journal articles which gave the reader a perspective of actual Legionella incidents, were also highlighted.

Chapter 3
The methodology used was covered in this chapter. The positivistic methodology used was discussed and justified, as opposed to the reason for non-use of
phenomenological methodology. The research instrument and data analysis were also described and justified in this chapter.

Chapter 4
Data analysis and the presentation of empirical findings or results to convert these data into information were covered in this chapter.

Chapter 5
The researcher’s interpretation and conclusions, as well as recommendations, were made in this last chapter of the research document. Both literature and empirical findings were used to draw the conclusions and recommendations.
Chapter 2

Literature Review on Legionella Species, Legionnaire’s Disease and the Management of Risks Posed to Businesses.

2.1 Legionella, the Organism

Legionella is a bacterium which, when visualized with the aid of a microscope, appears rod-shaped. It is Gram-negative (stains pink using Gram stain), motile (able to move under its own power) with an average cell size of 0.6 μm wide and 10 μm long. It is aerobic (needs oxygen), prefers neutral pH and its optimum temperature for growth is 35 – 37 degrees Celsius.

The United States of America’s Department of Labour OSHA Technical Manual (TED 01-00-015), Chapter 7, describes Legionella as “the name given to the genus that contains at least 40 different species, of which Legionella pneumophila is the most well-known”. Some species can be sub-divided into serogroups, e.g. Legionella pneumophila serogroup 1 (Lp1). Some species can also be further sub-divided into sub-types.

The sub-types of Lp1 include Pontiac, Bellingham, Benidorm, Knoxville, Philadelphia and OLDA. Currently, there are 16 recognized serogroups of Legionella pneumophila (L. pneumophila). Most of these are grouped together as L. pneumophila sg2-16, in order to distinguish them from the more common and pathogenic sg1 strain of L. pneumophila. All the serogroups of L. pneumophila are potentially capable of causing Legionellosis.

Each strain of Legionella has a unique marker on its cell wall, which allows it to be differentiated from other species and serogroups of Legionella. This marker is coded within the genetic make-up of the bacterium and will generally not change. For example, L. pneumophila sg1 is different to L. pneumophila sg3, which is different to L. bozemanii, and so on.
Some species have the ability to produce a fluorescent pigment when grown on laboratory media, a term known as “autofluorescence”. These so-called “fluorescent Legionella” are readily distinguishable from non-fluorescent Legionella using a UV lamp. L. bozemanii is an example of one of these “fluorescent Legionella”. L. pneumophila does not produce this pigment and is one of the non-fluorescent Legionella.

2.2 Legionnaire’s Disease

Legionnaire’s Disease obtained its name from the 1976 outbreak during the Pennsylvania State American Legion Convention, USA. During this outbreak, 221 people were infected by the disease, which was thought to be caused by contaminated water in the hotel's air-conditioning system. A total of 34 of the members died. McDade and Shepard, two biologists working for the US Centre for Disease Control and Prevention, discovered that the causative agent was a small, fastidious, gram-negative rod bacterium, which they named Legionella bacteria after the unfortunate victims.

A Legionella bacterium is a human pathogen. This means that it causes disease to humans. Any infection caused by Legionella bacteria is known as “Legionellosis” and can vary in severity from fatal pneumonia to a flu-like condition. The severity of the symptoms depends upon the virulence of the bacterium (the more virulent a bacterium. The more severe the infection caused by it), the greater the susceptibility of the host, the affected individual human being, would be.

Legionnaire’s Disease is a very specific form of Legionellosis caused by Legionella pneumophila (L. pneumophila). In the United Kingdom, Legionnaire’s Disease is most commonly caused by L. pneumophila sg1. All the other serogroups of L. pneumophila, and several other Legionella species, (including most of the fluorescent species), were capable of causing pneumonia. Several species, including L. pneumophila, could cause the milder, flu-like disease known as Pontiac Fever.
Those types of Legionella which don’t cause diseases are referred to as “non-pathogenic” or “environmental” species. The reason is that, to date, they have only ever been isolated from environmental sources and have, thus far, never been associated with disease.

For Legionnaire’s Disease, the attack rate in the general population is thought to be around 1%, i.e. out of a 100 individuals exposed to virulent Legionella, perhaps one will develop symptoms. However, the attack rate is known to be higher amongst susceptible individuals, for example, hospitalized patients, the elderly and people with pulmonary or liver dysfunction.

The fatality rate of infected persons is about 12%, but again, this can be higher in a more susceptible population. For Pontiac Fever, the attack rate can be much higher, but no fatalities have ever been reported. On average, there are between 200 and 250 reported cases of Legionnaire’s Disease each year in the United Kingdom, although this figure is thought to be an under-estimate.

**Transmission**

Legionellosis infection normally occurs after inhaling fine airborne water droplets, an aerosol that contains virulent Legionella bacteria. The fine droplets originate from an infected water source. The aerosol is created when mechanical action, for example, rotating pumps or air fans, break up or overcome the effect of the water’s surface tension to create small droplets of the contaminated water in the surrounding air. The bacteria in these airborne droplets or particles may be small enough to be inhaled into the lungs of nearby inhabitants.

There is also evidence that the disease could be contracted by inhaling the Legionella bacteria after ingestion of contaminated water. Transmission of the disease from person to person has not been reported to date. The dose of Legionella required for infection is not known and it is not safe to assume that low levels of Legionella will not pose a health risk.
The likelihood of contracting Legionnaire’s Disease is related to three conditions: (a) the extent of Legionella bacteria contamination of the water source, (b) the vulnerability or susceptibility of the person exposed and (c) the intensity of exposure. These conditions are possibly met in poorly-ventilated areas such as crowded hospital wards and prison cells where condensing air-conditioning takes place. The impact of this Legionella bacteria spread becomes significant due to the health vulnerability of the inhabitants. Bathing or showering presents a heightened threat of contracting the disease from a contaminated water system, due to the close contact between the aerosol source and the inhaling human being.

As previously noted in this paper, the high levels of vulnerable people in the South African workforce amplify this risk in the local workplace as well. The water bodies and sources with the potential to contribute to this health risk are noted and described in the following section of this paper.

2.3 Associated Utilities and Applications for Legionella Risk.

Deducing from the noted conditions that support the growth, proliferation and infection pathway of these bacteria, namely, a water body that can reach temperatures of 20 to 50 degrees Celsius that contains a food source with the chance and ability to create an aerosol, a number of business applications are identified as potential risk sites. A list of typical water systems is listed in Table 2.1 below.

The European Group on Legionella indicated that cooling towers and evaporative condensers were the most likely utilities posing risks. Bath showers were also noted as high risks, posing utilities even at low bacterial concentrations due to the close proximity potential between the individual and the aerosol. In the case of cooling towers, outbreaks have resulted from systems containing tens of thousands of Legionella per litre. This was possibly because the droplets were disseminated over a large area in the drift from the tower and the exposure time was, more than likely, relatively short.
In the domestic water systems situation, particularly showers, infections have been associated with only a few hundred Legionella per litre because there was closer and more prolonged contact with the host in the confined space of a shower.

Table 2.1: A list of typical risk applications in industry.

<table>
<thead>
<tr>
<th>Bath and safety showers</th>
<th>Garden hoses and sprinklers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaporative condensers and cooling towers</td>
<td>Fire hydrants</td>
</tr>
<tr>
<td>Hot and cold water systems, Water storage tanks</td>
<td>Tunnel pasteurisers and coolers</td>
</tr>
<tr>
<td>Vehicle wash bays</td>
<td>Conveyor lubrication</td>
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<tr>
<td>Waste water treatment plants</td>
<td>Vegetable washing</td>
</tr>
<tr>
<td>Ornamental fountains</td>
<td>Can/bottle washers</td>
</tr>
<tr>
<td>Machine tool cooling units</td>
<td>Ice-making machines</td>
</tr>
<tr>
<td>Spray humidifiers</td>
<td>Spa baths</td>
</tr>
<tr>
<td>Airs washers and scrubbers</td>
<td></td>
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</tbody>
</table>

The knowledge and high level of awareness of the potential contribution of a utility to such problems like the Legionella risk is critical to, and necessary for, Project and Process Managers. It is critical from a financial, health and safety point of view, because it prevents re-work and costly risk control actions in the future of the operations. At design and selection of plant process, this knowledge would enable the development of less risky designs when equipment and materials that posed the least risk, were selected for the plant.

- **Cooling Towers and Evaporative Condensers:**
  Cooling towers and evaporative condensers are designed to remove heat from a plant process that generates the heat to expel it into the atmosphere using water. This utilises the properties of water to flow in
liquid form, to accept heat through conduction and reject it through evaporation.

To achieve effective cooling by evaporation, towers have fans or mechanisms that blow air against or across a shower of water. The air quality around the tower will determine what contaminants or foulants the water will pick up through the scrubbing effect of the water. The solids scrubbed create sludge that settles in the tower sump. This provides food and harbours areas for microbes like algae and other bacteria including Legionella. These contaminants could either be organics or other chemicals that provide growth nutrients for bacteria or bacteria spores that then start growing in the water system due to conditions conducive for growth and proliferation.

These utilities also readily generate fine droplets of water as they operate by distributing water over a bundle of coil tubes or tower packing against which accelerated air flow blows. As the water in these systems performs the function of cooling, its own temperature elevates to the 20 to 50 degrees Celsius range. This factor promotes the growth and proliferation of bacteria, Legionella species included.

The design, construction and operation of these utilities are, therefore, critical in attaining acceptable safety concerning hazards from Legionella bacteria species. Within design considerations, there are issues to do with whether a water-based cooling system could be avoided for the particular process. For example, if the need were to provide room cooling for factory space, a choice to use air-cooled conditioning may be selected. If, however, water based cooling were the most cost- and technically-effective, a consideration would be to look at sizing that would avoid operations at temperatures that favoured bacterial growth especially around 40 degrees Celsius.

Another approach might be the erection of more than one unit that would allow one to be cleaned while the other(s) were running. The choice of
material of construction would be made at this point for materials that provided the least promotion of bacterial growth to be selected. For example, no wood or mild steel should be used. Preference should be given to stainless steel and plastics that did not corrode and provided smooth surfaces. Rough surfaces could act as starting points for bacterial growth and for mild steel this might be where corrosion could start. Corrosion could promote bacterial growth via some corrosion products providing food for some bacteria.

Besides design and construction factors, operational and maintenance considerations were also critical in safely running evaporative cooling and condenser towers. Towers in highly fouling areas would sludge and mud quickly. They would then require more frequent physical cleaning or installation of side-stream filtration systems that removed the solids, minimising under-sludge bacterial growths and food sources. Chemical treatment, including biocide-dosing programmes, would be required for these utilities as discussed later in this paper. The integrity of the equipment could contribute to good risk control, especially the state of drift eliminators that would minimise the drafting of water droplets into the atmosphere from the towers.

The good maintenance of pump seals and glands could also reduce the aerosol formation at the pumps, as well as minimising drip-tray water accumulation under the pumps in which bacterial growth could occur without effective biocide control. Tower packing which was poorly secured and positioned could also lead to water channelling in the towers with some areas remaining moist but not receiving good biocide dosing. These would act as bacterial growth sites where biomasses grew and contaminated the bulk water system as they fell off into the water stream with the real potential to be aerosolised.

- **Hot and Cold Water Supply Systems:**
  Hot and cold water supplies are basic needs for most business activities. Hot water is required for baths, showers, hand washing, laundry and
utensil cleaning (CIP). While municipal supply lines may be the main water supply, most operations facilities have local water storage tanks for pressure build-up into higher building floors and, for assured supply, buffer stock in case of municipal or primary supply problems.

Hot water systems vary from electrically-heated geysers, to fire–heated, steam-heated and solar-heated systems. A number of names like water heaters, hot water heaters, hot water tanks, boilers, calorifiers or geysers are given to appliances providing a constant supply of hot water. Whatever the method of heating or the name given, two conflicting health and safety risks or issues are of concern – (a) the risk of scalding when the water temperatures are high (i.e. greater than 55 degrees Celsius) and (b) the risk of bacteria incubation including Legionella species at lower temperatures that support their growth.

The European Guidelines for Control and Prevention of Travel Associated Legionnaire’s Disease recommend the storage of hot water at 60 degrees Celsius and distributed at 50 degrees Celsius minimum. Ideally, 55 degrees Celsius is required at point of use. Higher temperatures than 60 degrees Celsius are not encouraged, as they promote scale deposits, under which bacteria can grow in the system.

Good design and engineering protocols can achieve Legionella risk control safely and easily. Design should ensure that flow rates are high enough to prevent stratification that can lead to sludge settlement in system pipes and tanks. Ensuring that the hot water system water reaches temperatures of 60 degrees Celsius, including at distribution points, for at least 30 minutes once per day or even once per week to pasteurise the whole system, is sufficient to control Legionella risk. In this approach, the concerns of energy consumption and the risk of scalding are also addressed.

Cold water systems include all pipelines supplying water to the facility and all storage tanks and reservoirs that do not have in-plant deliberate
temperature adjustment. The risk of Legionella develops when the water gains temperature from the environment, bacterial spores are introduced through incoming water or from equipment installation, causing maintenance activities which grow and multiply. Often, when a municipal supply line bursts, muddy water comes out of taps, proving that contaminated water can enter the cold water supply system. This contaminated water can stagnate, for example, in copper piping running along a wall in the sun, reaching temperatures conducive for bacterial growth, within the 25 to 55 degree Celsius range. If exposure occurs through leaks or use, for example, baths, showers or spray irrigation, the risk of inhalation of contaminated air can take place.

Design and engineering protocols can ensure or minimise control of Legionella risk. Storage tanks should be insulated and placed away from the sun to prevent temperatures to soar above 20 degrees Celsius. Dead legs of cold water systems should be removed to ensure that the system is adequately disinfected and the water carries a good treatment chemical residual. Water stagnation can be prevented through the design of continuously recycling water reticulation systems.

- **Drip Trays and Ductwork:**
  Air conditioning systems and other water pumps use drip trays to trap pump coolant and/or seal leakage water. Drip trays and ductwork condensate, which may result in the collection of water that stands for long periods. This could reach temperatures which could promote the growth and proliferation of bacteria, potentially causing infection when pumps start or air flows in the ducts, forming aerosols.

  Pump lubricants and corrosion products that may accumulate in the drip trays could promote bacterial growth by providing food sources and harbouring bacteria. Design and maintenance programmes should ensure that water does not accumulate and stagnate in ductwork and drip trays.
Air-Washers or Scrubbers.

Air-washers or scrubbers are utilities used for cleaning air utilised in spaces like factories or for cleaning up processed effluent air to enable safe and legal discharge into the atmosphere. These utilities fall into two categories noted by the manner in which they remove contaminants from air, namely (1) the particulate removal scrubbers and (2) the mass transfer scrubbers.

The particulate removal scrubbers, also known as wet particle scrubbers, are normally of three basic designs: (a) the spray tower type, (b) the cyclonic and (c) Venturi. In these, the water and particulates in the air are forced to collide with sufficient energy to result in collection of the particles in the water phase. The particulate removal is completed through use of a clarifier.

The mass transfer scrubbers, on the other hand, are used for odour control and removal of gases from an air stream. Three types using water may be employed: (a) plate, (b) packed bed and (c) spray tower scrubbers. Examples are found in paper mill boilers, aluminium plants and foundry operations.

The Legionella risk exists in these utilities because all the factors for bacterial growth and proliferation can be established in these operations, including the possibility of aerosol formation.

Spray Ponds:

Spray ponds are large basins or pits filled with water and have a spray system that is located just above the water surface. The inlet water lines have headers that are equipped with nozzles that spray the hot (warmer) water into the immediate atmosphere where evaporation takes place. This results in the cooling of the bulk pond water. Airflow across the pond may be natural or forced, using air fans.
Ponds are open to the atmosphere and are generally wide-surfaced to maximise cooling by evaporation. This results in the collection of considerable quantities of foreign matter, foulants that may be spores of bacteria or food sources of bacteria. The fact that water is sprayed into the air stream can cause water droplets to be carried by air. If Legionella bacteria contaminate this stream of water droplets, the risk of Legionellosis is established.

The minimisation of risk with these systems at the design stage can be done by use of baffles or a louvered fence on the pond’s leeward side. Good vegetation around the pond area can assist to minimise dust pick up by the inflowing air.

- **Metal Casting Spray Water Systems:**
  
  In the metal industry, water cooling is used to remove heat from the process and for cooling machinery such as moulds. While scaling is the leading problem, microbiological fouling is the next major concern, followed by fouling and corrosion. These systems use lubricating oil and grease that can act as food sources in the cooling water aided by mill scale foulants that provide harbouring.

  All the factors that promote the risk of Legionella sp are combined in these processes, namely: warm water bodies with nutrients and growth areas, plus the water spraying that occurs. Infested aerosols are a potential problem.

  Risk control approaches for these systems include system design and good water treatment chemicals, with a properly managed biocide programme. The systems should be designed with a stage for oil removal through skimmers and foulants settling pits. Thereafter, filters should be used to minimise accumulation of contaminants that support microbiological growth.
Refrigeration and Air Conditioning Systems

Refrigeration equipment is found in applications requiring comfort cooling, for example, in buildings, hospitals, hotels, warehouses, cold storage facilities and universities. Refrigeration equipment is generally part of an air-conditioning system for the purpose of cooling air and humidity control within a facility. These systems generally include an open re-circulation cooling tower that cools a refrigerant gas system. This, in turn, cools a closed water loop that is finally used to cool and control humidity of the building air.

The Legionella risks discussed on cooling towers, drip trays and ductwork and air-washers apply to all these systems, depending on which are incorporated.

Humidifiers

A humidifier is an industrial or household utility that increases moisture (humidity) of the air in a room, factory or the whole house to eliminate discomfort and ill-effects of breathing dry air. Dry air can cause or aggravate respiratory ailments to inhabitants. A common type is the evaporative, cool mist or wick humidifiers that consist of a water reservoir, a wick and fan.

Vehicle Wash Bays

Vehicle wash bays that use water pose a risk of Legionella from stored and piped water that can achieve warm temperatures of between 30 and 60 degrees Celsius. Rubber piping increases this risk and should be shortened or replaced with poly tubing or metal piping. Biocides are generally not used at wash bays.

The use of pressurised sprays generates aerosols that can be inhaled by employees and clients alike. The risk control includes preventing stored water reaching warm temperatures or using instant supply units. Regular disinfection of the water system with a halogen-based disinfectant is one method of limiting the risk.
➢ **Baths and Safety Showers**
Baths and safety showers feature piped water and a spray mechanism. These aspects can contribute to proliferation and distribution of the harmful bacteria. The close proximity between the individual and water spray increases the danger of breathing in the bacteria. Safety showers are generally not used, often presenting enough time for bacterial proliferation. Risk minimisation should include designs without dead legs, pipes that can be easily flushed, material that does not rust and showerheads that can easily be removed and cleaned.

➢ **Machine Tool Cooling Units**
Machine cooling units recycle water that picks up dirt and oil from machined pieces, as well as heat from the machining process providing good bacterial growth environment. The turning of machines can cause aerosol formation, exposing the operator to inhaling potentially contaminated air. System designs allowing easy flushing and cleaning are necessary to minimise risk. Regular disinfection with a chlorine-based chemical is recommended.

➢ **Waste Water Treatment Works**
Waste water treatment works vary from domestic waste to industrial waste water treatment utilities. The industrial applications also vary, based on what each operation processes from food to chemicals, organic to inorganic materials. In all the various waste water works, dirty water that may reach temperatures between 20 and 45 degrees Celsius, and some pumping action, are involved. These conditions meet the Legionella risk profile.

Danger is heightened when equipment cleaning, for example, sumps and pump repairs, need to be completed. Service men can be exposed to
contaminated water as well. Proper disinfection procedures are, therefore, critical before repair work may be carried out.

- **Ornamental Water Features and Fountains**
  Ornamental water features are generally set up in community or public spaces like restaurants, hotel foyers, conference facilities, offices and in outdoor gardens. Water is recycled using a pump. The risk depends on bacterial loading of the water, the formation of aerosols from the pumping action as well as the proximity to breathing population. In indoor spaces, the accumulation of infected breathable droplets is possible. Tim Keane of Legionella Risk Inc. (2005), in a document commissioned by the South Dakota Department of Health (Http://www.legionellae.org/guidelines.htm), indicated that “most outbreaks reported have been linked to indoor ornamental features”. The control recommendations include not placing any fountains and fish tanks where vulnerable populations are and ensuring a practice of disinfection and maintenance.

The above utility description and discussion indicates that most business operations may be exposed to a risk of Legionella to varied degrees. Therefore, they need to assess, develop and put into place a site specific risk management programme.

### 2.4 Risk Management Practices

A successful business’s health and safety management programme for Legionella risk concerns itself completely with acceptable procedures in design, installation, commissioning, operation and maintenance of all its utilities. This comprehensive approach will ensure that the least cost-effective management programme possible is undertaken both at Greenfield developments, as well as for existing plants.
Where plant and operations already exist, an evaluation, followed by design and implementation of risk management programmes, should be adopted.

The summary approach or framework to successful Legionella risk management that this researcher noted from literature reading is sketched hereunder. The adoption of this holistic management will ensure successful control of Legionellosis outbreak and the meeting of all legal requirements by businesses.
LEGIONELLA RISK MANAGEMENT FRAMEWORK

Diagram 1: By researcher

Plant/facility is designed with utilities

Risky utilities not avoidable or do exist

Risk assessment

Risk control scheme:
- Construction design – e.g. no water stagnation
- Water Treatment - scale/corrosion inhibition
- Cleaning and disinfection (physical and chemical)
- Plant maintenance

Responsibility structure/organogram:
- Policy and leadership
- Management
- Task responsibility assignments

System Monitoring by competent centres or persons: e.g. Laboratory Testing.

Record keeping: Developed procedures and action log book maintenance

Legionella Risk Under Control/Managed

Risky utilities avoided at development stage
2.4.1 Risk Assessments and Audits

Sections above have noted the conditions that make a facility more susceptible to Legionella bacteria risk. Each plant or operation, therefore, needs to make a suitable and sufficient assessment and audit of its facility and processes to identify and assess the risk of exposure to the bacteria. Not all water systems do pose a risk! It is advisable that a verified and certified specialist be used, especially for the first facility audit.

Plant or system designs, as well as practices, need to be evaluated and documented in this audit. The assessment should go further to evaluate specific means possible to prevent exposure to the bacteria. However, if prevention is not possible, means of how exposure risk can be practically controlled should be devised. An example is when an infected system has to be cleaned; exposure is unavoidable. However, safety clothing, including breathing masks and pre-disinfection of the infected system, would control exposure.

Risk assessment/audits may be repeated as and when the business deems it necessary. However, a guide of every two years is noted by the European Hygienic Equipment Design Group (EHEDG) (August 2002) to confirm that the risk management efforts are indeed still relevant and adequately safeguarding the business.

2.4.2 Risk Management/Control Scheme

While general guidelines can be found in codes of practice documentation, risk management programmes should be site specific. This is why a risk assessment and/or audit for each facility or plant are fundamental to determine the potential risk, in order for the development of cost-effective mitigation measures to be undertaken. An effective management programme is, therefore, only as good as it is matched and developed for the specific site and operational conditions, and not only how many resources are used.
Three critical legs for risk management can be summarised as follows.

1. **Draw up control measures:**
   Similar to managing other business aspects, certain provisions should be made. Selection and appointment of capable individuals to develop a team for practicing Legionella management is required. Instruction, training, information and training programmes should be developed for these people to enable them to competently and safely carry out their mandate. Provision of a resource budget and the drawing up of programmes and procedures are critical aspects of the measures.

2. **Implement the control measures:**
   Many failures of management programmes do not occur at the intention and design stage, but occur at the implement and sustain stages. To ensure implementation, the drawn-up measures should form part of key performance factors in the business, highlighting the consequences of failure.

   Bonuses and awards should be developed for participating individuals, similar to other aspects of operations like product quality or production programmes. These would promote excellence in activities related to health and safety and, indeed, Legionella bacteria risk management. On the other hand, development of negative consequences for failure to adhere to requirements is necessary to ensure basic compliance to requirements. With the human factor commitment, it is necessary to avail material resources and knowledge resources on a continuous and adequate basis to prevent incomplete actions and projects.

3. **Ensure that control measures continue to be effective:**
   Effectiveness needs to be scientifically tracked and recorded through chemical and microbiological sampling and testing, as well as programme auditing. The control measures fall into two main areas; firstly, those that prevent or minimise growth and proliferation of the bacteria and, secondly, those that reduce exposure to water droplets and aerosols by the
workforce and surrounding community. The following are some of the measures:

- Avoid running of utilities at water temperatures between 20 to 45 degrees Celsius and other conditions of growth of Legionella bacteria, including unnecessary stagnation of water, for example, dead-legs in the water reticulation system and slow flow rates.

- Water spray prevention reduces exposure to individuals breathing air within the sprayed vicinity. Examples of spray prevention are ensuring that demisters on cooling towers work, that spray guards installed on water-cooled lathe machines and installation of baffles on spray ponds.

- Keeping systems and the water clean through physical maintenance and by means of chemical treatment.

- The use of appropriate chemical water treatment technology and programmes to prevent scaling, corrosion product accumulation and bacterial proliferation is a critical Legionella risk control component. This includes sampling and testing (monitoring) the water chemistry and microbiological activity of utility water on a regular basis as relevant to the utility.

- Follow recommended operations and maintenance of each utility or plant as provided by the manufacturer and/or as noted in the code of practice guidelines.

Major tools for Legionella risk management are water treatment and the cleaning and disinfection for the utility used by the business. As such, literature review shows that some aspects of water treatment in countries, where Legionella risk management has been legislated, are legal requirements. This research has noted critical aspects here below.
2.4.2.1 Water Treatment Programme

Different water systems would require specific methods of treatment. However, in general, the water treatment programme should include the following aspects:

- A programme based on physical and operating parameters of the utility and the quality of make-up water, including seasonal variability and source changes. Some municipalities may supply water from two different catchment areas and alternate supply to the same factory for their own technical or availability reasons, bringing in quality of makeup changes.

- Control and prevention of any of the following water-based problems: scale formation, corrosion, fouling and microbiological activity. Failure to control one could lead to the other. Once started in the system, regaining control would prove difficult, especially corrosion. Once a metal surface has been etched or pitted by corrosion processes, these scars act as sites for further corrosion or deposit build-up.

2.4.2.2 Cleaning and Disinfection

- The utility or equipment suppliers generally provide cleaning and disinfection procedures that must be followed. Appropriate intervals should be established, dependent upon water quality, levels of environmental fouling and the operating parameters of the system. This would also enable and determine effective chemical treatment. The use of water treatment specialist service providers are recommended for this aspect.

- All programmes should be monitored to ensure continued effectiveness. As noted above, variations of make-up water should be tracked to enable adjustment of control programmes.
2.4.3 Formal Responsibility Structure

Human input is critical and, as for any other management programme, a well-arranged and manned structure is required if programme design, commissioning and maintenance are to occur. Risk management is one of the top to bottom driven initiatives. As such, leadership should be of adequate institutional power and influence.

Ideally, the head of the facility or operations should be the driver of this programme, since he or she will be the answerable individual when an outbreak occurs or a legal suit is lodged against the business. The Legionella risk management policy should be developed and lead at this level. The strategic and site tactical aspects should be managed by middle managers at the business facility, who are involved with utility management, for example, factory engineer, maintenance manager or safety, health and environmental (SHE) managers.

At the level of task management, supervisors in the quality or laboratory services, or engineering maintenance, should be appointed to ensure that risk control activities are part of their key performance indicators. The choice of these supervisors would take into consideration the fact that they are already involved and familiar in the risk aspects. Engineering supervisors are already involved in utility equipment maintenance; laboratory personnel in water sampling and testing while SHE supervisors are knowledgeable about safety and work environmental issues.

2.4.4 Record-Keeping/Action Log Books

All activities, incidents and actions should be recorded as they occur. The purpose of records is to provide evidence of care activities undertaken in case of litigation, and to enable historical information management. The records include:
- Risk audit record – Identification of those personnel who conducted the audit and those who were responsible for implementing the recommendations, as well as the dates and periods of the programme.
- Audit report – The significant findings, the potential exposure processes and means to control exposure or mitigate exposure risks. Off-specification management procedures and protocols should be included.
- Results of monitoring, inspections, tests, and dates when these actions were undertaken.

While records are kept for internal continuity and control purposes, it should be noted that these should meet legal documentation standards. Even though these records are not directly required here in South Africa by law, they may be required and useful in courts of law and tested against the Labour Act to show that Legionella as an HBA (hazardous biological agent) was handled with due care by the business to prevent hazardous exposure to employees.

### 2.5 Environmental Forces

The practices and adoption of Legionella risk management practices, as with all other business decisions, are affected by internal and external pressures or forces acting on the business. Internal forces are those emanating from within the business organisation and may include employee welfare, unionism and company ownership and policy.

Internal pressures on businesses are exemplified in the South African context by the multinationals' policies impressing on local divisions the implementation of international programmes, for example, elimination of asbestos use in subsidiary facilities. External pressures are those coined with the acronym PESTLE. These factors, which emanate from outside the organisation, compel the business to undertake certain actions if they want to successfully operate in the particular environment. Legislation, market and consumer dictates are examples of pressure exerted on businesses in the practice of Legionella risk management.
2.5.1 Legislation

Businesses operate within, and strive to meet, the legal requirements of the country in which they do business. Breaking the law can result in businesses incurring fines and/or forced closure by the country’s government. It is, therefore, paramount for businesses to know and practice the law in order to avoid such costly effects.

This study established that Legionella risk management was legislated in Europe. In the United Kingdom, the Approved Code of Practice for Legionella is ACoP L8 of the Health and Safety Commissions (HSC). In the United States of America, it is not directly legislated. However, the Occupational Safety and Health Administration (OHSA), the Centre for Disease Control and Prevention (CDC) and the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), have developed recommended practices and guidelines which should be followed by businesses that have risk-prone water systems.

In South Africa, no direct legislation has been enacted on Legionella risk and the management thereof. Report number 827/1/01 of the Legionella Action Group note that no official guidelines existed in South Africa for the maintenance of water distribution systems and for the treatment of such systems contaminated with Legionella. The South African Regulations for Hazardous Biological Agents in the Occupational Health and Safety Act, however, identified Legionella Bacteria species as a “Group 2, HBA (Hazardous Biological Agent)”. It demanded the acceptance by the business of responsibility for the control of exposure of individuals to Legionella.

The need for businesses to provide adequate training and information, risk assessment, monitoring and record keeping is impressed upon all HBAs. The Legionella Action Group in South Africa developed a Green Paper that seeks to directly legislate on Legionella risk management by businesses in the future.
It is, therefore, socially and economically advisable, and legally beneficial, for South African businesses to undertake Legionella risk management in its complete form as highlighted in this work.

2.5.2 Market/Consumer Factors

With the increased sophistication and demands for service and care by consumers today, businesses cannot ignore the potential loss in goodwill in the market that could follow poor publicity. This is especially true when considering the quick and wide reach that contemporary communication channels have through cellular phone and computer technology. Legionella outbreaks may be reported as lack of care and disregard of employees and community welfare by the business. While consumer boycotts have not developed significantly in South Africa, with globalisation, this may well affect businesses here in the near future. Expensive brand damage may result. Businesses that enjoy the patronage of overseas/developed countries, for example, hotels, may already suffer customer rejection.

2.5.3 Corporate Policy and Ethics

South Africa is regarded in the international financial and investment arena as the launch pad into Africa. As such, it enjoys significant foreign direct investments from organisations whose vision it is to do business in Africa. As a result of this drive, more and more businesses are being bought into by international investors or merge with international concerns that would impose these heightened conformances to operational welfare and ethics.

International corporate policy dictates and audits are known to govern operations of organisations like Nestle SA, Schaeffler SA and Mercedes-Benz South Africa, to name just a few. Legionella risk management is one of the aspects in these policies, especially in the food and beverages industry.
Local businesses and managers that meet these criteria, like Legionella risk management, have greater potential for such capital investments.

2.6 International and National Incidents.

Legionella incidences occur all over the world. The researcher merely selected a few examples to demonstrate that the risk from Legionella was not just a theoretical fear, but a real potential problem for businesses. In all these cases, high potential losses or costs of redress could be envisaged. Unplanned plant or facility grounding disrupt production and result in cost due to forced cleaning and maintenance. Goodwill may suffer irreparably, especially for hoteliers and spas.

2.6.1 USA, New Jersey, Nursing Home, 2 Cases, 1 Death, July 2004

Two cases of Legionnaire's Disease were reported in early July 2004 in Paterson, New Jersey. Both were residents of the same senior housing centre. One of the cases, an 82-year-old man, died on 8 July. The other, a 76-year-old woman, recovered in the hospital as at 14 July 2004. After finding Legionellae in the hot water, the Paterson Housing Authority officials shut off the system and prepared to disinfect it.

2.6.2 Britain's Worst Outbreak: 131 Cases, 4 Deaths; July 2002.

Legionnaire's Disease was confirmed in 131 people who had been in or around the center of Barrow-in-Furness, Cumbria in July 2002. Nearly 330 others received hospital treatment for Legionnaire's-like symptoms. Four people died; an 88-year-old man and three women aged 54, 56, and 76 respectively. The death toll may actually be five people. A mother of four in her 50s, who contracted Legionnaire's in early August that year, and was discharged from the hospital after apparently recovering, died at her home about two weeks later. However, a hospital official said that her death could
not be definitely related to the Legionella infection. Investigators said that the source was "beyond all reasonable doubt" the air-conditioning plant at the town's arts and civic centre. Legionella bacteria were found in the cooling water.


2.6.3 United Arab Emirates: Legionnaire’s Disease

There was a suspected outbreak of Legionnaire’s Disease in a 5-star hotel in Dubai, United Arab Emirates among three guests of the Westin Dubai Mina Seyahi. One of them was a 69-year-old British male who stayed in the hotel in mid-January 2009, returned to United Kingdom on 20 January 2009 and died on 29 January 2009. Tests by European and American experts on the hotel have so far not found the Legionella bacterium.

(Source: ProMED-mail 5 February 2009) (Accessed 23/09/2009)

2.6.4 South Africa

Unfortunately, in South Africa, culturing for Legionella was not a common practice for patients with respiratory illnesses. As a result, the true extent of the "problem" is largely unknown.

Two Paper Mill Employees, South Africa, August 2007

Legionnaire’s Disease was confirmed in two employees of a paper mill in Mpumalanga, South Africa, in August 2007. Both were treated and recovered. A cooling tower was the suspected, but unconfirmed, source of Legionella.


The above incidents and outbreaks are just a few noted in this work to show that Legionella risk is real and could affect different forms of business in various geographical locations worldwide. Risk management was definitely more cost-
effective and contributed significantly to sustainable business enterprise, rather than ignoring the problem.
Chapter 3

Research Methodology

3 Introduction

In the preceding chapter, the researcher sought to understand the subject of Legionella risk to business, starting from the organism, the disease, the management plan and process through to forces that influenced the level and quality of attention to this aspect. In this chapter, a discussion of the methodology was used to investigate the situation that existed in the subject business geographical area, which was undertaken in relation to the literature.

3.1 Research Plan

The researcher’s next step, having decided to undertake the quantitative research strategy, was to choose the research design and method. Alan Bryman and Emma Bell (2007:39) referred to research design as a framework for the generation of evidence that suited both to a certain set of criteria and to the research question in which the investigator was interested. The five methods they noted were experimental, cross-sectional or social survey, longitudinal, case study and comparative designs.

1. The experimental design involved the conducting of experiments either in a laboratory or in a natural setting, in a systematic way, with some control to certain variables.
2. The cross-sectional design entailed the collection of data in more than one case and, at the same time, on more than one variable, so as to examine and detect patterns of association through quantitative means.
3. The longitudinal design was generally a positivistic approach and involved studies of variables or groups of subjects over time.
4. A case study design was mainly related to phenomenological methodology and involved extensive examination of a single instance of a phenomenon of interest.
5. The comparative design entailed the study of two or more contrasting cases using identical or similar methods. It sought to compare results of one case to the next in terms of similarities or differences.

This study intended to establish facts/data on many cases (businesses) in the geographical area noted on a number of variables including awareness, capability and motivational factors at a point in time (July/August 2010). Therefore, the cross-sectional design, which was most ideal, was selected.

Alan Bryman and Emma Bell (2007: 55) indicated the following methods as applicable to cross-sectional design research: questionnaires, structured interviews, structured observation, content analysis, official statistics and diaries. The study used a questionnaire with a total of 26 questions that sought information around the background of the respondents businesses; awareness of issues on Legionella risk and management thereof, as well as questions on motivational forces, for this risk management.

3.2 Subject Businesses/Cases of Study

Selecting a sample is a basic requirement of a positivistic study. A sample is made up of some of the members of a population. The size of the sample was noted by Alan Bryman and Emma Bell (2007:195) as “dependent on more than one aspect but includes cost, time and the need for precision”. In reference to this study, the issue related to the size of sample was not a problem, since the population was used. The population specification was business entities in the East London and Border areas of the Eastern Cape that run water cooling towers, safety showers, waste water treatment plants, humidifier air conditioning and water fountains at their operations. The researcher’s knowledge of the business and industrial operations in the geographical area of study was the main source of location of these subject businesses. The whole population was included in the survey through physical distribution of the questionnaire after verifying the above specifications of the subject business by the researcher.
3.3 Research Instruments

The study made use of both secondary and primary data. Collis and Hassey (2003:161) noted that “secondary data is that which already exists, such as books, documents, and films”. The advantages of secondary data are its current availability presenting short access time and that it is often less expensive. The disadvantages, however, may be its relevance, accuracy, reliability and actuality. Secondary data was the main source of the study write up in Chapter 3. It was utilised, as well, to inform the investigation structure and questions of the questionnaire. The main sources of secondary data were the internet, association reports and internal company (ImproChem and Nalco) training manuals.

Primary data, on the other hand, is data collected at source through surveys and or experiments for the specific study. The advantages are better relevance and control of accuracy, while it generally has high cost and time drawbacks. The questionnaire was the instrument used to obtain all the primary data used in this study. Collis and Hussey (2003, 173) defined a questionnaire as “a list of carefully structured questions, chosen after considerable testing, with a view to eliciting reliable responses from a chosen sample”. Being a positivistic study, the question format was closed as opposed to the open-ended questions generally used for phenomenological approaches. The respondent characterisation part of the questionnaire had options next to which a tick could be placed, while the rest of the questionnaire had statement and question answers ranging from: “Agree” – “Partially Agree” – “Partially Disagree” – “Disagree” to “Not Applicable”.

3.4 Data Collection Procedures

The data collection methods of this quantitative methodology study had to enable the attempt to measure variables or counting occurrences of the Legionella risk management phenomenon. In comparison, “data collection procedures for qualitative methodologies should enable the attempt to emphasise meanings and experiences related to the phenomena” (Collis and Hassey 2003:17). The procedures, therefore, needed to ensure reach to all the businesses that met the
study criteria. It also had to be possible for the responses to be returned within a reasonable time at an affordable cost. The distribution procedure involved the researcher physically delivering the questionnaire to the subject businesses with pre-qualification of each business in meeting the criteria set for the respondent in terms of utilities being run. The questionnaire return was achieved through physical hand delivery to the researcher, faxing, scanning and/or e-mailing the researcher.

3.5 Data Presentation and Data Analysis

Statistical methods were used for data analysis in this quantitative study. Collis and Hassey (2003:196) noted that the choices for analysis techniques depended on the following criteria:

- Exploratory data analysis to summarise, describe or display the data or confirmatory data analysis to make inferences from the data.
- Whether the data had a normal distribution, allowing the use of more powerful parametric techniques, or if the data distribution was skewed when a non-parametric technique had to be used.
- Whether one or more variables had to be analysed at the same time.
- Whether the measurement scale of the data, in case use of inferential technique, would have to be used.

This study utilised the exploratory data analysis technique since univariate data was presented to show frequencies. No confirmatory data analysis was necessary, since the whole population was used in the study. A tally chart was developed from the questionnaire responses before capturing the frequencies into an Excel programme to enable percentage and chart presentations.

3.6 Conclusion

The chapter presented a discussion of the quantitative research methodology undertaken for this study. The discussion looked at the selection of the cross-sectional design as the optimal research plan, and explained how the researcher
addressed the research questions and objectives. The choice of research methodology was discussed to show its suitability for this type of study.

Subject cases, the businesses, were specified and justified, based on the utilities they employed with relevance to Legionella risk. Both secondary and primary data collection instruments were discussed as used. Collection procedures including questionnaire collection by the researcher as well as use of fax and email technology were discussed in the last part of the chapter.
Chapter 4

Data Presentation and Discussion

4 Introduction

This fourth chapter of the study provides the results and discussion of the findings. The literature review in Chapter 2 guided the design of the questionnaire and the selection of survey subject businesses herein referred to as “respondents”. The discussion of the results will continue to refer to and be guided by the literature. The questionnaire, as indicated in the methodology section of the study, was distributed to all businesses that were known to have at least a water cooling tower, safety shower, waste water treatment plant, water fountain feature and/or water based air-conditioning at industrial and commercial level.

In total, 57 questionnaires were distributed, of which 32 were completed and returned. This level of apathy may be related to the low regard placed on the subject of Legionella risk in the study area. However, no conclusions could be drawn without a specific study to verify the fact. The number of returned questionnaires was more than 30, sufficient to meet statistical requirements. The analysis was divided into four sections covering specification of respondents, awareness results, capability issues and, finally, motivational forces influencing the effort to meet requirements of the Legionella risk management programme.

4.1 Detailed Findings and Analysis

Below is the detailed analysis of responses to the research survey. The survey questionnaire responses were analysed using statistical instruments and techniques to obtain the general view or findings with regard to the subject respondents. Bar graphs and pie charts were used to show the percentage score on each question.
4.1.1 Respondents’ Analysis

The composition and characteristics of those participants who completed the questionnaire and returned them for this survey analysis, were included to inform the reader and potential user of the deductions to relate and, therefore, to match to their own circumstances. The characteristics of those respondents who completed and returned the research questionnaire were consolidated in a summary of replies to questions numbered one to five on the questionnaire.

Table 4.1: Industrial sector of respondents.

<table>
<thead>
<tr>
<th>Industry</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Manufacturing</td>
<td>8</td>
<td>25%</td>
</tr>
<tr>
<td>Hoteliers and Commercial Property/Shopping Centres</td>
<td>4</td>
<td>13%</td>
</tr>
<tr>
<td>Hospitals and Health Facility</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>Engineering Manufacturing</td>
<td>10</td>
<td>31%</td>
</tr>
<tr>
<td>Chemical and Plastic Manufacturing</td>
<td>3</td>
<td>9%</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>19%</td>
</tr>
<tr>
<td>Other (name)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>100%</td>
</tr>
</tbody>
</table>

Chart 4.1: Industrial sector of respondents.

Most of the respondents, namely 69%, were geographically located in the town of East London, which was the main industrialised centre of the survey area. The description of those respondents, according to geographical spread or scale of
operations, revealed that most were Eastern Cape-based (i.e. provincial) businesses. The next predominant description was the international business. The detailed chart below shows the respondent business category distribution.

Chart 4.2: Description of respondents based on geographical spread of operations.

The size of operations, based on the number of employees, revealed that the respondent businesses employed between 51 to 200 people, followed by those that employed over 1001 employees in their businesses.

Chart 4.3: Number of employees per respondent businesses.

The literature research indicated that the most likely utilities to present potential Legionella risk were those that used water at temperatures of between 20 and 50 degrees Celsius, had a means of exposure to some fouling with bacterial food source and had the potential to form aerosols. Cooling towers and fire hydrants were capable of presenting those conditions. Cooling towers presented the highest risk, since they generally operated continuously, unlike fire hydrants that only had the capacity to produce aerosols during fire fighting or demonstrations of fire fighting.
Of the respondents, 84% ran cooling towers and 88% had fire hydrants. A significant number also had safety showers, water fountains and cleaning-in-place (CIP) facilities. This indicated or confirmed that the potential risk of Legionella outbreak in the businesses surveyed was real and, therefore, the need for Legionella risk management was important. The detailed results of responses, in answer to what utilities the respondent businesses ran, are shown in Chart 4.4 below.

4.1.2 Awareness of Legionella Bacteria and the Risks Posed to Firms

Unknown and, therefore, unforeseen, risks cannot specifically be prepared for adequately and can, therefore, ruin a project or business. This study sought to establish the extent to which the lack of knowledge in business organisations existed around the management of one such risk, Legionella bacteria risk.

The findings showed that the lack of, or poor awareness of, the bacteria and growth conditions could be a major contributing cause for poor Legionella risk management in the study business area. Questions designed to probe knowledge and/or awareness of the bacteria, its growth conditions, the disease it causes, historical occurrences, where to obtain assistance with regard to the management and whether any training was done, indicated the following findings.
Chart 4.5: Awareness of Legionella and Legionnaire’s Disease.

The pie chart revealed that 66% of the respondents did not know about Legionella bacteria and the diseases they could cause. A question was used to probe whether the conditions that promoted the growth and proliferation of these bacteria were known or not. These results showed a congruent picture to the above result.

Chart 4.6 below indicated that only 13% of respondents had a comprehensive knowledge of conditions that supported Legionella growth and proliferation in their business-run utilities.

A deduction from the above responses, therefore, indicated that only about 13% of the businesses could commence putting into place risk management systems that would control growth and proliferation of Legionella bacteria in their utilities. The rest were not expected to put in place risk management of some unknown phenomenon.
Literature reviewed in the preceding chapters indicated that the occurrence of Legionella infections may have been under-reported. This could have been due to lack of specific diagnosis for Legionnaire’s, especially in the developing world through sufferers being treated for common cold or influenza, if not tuberculosis, especially when patients were HIV positive. Unsurprisingly as well, the survey indicated neither a positive case of Legionella outbreak, nor Legionnaire’s patient's case, historically recorded as having occurred in and around respondent businesses. Governments did enact and use laws to ensure that their subjects achieved a certain desirable order or state of affairs in the nation.

The survey sought to establish whether the legislation ruling in South Africa on Legionella was known at the business social order level. The response to this question was represented by Chart 4.7 below. It indicated that not even a single response confirmed comprehensive knowledge of the laws pertaining to Legionella bacteria as applied to business operations. Literature review noted that, in South Africa, no legislated “Approved Code of Practice and Guidance Document” for the control of Legionella bacteria in water systems existed. However, businesses should be aware that the law would hold them responsible for the control of exposure of individuals to Legionella at their facilities.

The OHS Act, Number 85 of 1993, identified Legionella as a “Group 2, Hazardous Biological Agent” regulated under GNR 1390 of 27 December 2001. Businesses
should be aware of this regulation and, therefore, be motivated by it to build capability to manage Legionella bacteria growth and proliferation as a means to prevent and/or control exposure by their employees and other associated persons.

Breaking the law and facing the consequences, including payment of fines, is a big motivator to compliance. However, this revelation of lack of knowledge of the law and consequences meant that this compliance drive effect did not benefit Legionella risk management.

Chart 4.7: Knowledge of South African Legislation on Legionella Bacteria.

A similar picture was drawn from responses to whether training on Legionella risk control had been conducted in the respondent businesses. No business confirmed that they had carried out specific training on Legionella control. Chart 4.8 below shows the summarised results. The regulations on hazardous biological agents demanded that businesses provide adequate information and training on HBAs associated with their operations.

For the surveyed businesses, Legionella became a factor even though it may not have been by design, but indirectly, through their use of the noted water based utilities in which these bacteria could grow and proliferate to result in individuals’ exposure.
This analysis of results of the study on awareness showed that businesses investigated revealed a lack of awareness of the risk posed by Legionella to their businesses. This ignorance was noted on the following levels of the subject.

- **The bacteria and the disease it caused:** Respondents demonstrated poor knowledge of the pathogenic micro-organisms. The various species and identification, including the necessary sampling and testing regimes for evaluation, therefore, could not be expected to be sought and achieved at this awareness state by such businesses. Poor knowledge of Legionellosis disease variants meant that even if individuals, employees or community members, presented with symptoms, suspicion and then confirmation of the disease, this was not expected. This compounded the poor attention given to this highly potentially dangerous micro-organism.

- **Conditions that promoted the growth and proliferation of the hazardous agent:** While businesses may not have been able to alter conditions at their utilities, the lack of knowledge on the risk to which they exposed themselves with these conditions made them insensitive and, therefore, vulnerable. An example was with hot water systems that could be run at temperatures between 25 to 45 degrees Celsius to control risk from bacterial proliferation including Legionella species.

- **The legislation pertaining to Legionella bacteria:** Even if businesses and people in general might wish to be law abiding, they should be aware of the
laws and penalties pertaining to the specific subject. The finding that businesses lacked awareness of the current legislation on Legionella, and the implications of not meeting the requirements, meant that they operated at risk from the law.

It could be concluded that lack of awareness was a significant contributor to the poor state of Legionella risk management by businesses in the East London and Border Areas of the Eastern Cape, South Africa. Any programmes to address or aim to improve the level of Legionella risk management in the businesses located in the geographical study area, therefore, demanded a significant focus on raising Legionella awareness if any success should be attained.

4.1.3 Analysis of Capability to Manage Legionella Risk.

Capability, the synergistic result of capacity (quantitative resources) and ability (qualitative resources) was defined in the Thesaurus as “the ability to perform, power to act”. This was required for successful Legionella risk management.

The availability of resources and the deployment of knowledge and effort were surveyed to evaluate capability to manage Legionella risk by subject businesses, referred to here as “respondents”. The survey sought to establish the management level at which Legionella risk management was lead and driven in assessing both material and human effort that would be available to control this risk.

The results on the chart below showed that only a few respondent businesses deployed senior managers to lead this work. This state of affairs meant that tactics and tasks aimed at Legionella risk management would have low budgets and, mostly likely, piecemeal approaches, due to lack of structural power by those wishing to conform. The typical piecemeal attention was the once or twice per annum utility water sampling and testing for Legionella
bacteria done by businesses in the description of Legionella risk management.

Chart 4.9: Is Legionella Risk Management Lead by a Senior Manager?

Access to and use of expert and specialist services from suppliers is one common approach that modern businesses are using to bridge internal shortcomings or reducing costs. The term used for this is “outsourcing”. By establishing whether the respondents knew of Legionella risk management consulting companies or not, this would give an indication as to whether that capacity could be provided from outside the business.

The results indicated that almost half of the respondents did not know any such service providers. An opportunity, therefore, still existed for service providers to market themselves in this area of the Eastern Cape. Combining findings on awareness and capability, these consulting firms could adopt a strategy based on improving awareness of the risk in their health and safety dimension, as well as legislation risk dimension. Therefore, training and risk management outsourcing could be offered to respondents.

Chart 4.10: Knowledge of Legionella risk management service providers.
Many business programmes collapsed due to poor funding. This study sought to establish the impact of funding and management focus. Of the respondents, 72% indicated that the programme was neither well-funded nor well-managed.

The survey also established that most of the businesses sampled and tested their utility water, and also did the same with chemical water treatment. As many as 84% of the respondents indicated having a chemical and biocide treatment programme for their utility water. Only 34% of the businesses confirmed that they tested for Legionella. The literature review showed that a complete Legionella risk management involved a number of systematic programmes including fundamentally, risk assessment/audits that could reveal design and/or process deficiencies that needed to be addressed by the site-specific management programme. Only 16% of the respondents performed audits.

Another aspect of Legionella risk management requirement was the maintaining of up-to-date action log books and/or records. Only 9% of respondents admitted to keeping log books. The lack of documents to show control of employees' exposure to Legionella bacteria, an HBA in the current South African Labour Law Act, meant that respondents had no capability to defend themselves in courts of law in case litigation against them became an issue.

Procedures to handle off-specification situations scored only 16%, indicating that businesses might be unaware of what to do in the case of a high bacteria count or an outbreak.

Non-systematic and non-procedural responses to emergency situations would result in greater damage and more costly mistakes being made. This was especially true when handling communication with the media, who could easily cost business their goodwill in a short period, due to modern broadcast technology.
Chart 4.11: Response to carrying out of requisite aspects of Legionella risk management.

The ability to manage any form of risk to a business was enabled through people training and the development of a culture that was preventative when it came to problems. The survey results on Legionella risk training conveyed a weakness in knowledge development, with none of the respondents confirming that they had training programmes in place for Legionella risk control. Chart 4.8 above highlighted the level of apathy to this capability building measure, with more than 80% having no training in place with regard to Legionella risk management.

4.1.4 Analysis of Motivation to Manage Legionella Risk

Businesses undertake programmes for the value they can bring or the value they prevent from being lost. Risk management programmes are, by nature, designed to prevent value loss. This value may be monetary, goodwill in the market, goodwill in the community of operations, or goodwill with the government and/or political environment. This could also be explained by prevention of risk at internal environment level or market/task environment, or at the macro-environment level factors, acronym PESTLE. Legionella risk, as noted in the introductory sections of this study, impacted at all levels of business value arrangements.

The study sought to establish at what level some of the driving forces encouraged the undertaking of Legionella risk management in the business area of study. The
forces investigated included monetary, legal, market, international ownership or connection issues.

Businesses undertake programmes to minimise outflow of money that have little or no return. The study established that a great deal of the respondents did not have a good comprehension of cost related to Legionella outbreak as shown in Chart 4.12. It was clear that costs related to Legionella risk were not a main driving force towards compliance with Legionella management procedures.

Chart 4.12: Level of comprehension of costs related to Legionella outbreak.

Note: The pie chart information was obtained by combining results of respondents who agreed and those who partially agreed that costs were known, as well as combining those that said they partially disagreed and disagreed.

Legislation, combined with the level of penalties and policing around a business requirement, compel businesses and people, in general, to adhere to the prescriptions of the particular law. More than 78% of the respondents did not know the legal implications of an outbreak at their business operations. It was, however, shown that, if and when legislation with fines was instituted, more than 81% of respondents would ensure that the requirements would be met. Charts 4.13 and 4.14 demonstrate this.
The quest to gain and/or at least, maintain, market share, was a driving force for many businesses. To do this, many activities were undertaken to ensure optimum market position, especially growth. The study revealed that 19% of the respondent businesses agreed that markets and/or customers would benefit from a good Legionella management programme.

Table 4.2: Customer benefits can be gained by the business from a good Legionella management programme.

<table>
<thead>
<tr>
<th>Response</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>6</td>
<td>19%</td>
</tr>
<tr>
<td>Partially Agree</td>
<td>14</td>
<td>44%</td>
</tr>
<tr>
<td>Partially Disagree</td>
<td>3</td>
<td>9%</td>
</tr>
<tr>
<td>Disagree</td>
<td>6</td>
<td>19%</td>
</tr>
<tr>
<td>Not Applicable</td>
<td>3</td>
<td>9%</td>
</tr>
</tbody>
</table>
Chart 4.15: Customer benefits can be gained by the business from a good Legionella management programme

While local customers were becoming more demanding and knowledgeable, First World customers, especially those from Europe and the United States of America, were known to demand suppliers’ compliance on environmental aspects of operations. The study result on exposure to overseas markets/customers was demonstrated on Chart 4.16. The assumption was that, the more a business was exposed to international customers, the greater the need was for it to comply with activities such as Legionella risk management.

While most respondents were not currently exposed to international customers, globalisation was fast changing this situation and there could be insufficient time for those businesses to adapt and satisfy some of those fundamental dictates.

Chart 4.16: How significant was direct business from overseas customers?
4.2 Conclusion

In this chapter the researcher discussed the findings of the questionnaire based on a survey of Legionella risk management in the East London and Border areas of the Eastern Cape. The survey looked at the level of awareness of Legionella risk in business operations that ran water utilities linked to high Legionella risks like cooling towers.

The level of capability to manage the risk posed by Legionella to these businesses was also discussed. The results of the motivational forces that influenced compliance on Legionella risk management practice were also presented. In summary, the responses to the following questions were discussed; who the respondents were; did they know about the Legionella risk; could they manage it and, finally, what forces drove their action in this regard.

The findings showed that a variety of types and sizes of businesses responded showing little awareness of Legionella risk and, therefore, very poor capability to manage the risk. The above scenario may be related to the low impact of coercion factors internally and externally that the businesses currently experienced in the surveyed region.
Chapter 5

Conclusions and Recommendations

5.1 Problems and Limitations

No major problems were encountered during the study. The following notes should, however, be taken into account:

5.1.1 Public hospitals were not allowed to be included in the results of the study because the necessary procedures for them to participate were not met by this study. Any research or survey to be conducted at all government health facilities in the Eastern Cape needed to be applied for, and sanctioned by, head office in Bhisho, a procedure that could not be met during this study.

5.1.2 A 56% questionnaire return rate was achieved. The apathy could not be ascribed to only one particular reason but could have been due to:

- The subject of Legionella risk being of no major interest to the subject businesses, referred herein as “respondents”. The lack of interest may also have been related to one of the conclusions of this study that there was a lack of awareness of the potential harm that Legionella bacteria could have on the business;
- The questionnaire could have been regarded as being too long, or
- Methods of return that were considered ineffective.

5.1.3 Agricultural operations like green houses located out of town industrial settings were not surveyed, even though they could have met the specifications of case subjects. This was due to the researcher's inadequate resources.
5.2 Summary of Study

The primary objective of this study was to improve risk management in business firms by investigating their:

- Awareness of the risks posed to them by Legionella bacteria in water systems,
- The preventative actions being taken to prevent and/or manage outbreaks.
- Motivating factors that would ensure that these risks were managed adequately through deployment of effort and resources.

Secondary objectives of the study were:

- To assess the market’s (local or export) influence on the practice of Legionella risk management by the firms.
- To investigate the impact that legislation would have had on the quantity of resources, including time, allocated to Legionella risk management.

The study concluded that the levels of awareness and knowledge of Legionella bacteria, and the diseases they caused, were very low in businesses that ran susceptible water utilities in the East London and Border areas of the Eastern Cape.

The study also concluded that market or customer pressure had very little, or no, influence at the present time with regard to the level and quality of Legionella risk management practices by the businesses in the business area of study.

The study showed that the development of law, and the enforcement thereof through fines on Legionella risk management practice, would certainly compel businesses in the study area to adopt and meet requirements.

5.3 Recommendations

Based on the findings and conclusions in this study, the following recommendations were made.
Information Dissemination: In the interest of value creation, or at least prevention of loss as a result of keeping the status quo on Legionella risk, it was recommended that all interested parties on Legionella risk develop communication instruments to improve awareness of Legionella risk. These included the Legionella Action Group (LAG), Department of Labour with the research and advice of the Advisory Council for Occupational Health and Safety, learning institutions, specialist private entities, including water treatment companies. Private companies had an opportunity to create value for themselves through training, risk assessments, as well as continued outsourced risk management services when businesses were conscious of Legionella risk.

The second recommendation was that the Government should, in the interests of maintaining labour productivity and welfare, increase focus and impetus towards development and enactment of specific laws governing the practice of Legionella risk management. As found by the study, enforcement of law through a suitable fine would compel most respondent businesses in the study area to allocate more effort and resources to risk management activities.

5.4 Conclusion

Legionella risk was a little-known potential hazard to businesses that could continue to harm without notice. The low screening rates for Legionella bacteria infection on respiratory ailment patients, and the deceased in South Africans, continued to underplay the risk.

Low awareness levels of Legionella bacteria and the diseases they caused, including lack of some monetary value attached to it, poor allocation of capacity and ability, were found at businesses studied.

An education drive was required to improve adoption and practice of Legionella risk management, especially in the face of globalisation and the need for attracting foreign capital and/or markets by South African and, indeed, African companies.
Bibliography


g) Co-ordinating Centre for Infectious Diseases/ Division of Bacterial and Mycotic Diseases (12 October 2005), Legionellosis [online] http://www.cdc.gov/ncidod/dbmd/diseaseinfo/legionellosis_g.htm


# ANNEXURE 1:

## Figure 1: Quantitative versus Qualitative Research Paradigms

<table>
<thead>
<tr>
<th></th>
<th>QUANTITATIVE</th>
<th>QUALITATIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PURPOSE</strong></td>
<td>Explain and predict</td>
<td>Describe and explain</td>
</tr>
<tr>
<td></td>
<td>Confirm and validate</td>
<td>Explore and interpret</td>
</tr>
<tr>
<td></td>
<td>Test existing theory</td>
<td>Build new theory</td>
</tr>
<tr>
<td><strong>PROCESS</strong></td>
<td>Focused</td>
<td>Holistic</td>
</tr>
<tr>
<td></td>
<td>Known variables</td>
<td>Unknown variables</td>
</tr>
<tr>
<td></td>
<td>Established guidelines</td>
<td>Flexible guidelines</td>
</tr>
<tr>
<td></td>
<td>Preset methods</td>
<td>Emergent methods</td>
</tr>
<tr>
<td></td>
<td>Detached view, and context-free</td>
<td>Personal viewpoint, and context-bound</td>
</tr>
<tr>
<td><strong>DATA COLLECTION</strong></td>
<td>Numeric data</td>
<td>Textual and image-based data</td>
</tr>
<tr>
<td></td>
<td>Representative, large sample</td>
<td>Informative, small sample</td>
</tr>
<tr>
<td></td>
<td>Standardised measuring instruments</td>
<td>Loosely structured, non-standardised observations and interviews</td>
</tr>
<tr>
<td><strong>DATA ANALYSIS</strong></td>
<td>Statistical analysis</td>
<td>Search for themes and categories</td>
</tr>
<tr>
<td></td>
<td>Objectivity is key</td>
<td>Acknowledgement that analysis is subjective</td>
</tr>
<tr>
<td></td>
<td>Deductive reasoning – based on numeric and statistical facts</td>
<td>and emotionally biased</td>
</tr>
<tr>
<td></td>
<td>Inductive reasoning</td>
<td>Inductive reasoning</td>
</tr>
<tr>
<td><strong>REPORTING</strong></td>
<td>Numbers</td>
<td>Words</td>
</tr>
<tr>
<td><strong>RESEARCH FINDINGS</strong></td>
<td>Statistics, aggregated data</td>
<td>Narratives, individual quotes</td>
</tr>
<tr>
<td></td>
<td>Formal voice, scientific style</td>
<td>Personal voice, literary style</td>
</tr>
</tbody>
</table>

The researcher would like to ask a few questions on the management of risk posed by Legionella bacteria. The researcher is a Master of Business Administration (MBA) student at the Nelson Mandela Metropolitan University and is also a water treatment specialist. This study is undertaken in partial fulfilment of his degree programme and to help to understand the incidence and management of Legionella within businesses.

The overall aim of the study is to have information that will help in the development of an effective Legionella risk management strategy in the Eastern Cape.

The objectives of the study are:

1. To establish how well the risk posed by Legionella bacteria in water systems in industry is known.
2. To find out what risk management programmes or strategies are in place at businesses to manage the risk of Legionella bacteria.
Your answers will be handled in confidence. No direct reference to any person or business name will be made.

If you have any questions pertaining to the study, please contact Mr. Christopher Mahwehwe on 082 802 9160 or the promoter, Mr. C. Ndhlovu, on 083 620 7482.

The University and the student greatly appreciate and would like to thank you for completing this questionnaire by the 20th of August 2010. If you would like to receive the results of this survey, please indicate below.

When complete please send the 2 questionnaire pages:
Fax to : 086 610 5381 or 043 721 1398 or
Scan and email to : mahwehwe@yahoo.com or
Call for collection : 082 802 9160.

----------------------------------------------------------------------------------------------------------------------

I would like the results of the survey – My fax/ email is

----------------------------------------------------------------------------------------------------------------------

Please note that this information sheet is for you to keep unless the results of the survey are wanted.
ANNEXURE 3:
Research Questionnaire

1) How would you classify the industrial sector your business belongs to? (Tick)
   - Food Manufacturing
   - Hoteliers and Commercial Property/ Shopping Centres
   - Hospitals and Health Facility
   - Engineering Manufacturing
   - Chemical and Plastic Manufacturing
   - Other (name)............................................

2) Tick the location of your business:
   - Q/town
   - EL
   - KWT
   - Butt/wth
   - Mtata
   - Other.................................

3) Tick the best description of your business:
   - Local (Eastern Cape only)
   - National (South Africa only)
   - International (more than 1 but less than 10 countries)
   - Global (above 10 countries & more than 2 continents)

4) What is the total number of employees in your business? (tick)
   - 1 to 50
   - 51 to 200
   - 201 to 500
   - 501 to 1000
   - Above 1000

All questions below are focused on utilities or systems that use water at your business.

5) What utilities do you run?: (Tick all applicable)
   - Cooling Towers
   - Safety Showers
   - Spa baths
   - Water fountains
   - Cleaning-In-Place/CIP
   - Fire hydrant
   - Humidifiers/ Misters
   - Waste water plant
   - Other (list)..............................

   *Tick over the most applicable response*

6) Legionella bacteria and the disease it causes (Legionnaire’s) are well known in the
   - Agree
   - Partially Agree
   - Partially Disagree
   - Disagree
   - Not Applicable

7) Conditions promoting growth and proliferation of Legionella bacteria are known in the business.
   - Agree
   - Partially Agree
   - Partially Disagree
   - Disagree
   - Not Applicable

8) Conditions of growth and proliferation of Legionella bacteria are under control in the business.
   - Agree
   - Partially Agree
   - Partially Disagree
   - Disagree
   - Not Applicable

9) In case of an outbreak of Legionnaire’s at the business, related costs are clearly
   - Agree
   - Partially Agree
   - Partially Disagree
   - Disagree
   - Not Applicable

10) In the case of an outbreak of Legionnaires at the business, the legal implications are known.
    - Agree
    - Partially Agree
    - Partially Disagree
    - Disagree
    - Not Applicable

11) A senior manager "drives" / leads Legionella risk management in the business.
    - Agree
    - Partially Agree
    - Partially Disagree
    - Disagree
    - Not Applicable
12) Legionella risk management is audited and enforced from head office outside South Africa.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
</table>

13) Outbreak or cases of Legionnaires’ are known to have occurred within or around the business.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
</table>

14) At least one Legionella risk management company/specialist is known to the business.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
</table>

15) The Legionella risk management programme is well-funded and managed.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
</table>

16) The sampling and sending of utility water for Legionella testing is done.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
</table>

17) Chemical water treatment, including biocide dosing for utilities water, is done.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
</table>

18) Legionella risk assessment and regular audits are done at the business’s facilities.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
</table>

19) The business gets significant business directly from overseas customers.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
</table>

20) The Legionella risk management programme consisting of the following is in place:

<table>
<thead>
<tr>
<th>Risk assessments/audits</th>
<th>Utility physical cleaning &amp; maintenance plan</th>
<th>Water Treatment programme</th>
<th>Regular water sampling and testing</th>
<th>Out of specification procedures</th>
<th>Maintenance action log books</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>Partially Agree</td>
<td>Partially Disagree</td>
<td>Disagree</td>
<td>Not Applicable</td>
<td></td>
</tr>
</tbody>
</table>

21) Customer benefits can be gained by the business from a good Legionella management programme.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
</table>

22) A full risk audit would be considered if an employee were to be diagnosed with

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
</table>

23) The legislation on Legionella risk management for South Africa is known in the business.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
</table>

24) A non-compliance fine would compel achievement of Legionella risk management requirements.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
</table>

25) Training on Legionella risk control has been done in this business.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
</table>

26) There are bigger risks in this business to worry about Legionella risk!

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
</table>

End of Questionnaire
**ANNEXURE 4:**

**Results of the Empirical Data**

| Total number of questionnaires distributed | 57 | 100% |
| Total received back | 32 | 56% |

1) How would you classify the industrial sector your business belongs to? (tick)

<table>
<thead>
<tr>
<th>Industry</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Manufacturing</td>
<td>8</td>
<td>25%</td>
</tr>
<tr>
<td>Hoteliers and Commercial Property/ Shopping Centres</td>
<td>4</td>
<td>13%</td>
</tr>
<tr>
<td>Hospitals and Health Facility</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>Engineering Manufacturing</td>
<td>10</td>
<td>31%</td>
</tr>
<tr>
<td>Chemical and Plastic Manufacturing</td>
<td>3</td>
<td>9%</td>
</tr>
<tr>
<td>Other (name)</td>
<td>6</td>
<td>19%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>32</td>
<td>100%</td>
</tr>
</tbody>
</table>

2) Tick the location of your business:

<table>
<thead>
<tr>
<th>Location</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q/ town</td>
<td>22</td>
<td>69%</td>
</tr>
<tr>
<td>EL</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>KWT</td>
<td>3</td>
<td>9%</td>
</tr>
<tr>
<td>But/wth</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>Mtata</td>
<td>5</td>
<td>16%</td>
</tr>
<tr>
<td>Other (list)</td>
<td>32</td>
<td>100%</td>
</tr>
</tbody>
</table>

3) Tick the best description of your business:

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local (Eastern Cape only)</td>
<td>16</td>
<td>50%</td>
</tr>
<tr>
<td>National (South Africa only)</td>
<td>6</td>
<td>19%</td>
</tr>
<tr>
<td>International (more than 1 but less than 10 countries)</td>
<td>9</td>
<td>28%</td>
</tr>
<tr>
<td>Global (above 10 countries &amp; more than 2 continents)</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>32</td>
<td>100%</td>
</tr>
</tbody>
</table>

4) What is the total number of employees in your business? (Tick)

<table>
<thead>
<tr>
<th>Number of Employees</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 50</td>
<td>3</td>
<td>9%</td>
</tr>
<tr>
<td>51 to 200</td>
<td>16</td>
<td>50%</td>
</tr>
<tr>
<td>201 to 500</td>
<td>4</td>
<td>13%</td>
</tr>
<tr>
<td>501 to 1000</td>
<td>3</td>
<td>9%</td>
</tr>
<tr>
<td>Above 1000</td>
<td>6</td>
<td>19%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>32</td>
<td>100%</td>
</tr>
</tbody>
</table>

All questions below are focused on utilities or systems that use water at your business.

5) What utilities do you run?: (Tick all applicable)

<table>
<thead>
<tr>
<th>Utility</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling Towers</td>
<td>38%</td>
<td></td>
</tr>
<tr>
<td>Safety Showers</td>
<td>38%</td>
<td></td>
</tr>
<tr>
<td>Spa baths</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Water fountains</td>
<td>31%</td>
<td></td>
</tr>
<tr>
<td>Cleaning-In-Place/CIP</td>
<td>41%</td>
<td></td>
</tr>
<tr>
<td>Fire hydrant</td>
<td>88%</td>
<td></td>
</tr>
<tr>
<td>Humidifiers/ Misters</td>
<td>22%</td>
<td></td>
</tr>
<tr>
<td>Waste water plant</td>
<td>34%</td>
<td></td>
</tr>
<tr>
<td>Other (list)</td>
<td>6%</td>
<td></td>
</tr>
</tbody>
</table>

**Tick-over the most applicable response**

6) Legionella bacteria and the disease it causes (Legionnaire’s) are well-known in the business.

<table>
<thead>
<tr>
<th>Agreement</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Percentage</td>
<td>13%</td>
<td>22%</td>
<td>3%</td>
<td>63%</td>
</tr>
<tr>
<td>Disagree</td>
<td>Not Applicable</td>
<td>0</td>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td>Percentage</td>
<td>13%</td>
<td>28%</td>
<td>0%</td>
<td>53%</td>
</tr>
</tbody>
</table>

7) Conditions promoting growth and proliferation of Legionella bacteria are known in the business.

<table>
<thead>
<tr>
<th>Agreement</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>4</td>
<td>9</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Percentage</td>
<td>13%</td>
<td>28%</td>
<td>0%</td>
<td>53%</td>
</tr>
<tr>
<td>Disagree</td>
<td>Not Applicable</td>
<td>0</td>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td>Percentage</td>
<td>13%</td>
<td>28%</td>
<td>0%</td>
<td>53%</td>
</tr>
</tbody>
</table>
8) Conditions of growth and proliferation of Legionella bacteria are under control in the business.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>5</td>
<td>1</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>19%</td>
<td>16%</td>
<td>3%</td>
<td>56%</td>
<td>3%</td>
</tr>
</tbody>
</table>

9) In case of an outbreak of Legionnaire's at the business, related costs are clearly known/projected?

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>1</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>3%</td>
<td>22%</td>
<td>3%</td>
<td>69%</td>
<td>3%</td>
</tr>
</tbody>
</table>

10) In the case of an outbreak of Legionnaire's at the business, the legal implications are known.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>3</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>3%</td>
<td>9%</td>
<td>9%</td>
<td>75%</td>
<td>3%</td>
</tr>
</tbody>
</table>

11) A senior manager "drives" / leads Legionella risk management in the business.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>3</td>
<td>1</td>
<td>19</td>
<td>3</td>
</tr>
<tr>
<td>19%</td>
<td>9%</td>
<td>3%</td>
<td>59%</td>
<td>9%</td>
</tr>
</tbody>
</table>

12) Legionella risk management is audited and enforced from head office outside South Africa.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>0</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>6%</td>
<td>6%</td>
<td>0%</td>
<td>50%</td>
<td>38%</td>
</tr>
</tbody>
</table>

13) Outbreak or cases of Legionnaire’s are known to have occurred within or around the business.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>94%</td>
<td>6%</td>
</tr>
</tbody>
</table>

14) At least one Legionella risk management company/specialist is known to the business.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>4</td>
<td>0</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>41%</td>
<td>13%</td>
<td>0%</td>
<td>41%</td>
<td>6%</td>
</tr>
</tbody>
</table>

15) The Legionella risk management programme is well-funded and managed.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3</td>
<td>3</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>13%</td>
<td>9%</td>
<td>9%</td>
<td>63%</td>
<td>6%</td>
</tr>
</tbody>
</table>

16) The sampling and sending of utility water for Legionella testing is done.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>1</td>
<td>0</td>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td>34%</td>
<td>3%</td>
<td>0%</td>
<td>53%</td>
<td>6%</td>
</tr>
</tbody>
</table>

17) Chemical water treatment, including biocide dosing for utilities water, is done.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>84%</td>
<td>3%</td>
<td>0%</td>
<td>13%</td>
<td>0%</td>
</tr>
</tbody>
</table>
18) Legionella risk assessment and regular audits are done at the business’ facilities.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3</td>
<td>1</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>9%</td>
<td>9%</td>
<td>3%</td>
<td>75%</td>
<td>3%</td>
</tr>
</tbody>
</table>

19) The business gets significant business directly from overseas customers.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>5</td>
<td>3</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>19%</td>
<td>16%</td>
<td>9%</td>
<td>41%</td>
<td>16%</td>
</tr>
</tbody>
</table>

20) The Legionella risk management programme, consisting of the following, is in place:

<table>
<thead>
<tr>
<th>Risk assessments/ audits</th>
<th>16%</th>
<th>Utility physical cleaning &amp; maintenance plan</th>
<th>66%</th>
<th>Water Treatment programme</th>
<th>69%</th>
<th>Regular water sampling and testing</th>
<th>75%</th>
<th>Out of specification procedures</th>
<th>16%</th>
<th>Maintenance action log books</th>
<th>9%</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>18</td>
<td>3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>9%</td>
<td>56%</td>
<td>9%</td>
<td>19%</td>
<td>6%</td>
</tr>
</tbody>
</table>

21) Customer benefits can be gained by the business from a good Legionella management programme.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>14</td>
<td>3</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>19%</td>
<td>44%</td>
<td>9%</td>
<td>19%</td>
<td>9%</td>
</tr>
</tbody>
</table>

22) A full risk audit would be considered if an employee were to be diagnosed with

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>78%</td>
<td>13%</td>
<td>0%</td>
<td>3%</td>
<td>9%</td>
</tr>
</tbody>
</table>

23) The legislation on Legionella risk management for South Africa is known in the business.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
<td>4</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>0%</td>
<td>13%</td>
<td>13%</td>
<td>72%</td>
<td>3%</td>
</tr>
</tbody>
</table>

24) A non-compliance fine would compel achievement of Legionella risk management requirements.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>81%</td>
<td>6%</td>
<td>3%</td>
<td>9%</td>
<td>3%</td>
</tr>
</tbody>
</table>

25) Training on Legionella risk control has been done in this business.

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
<td>2</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>0%</td>
<td>13%</td>
<td>6%</td>
<td>75%</td>
<td>3%</td>
</tr>
</tbody>
</table>

26) There are bigger risks in this business to worry about Legionella risk!

<table>
<thead>
<tr>
<th>Agree</th>
<th>Partially Agree</th>
<th>Partially Disagree</th>
<th>Disagree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>2</td>
<td>0</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>16%</td>
<td>6%</td>
<td>0%</td>
<td>53%</td>
<td>25%</td>
</tr>
</tbody>
</table>

End of Questionnaire