University of Southern Queensland

Faculty of Health, Engineering and Sciences

Risk Management in the Construction of Communication Towers

A dissertation submitted by

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In fulfilment of the requirements of

Courses ENG4111 and 4112 Research Project

Towards the degree of

Bachelor of Construction (Management)

Submitted: October, 2016

ABSTRACT

Global requirements to improve telephone coverage, provide high speed data transmission and cutting edge communication solutions are increasing at a rapid rate. The requirement for new construction and upgrade of existing communications infrastructure in on the rise and there is currently minimal industry documentation that investigates risk management on these type of projects.

The main objective of this research project is to investigate risk management on the construction and upgrade of communication facilities. This project considers the effect of project specific elements as well as project management constraints to understand the effect of risk on the project performance. An extensive literature review was completed to understand the key principles and dependencies which affect risk management before case study data was collected. The case study data was then analysed to understand how elements of the project affect the risks and how these risks can be best managed in the future.

The combination of the literature review and case studies has provided an opportunity for an analysis to understand how risks are currently being effectively managed, and where there is potentially room for improvement in the future. One of the key outcomes of the research is attempting to identify elements of the project which affect the risk impact or probability.

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Certification of Dissertation

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

J. Adams

0061032326

Acknowledgements

I would like to show my thanks and appreciation to the following people

- My Supervisor, Dr David Thorpe for his guidance and support throughout the duration of this project
- My family and friends for their guidance and input
- My current and past colleagues who have shared their experiences with me and provided me with feedback when required.

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October 2016

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NOMENCLATURE AND ACRONYMS (OR ABBREVIATIONS)

Blackspot – An area with lack of mobile phone service coverage

EWP – Elevated Work Platform

GM – Gross Margin (%)

MOP – Method of Procedure

NBN – National Broadband Network

PMBOK – Project Management Body of Knowledge

PMI – Project Management Institute

RF – Radio Frequency

Telstra – Mobile Services Provider

USQ – University of Southern Queensland

CHAPTER 1 – INTRODUCTION

1.1 Background

With the growing requirement for mobile and data technologies to be at everyone's finger tips, the mobile communication and data industries are set to continue to grow at a rapid pace. The Australian Government Department of Communications and the Arts (2016) indicate that the services are available in urban areas, some regional areas, and along national highways currently reaching 99% of the Australian population. This leaves a significant part of Australia that is currently not serviced by mobile phone services as shown in figure 1. The Australian Government has recently begun providing funding for a Mobile Black Spot Programme which aims to provide service coverage in some of the identified blackspot areas (Telstra 2016). These programs are going to increase the amount of new towers being constructed in the country in various locations, often remote locations. Remote locations provide construction risks to the contractor the need to be effectively managed to ensure that the projects is successful. Figure 1 shows the Australia wide mobile phone coverage map of Australia's largest mobile phone service provider.

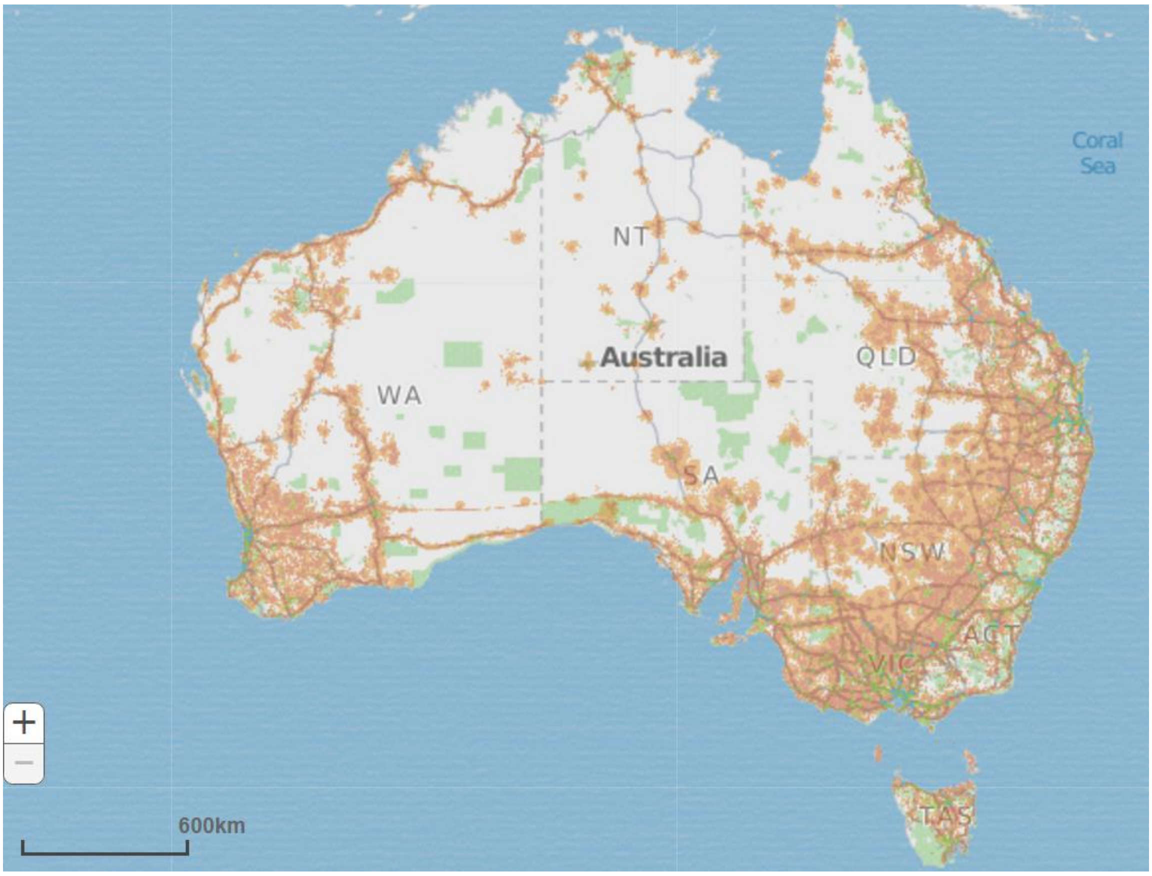

Figure 1: Telstra's Australia wide coverage map (Telstra 2016)

1.2 Aim

This project seeks to investigate the risks associated with the construction and upgrade of mobile communications towers, poles and facilities. This report endeavours to identify the key commercial risks and identify the strategies that can be utilised to manage the commercial risks that are faced by contractors throughout the construction phase. Risk management will be the focus area with particular reference to the planning and implementation phases of the construction lifecycle. The methodology section of the report will use assessments of current projects as case studies, while considering the PMBOK risk management and project management methodology.

1.3 Objectives

The broad objective of this study is identifying the key risks in the construction and upgrade of communication towers, and develop a document that will assist professionals in the industry. The specific objectives of the project are:

- Provide a clear understanding of risk and how to manage it
- Identify the effects of risk and how they will impact on success.
- Provide a framework to manage project risk
- Complete case studies on current projects
- Provide a starting point for future studies into the risks associated with the construction of communication towers.
- Provide recommendations on risk management on communication projects.

1.4 Limitations

Given the time available for this undergraduate project, the study will not consider risks associated within the initiation or closing activities of the single phase project as shown in figure 2. This project will focus on the commercial risks and will not consider construction risks related to the Environment, Health or Safety due to time constraints. The case study data will be limited to that which is available from the industry at the time of completion. It is expected that during the completion of the dissertation that additional limitations will be identified.

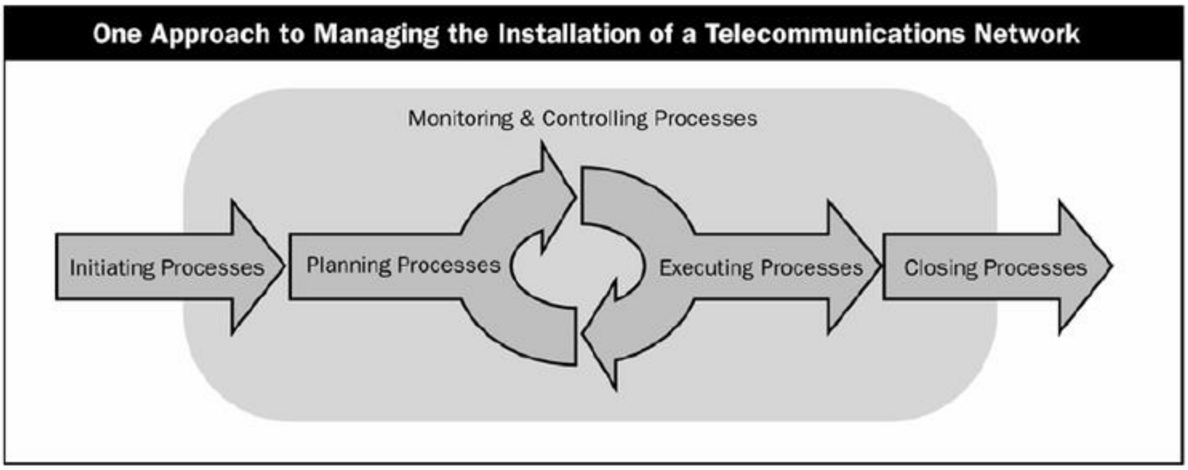

Figure 2: Activities within a single phase project (PMI 2016, p42)

CHAPTER 2 – LITERATURE REVIEW

2.1 Introduction

The purpose of this literature review is to understand risk management, identify the PMBOK risk management processes and understand the type of project that is to be investigated within this dissertation. The literature review will look into the risk management strategies and how they can be used to control project performance. This chapter will identify the knowledge required prior to completing the case studies on real world projects from the contractor's perspective.

2.2 Risk Management

This section aims to identify background research and processes used to manage risk in projects where communication towers are constructed and upgraded. The section will focus on risk related to projects within the planning and implementation phases of the project lifecycle. The risk management processes used will be based around the PMBOK 5th edition which is a world recognised guide for use by project managers. Imbeah & Guikema (2009) suggest that a management model that simultaneously addresses cost, schedule, quality and risk as one will provide the best decision making for a construction manager. This suggests that the PMBOK guide will be adequate for use in this case study. Due to the time constraints of this project, the PMBOK process will be the only one considered within the dissertation. The PMBOK process for risk management has been developed in accordance with the international standard for Risk Management ISO 31000:2007. This has made it the methodology of choice for many companies and professionals within the industry.

International Organization for Standardization (2009) defines risk to be:

> "Organisations of any kind face internal and external factors and influences that make it uncertain whether, when and the extent to which they will achieve or exceed their objectives. The effect this uncertainty has on the organizations objectives is risk".

Alternatively, Akintola & MacLeod (1997) identified risk in construction as "an exposure to economic loss or gain arising from involvement in the construction process". Akintola & MacLeod (1997) also identified risk in relation to construction as a "variable in the process of a construction project whose variation results in uncertainty as to the final cost, duration and quality of a project". The study goes on to identify that the management of risk does not necessarily only apply to construction, suggesting that it is also a feature of the free enterprise system.

Project risk management is defined by (PMI 2013, p 309) as:

> "The process of conducting risk management planning, identification, analysis, response planning, and controlling risk on a project. The objectives of project risk management are to increase the likelihood and impact of positive events, and decrease the likelihood and impact of negative events in the project".

Risk can have a negative effect on a project; however it has the potential to bring a positive effect on the delivery of objectives by providing opportunities to add value to the project. Risk can be measured by examining the probability and impact (threat or opportunity) of the risk to the success of the project. Zhao et al. (2015) identified risk as the responsibility of all stake holders due to the often fragmented nature of large projects.

PMI (2013, p309) identified the following steps that are critical for an effective risk management process:

- Plan risk management
- Identify risks
- Perform qualitative risk analysis
- Perform quantitative risk analysis
- Plan risk responses
- Control risks

These steps will be further analysed in the following sections to understand their role in the risk management process and how they can be best used in a project environment.

2.2.1 Plan Risk Management

Planning of risk management is defined by PMI (2013, p309) as "the process of defining how to conduct risk management activities for a project". The planning aspect of risk management involves the writing of the Risk Management Plan and Project Management plan which are completed during the initiation phase of the project. This document will form the baseline for the expectations of risk management on the project. As this dissertation does not consider the initiation phase of the project, the development of these documentations is not to be considered within this project.. However the document itself is important as it should be used during the planning and implementation phases of the project as the baseline for how risk management is to be conducted.

PMI (2013, p313) suggest that the importance of planning risk management is to ensure that the processes align with both the risks and the importance of the project to the organisation. This is important to ensure that the risk management plan is relevant to the project type and the goals of the project. PMI (2013, p316) indicate that an effective project management plan will identify the methodology, budgeting, timing, and roles and responsibilities of the project team.

2.2.2 Identify Risks

Identifying risks is defined by PMI (2013, p319) as “the process of determining which risks may affect the project and documenting their characteristics”. This process is important so that all risks can be documented and provided to the project team for constant monitoring throughout the planning and implementation phases. International Organization for Standardization (2012) suggests that the identification of risks is “a repeatable process because new risks may become known or risks may change as the project progresses through its life cycle”. Risk identification is an ongoing process that needs to be continually completed to identify any potential threats and opportunities that the contractor can address or monitor. All identified risks should be documented in the project risk register where all members of the project team can view and review the risk and the recommended management process. Figure 3 shows the inputs required prior to the use of tools and techniques to develop the risk register. The risk register is an important document which lists all of the identified risks; all risk analyses and responses (PMI 2013, p319). The risk register will be discussed in more detail later in this dissertation.

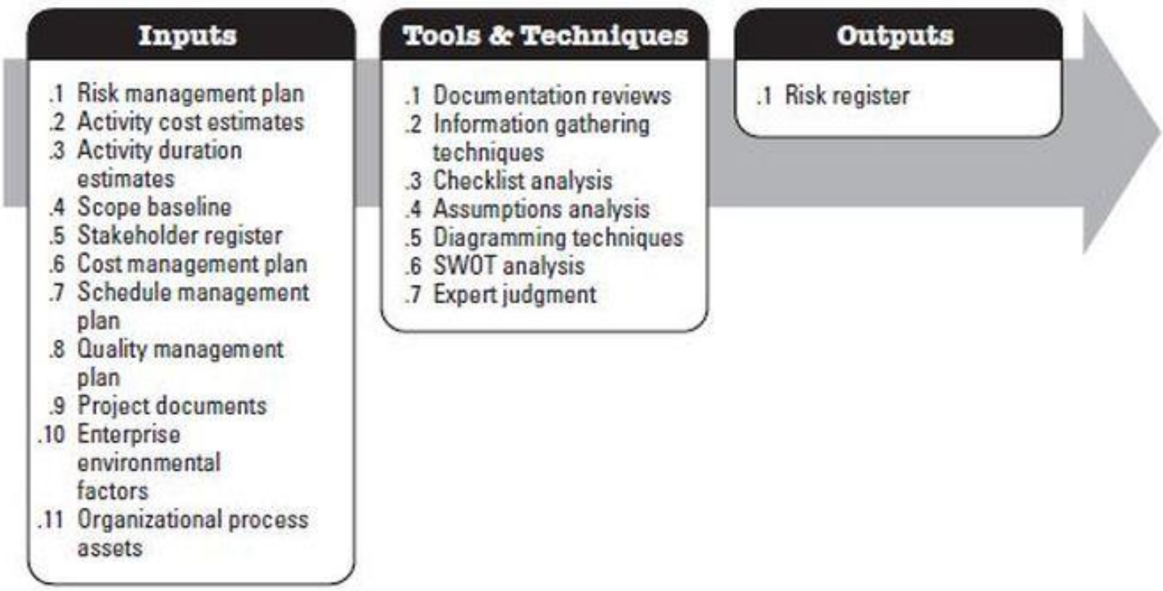

Figure 3: Risk identification process (PMI 2013, p319)

2.2.3 Perform Qualitative risk analysis

Once the risk has been identified it is most important that it is analysed to understand the probability and impact to the project. PMI (2013, p313) defines performing of the qualitative risk analysis as "the process of prioritising risks for further analysis or action by assessing and combining their probability of occurrence and impact". The probability and impact of the threats and opportunities can be analysed using the Probability and Impact Matrix shown in figure 4. The difficulty with the probability and impact matrix is that it is often hard to define numerical figures that can be used to identify the threats and opportunities.

Probability and Impact Matrix

Probability	Threats					Opportunities				
0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04
0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03
0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02
0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01
	0.05	0.10	0.20	0.40	0.80	0.80	0.40	0.20	0.10	0.05

Impact (numerical scale) on an objective (e.g., cost, time, scope or quality)

Each risk is rated on its probability of occurring and impact on an objective if it does occur. The organization's thresholds for low, moderate or high risks are shown in the matrix and determine whether the risk is scored as high, moderate or low for that objective.

Figure 4: Probability and Impact Matrix (PMI 2013, p 331)

Figure 5 shows the impact assessment ratings that can be used to evaluate the impacts of the threats and opportunities from the probability and impact matrix results. These ratings will generally be developed a recorded in the risk management plan to identify how the ratings will be developed as part of the analysis phase.

Defined Conditions for Impact Scales of a Risk on Major Project Objectives
(Examples are shown for negative impacts only)

Project Objective	Relative or numerical scales are shown				
	Very low /.05	Low /.10	Moderate /.20	High /.40	Very high /.80
Cost	Insignificant cost increase	<10% cost increase	10-20% cost increase	20-40% cost increase	>40% cost lincrease
Time	Insignificant time increase	<5% time increase	5-10% time increase	10-20% time iIncrease	>20% time increase
Scope	Scope decrease barely noticeable	Minor areas of scope affected	Major areas of scope affected	Scope reduction unacceptable to sponsor	Project end item is effectively useless
Quality	Quality degradation barely noticeable	Only very demanding applications are affected	Quality reduction requires sponsor approval	Quality reduction unacceptable to sponsor	Project end item is effectively useless

This table presents examples of risk impact definitions for four different project objectives. They should be tailored in the Risk Management Planning process to the individual project and to the organization's risk thresholds. Impact definitions can be developed for opportunities in a similar way.

Figure 5: Risk impact rating (PMI 2013, p318)

2.2.4 Perform Quantitative risk analysis

Performing of a quantitative risk analysis is defined by PMI (2013, p333) as "The process of numerically analysing the effect of identified risks on overall project objectives". PMI (2013) identified that this process is often not required on smaller projects or where lack of sufficient data is available and the further analysis is not deemed to be required by the project manager. The quantitative risk analysis is helpful in large projects to understand aggregate effect of all risks on the project objectives. The outcome of a quantitative risk analysis is estimations of potential cost and schedule changes. These are most important on projects where deadlines are critical to the project success, and failure to meet these could expose the contractor to liquidated damages and additional costs. PMI (2013, p334) have identified that a quantitative risk assessment may not be possible due to lack of sufficient data being available to develop appropriate models.

Passionate Project Management (2011) believes that high quality data, a well-developed project model and a prioritised list from the qualitative risk assessment are all required to complete a quantitative risk analysis. In some cases this data may not be easily accessible or available making it difficult to complete this process. The quantitative risk analysis is much more time consuming however the outcome is more of a project based analysis rather than a risked based analysis (Passionate Project Management, 2011).

2.2.5 Plan risk responses

Planning of Risk Responses is defined by PMI (2013, p 342) as "The process of developing options and actions to enhance opportunities and to reduce threats to project objectives". There are several risk response strategies available that can be selected in conjunction with another strategy to best manage risk. It is important that the contractor understands that additional secondary risks may arise from the potential responses, and these will also need to be monitored. PMI (2013, p 343) suggests the development of a fall back plan which can be implemented if the strategy is not completely effective. The risks response strategies can be selected to manage negative threats or opportunities.

2.2.5.1 Strategies for Negative Risks or threats

PMI (2013, p 344) believes that there are four strategies that can be utilised to deal with negatives risks or threats:

- Avoid – Complete elimination of the risk from the project
- Transfer – Transferring the responsibility of the risk to a third party to manage.
- Mitigate – Where the project team acts to reduce the probability of occurrence or the impact of a risk.
- Accept – The project team will acknowledge the risk and not take any action until the risk occurs.

The selection of the strategy for managing an individual risk will be outlined in the Risk Management plan. With assistance from the quantitative risk analysis, the final strategy can then be decided.

2.2.5.2 Strategies for positive risks or opportunities

PMI (2013, p 345, 346) believes that there are four strategies that can be utilised to deal with positive risks or opportunities:

- Exploit – Ensuring that the opportunity happens.
- Enhance – Increase the probability and/or impact of the opportunity.
- Share – Allocating some or all of the opportunity to a third party best positioned to benefit the project.
- Accept – accepting the opportunity but not actively pursuing it.

The criteria for selection of a strategy will be outlined in the projects risk management plan as a guide to the decision making process of the project.

2.2.6 Control risks

Controlling risks is defined by PMI (2013, p348) as "the process of implementing risk response plans, tracking identified risks, monitoring residual risks, identifying new risks, and evaluating risk process effectiveness throughout the project". The actions to be taken in the control risks phase include the execution of the planned responses as per the processes indicated in the risk management plan, identifying new risks, using fall back controls and monitoring of the effectiveness of the process. The responses and management plan can both be reviewed and amended during the control phases as required to ensure the appropriate responses are used. Figure 6 shows the data flow throughout the controlling of risk function.

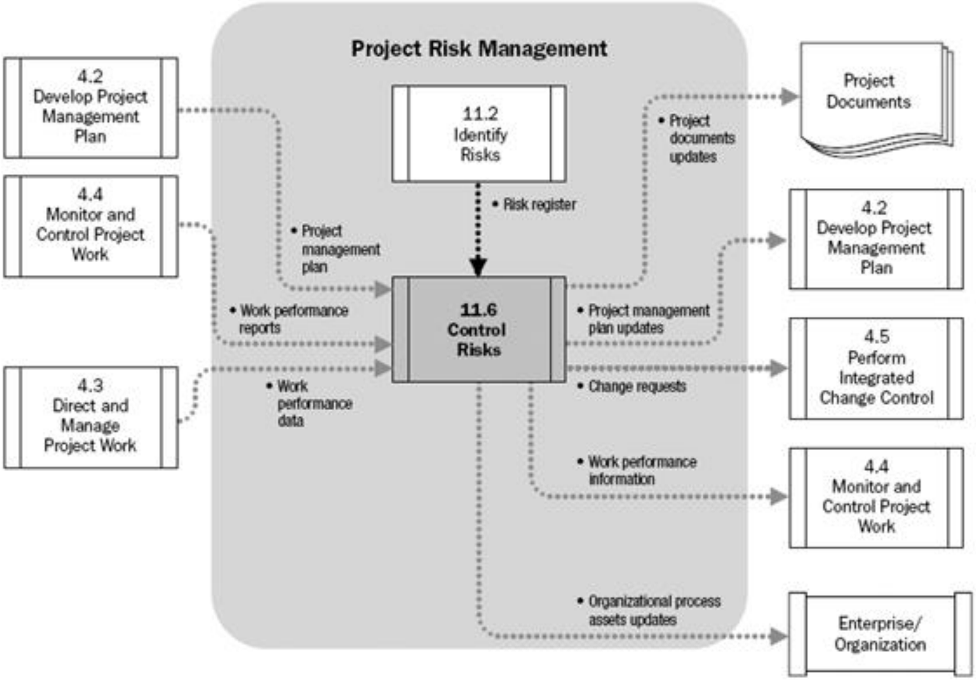

Figure 6: Risk control data flow diagram (PMI 2013, p349)

2.2.7 ISO 31000:2009 Risk Management – Principles and Guidelines

The Australian and New Zealand Standard for Risk Management 31000:2009 have been selected by ISO for use as the international standard. The standard provides principles for managing risk, frameworks for managing risk and its own risk management process, which is similar to the process suggested by PMI. The PMBOK process for risk management is aligned to ISO 31000:2009 to ensure that project managers are using the standardised process shown in figure 7.

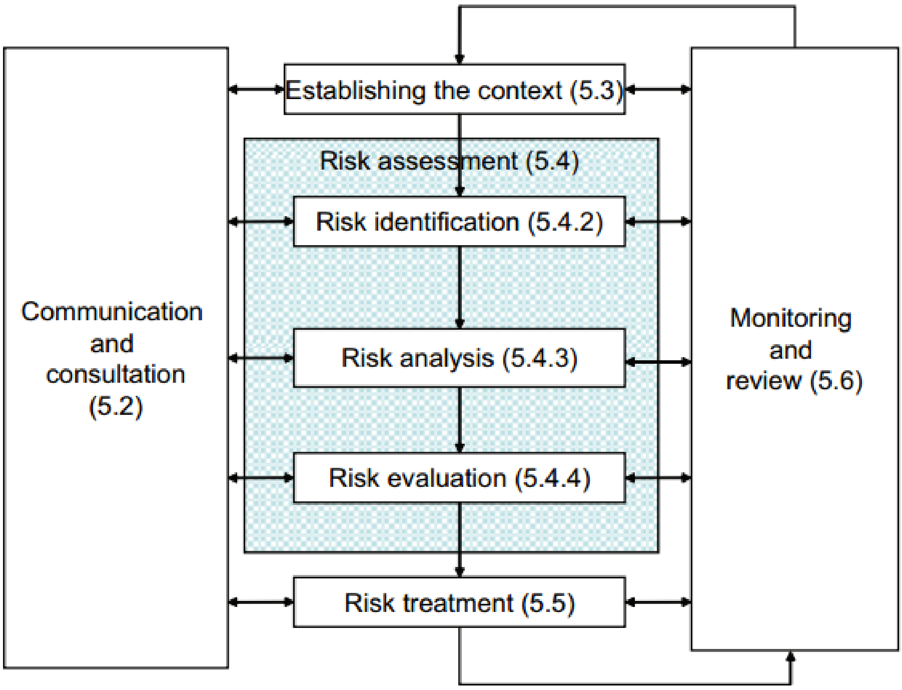

Figure 7: ISO Risk Management Implementation Process (International Organization for Standardization 2009)

International Organization for Standardization (2009) identified that continuous improvement is essential to determine the most effective framework for each different project. PMI (2013) identified constantly reviewing risk as one of the most important elements. The completion of monitoring and reviewing the risk will provide continuous improvement to the process.

2.3 Tools and Techniques

The literature review has identified several different tools and techniques which can be of great assistance to the project manager. Tools and techniques are an important part of the PMBOK process for risk management to ensure that the correct outputs are produced and executed.

2.3.1 Measuring Project Complexity

Project complexity is believed to be related to project risks, uncertainty and performance, however the link between all of these is still very unclear. Vidal & Marle (2015) have identified that complexity contributes to project failure in organisations however it is not yet clear to what degree. With the link between project risk and complexity to be clarified, complexity is believed to be one of the main contributors to uncertainty within a project (Vidal & Marle 2015). This requires the project manager to be well versed in the project complexities to ensure the risks are effectively managed and the correct opportunities are seized.

2.3.1.1 The NTCP Diamond Approach

Shenhar & Dvir (2007) developed the NTCP Diamond Approach which is used to understand risk and uncertainty of a project. The Diamond approach gives the scores on specific dimensions of the project which provides a set of rules or actions for each project type. The Diamond Approach provides an additional method for measuring potential risk based on the project scope. (Shenhar & Dvir 2007)'s project uncertainty model uses the following criteria to fill out the diamond shown in figure 9 to understand the project complexity and complexity:

1. Novelty
2. Technology
3. Complexity
4. Pace

(Shenhar & Dvir 2007)

Novelty

This criterion represents the uncertainty of the project goal due to how well the initial product requirements are defined:

1. Derivative: A derived offering of a successful product.
2. Platform: A new version of an existing product.
3. Breakthrough: Prototypes, often based on trial and error.

(Shenhar & Dvir 2007)

Technology

This criterion represents the technological uncertainty that the project is exposed to using the following measurable:

1. Low-tech: Almost no technical risk.
2. Medium-tech: Moderate technical risk.
3. High-tech: High technical risk.
4. Super-high-tech: Super high risk of delays, cost overruns and product failure.

Shenhar & Dvir (2007) identified that as the level of complexity increases, the risk and likelihood of failure increase.

Complexity

Complexity refers to the challenging characteristics of the project:

1. Assembly: The lowest degree of complexity.
2. System: Moderately difficult complexity. Examples include computers, cars, ships and buildings.
3. Array (or system of Systems): Coordination of multiple systems that is hugely complex. Examples include the construction of a gas mine.

(Shenhar & Dvir 2007)

Pace

Pace refers to the speed of construction required to meet the client deadline.

1. Regular: Business as usual.
2. Fast/Competitive: Moderate urgency.
3. Time-Critical: Failure to meet project deadlines can result in project failure.
4. Blitz: Crisis mode with extremely important timing.

(Shenhar & Dvir 2007)

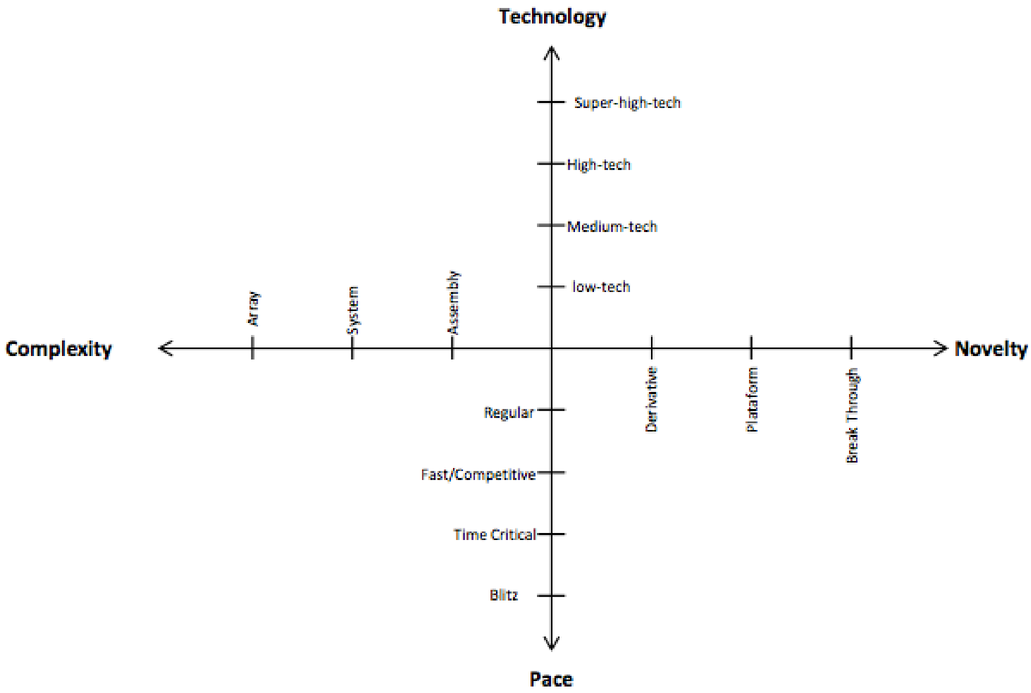

Figure 8: The NTCP Model (Shenhar & Dvir 2007)

The NTCP Diamond Model is a tool which can be used to understand low to high benefit opportunity and low to high risk difficulty (Shenhar & Dvir 2007). The more complex the shape is and the larger the size of the diamond is indicates the style of management and focus areas for project success (Shenhar & Dvir 2007). The model can be used as I guide to understand where the complications of the project are, and potentially when it may be best to outsource to a subcontractor.

2.3.2 The Risk Management Plan

The risk register is the most important project document that has been identified throughout the literature review for risk management. The risk management plan can be either a standalone document, or can be incorporated within the project management plan for a project. PMI (2013) suggest that a risk management plan should include the following;

- Methodology – Defines all approaches and procedures that will be used to perform risk management on the project.
- Roles and responsibilities – Defines the roles and responsibilities for all stakeholders and project members.
- Budgeting – Estimation of the funds required for inclusion in the cost baseline and contingency and management reserves.

- Timing – defines when and how often the risk processes are likely to be performed within the project lifecycle.

PMI (2013)

The reason for the importance of the risk management plan is that it should identify all of the processes and procedures for risk management and provide a baseline for all decisions. While the risk management plan itself does not control individual risks, it provides the project team with a framework and process which will increase the control of the risk management process (PMI 2013). A project that does not have a risk management plan is not likely to be managed as effectively by all team members as they may not all follow the same methodologies. In larger projects this will cause huge complexities and could potentially reduce the project performance.

2.3.3 Checklists

The use of checklists has been identified consistently throughout the literature review as an effective tool to ensure that all processes have been followed and accounted for. PMI (2013) frequently suggests the use of checklists based around historical information and knowledge. PMI (2013) identifies that a checklist is a quick and effective process; however factors outside a checklist always need to be considered. This indicates that a checklist is an effective tool, however is should not be relied on as the only tool because it may miss important information. Risk checklists are often used to assist with understanding the risk prior to documentation within the risk register.

2.3.4 The Risk Register

The risk register is one of the most important project documents that have been identified throughout the literature review. PMI (2013) defines the Risk Register to be the document where “the results of risk analysis and risk response planning are recorded”. The key information included in the risk management is the list of identified risk and a list of the potential responses to those risks. The risk register relies on being constantly updated as the main point of contact for project staff to understand the risks associated with the project and the planned responses. The document ideally should be in the form of a live document that can be accessed by all project staff to provide the best indication of the current status of all project risks.

The risk register should begin during the identification of risks phase where all identified risks should be input along with a list of potential responses (PMI 2013, p327). PMI (2013) also identifies the following key pieces of information which should appear in an effective risk register:

- Quantitative analysis
- Risk owners
- List of potential responses
- Risk priority

2.4 The Project Management Triangle

The project management triangle (also known as the triple constraint or Iron Triangle) is a framework which is used to understand the balance of competing elements of a project. As shown in figure 9 the iron triangle includes three criteria; time, cost and quality. The concept of the Iron Triangle is that all three elements are dependent on each other and any change of performance in one element will affect the performance of at least one other (Ebbesen & Hope 2013). An example of this would be if the project schedule was decreased, the quality could be decreased and the cost increased.

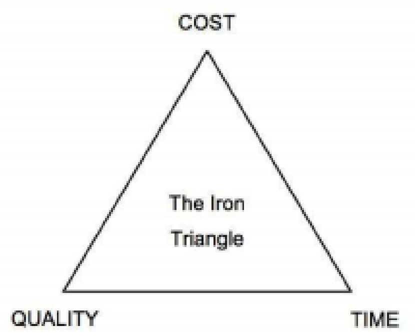

Figure 9:The Iron Triangle (Ebbesen & Hope 2013).

The validity of the iron triangle has been debated many times academically and within the industry where researchers believe that scope, risk and other characteristics of a project could be used to develop a better representation (Ebbesen & Hope 2013). Ebbesen & Hope (2013) also found that the iron triangle does not consider customer satisfaction. Researchers have developed several other solutions as shown in Figures 10 &11. These re-imagined versions include additional constraints that are considered to be more relevant to the industry.

2.4.1 The PMBOK 5th Edition Project Management Constraints

PMI have adjusted the original iron triangle to assist with the clarity between project inputs and project processes. PMI 5th edition identified additional constraints as shown in Figure 10 including the addition of risk, resources and scope.

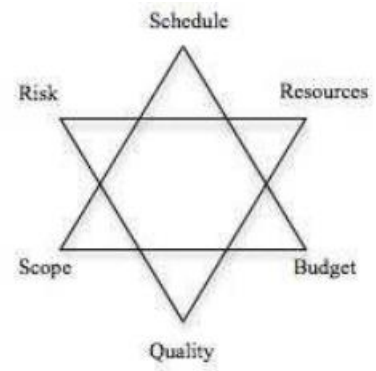

Figure 10: The PMI Triple constraint in Project Management (Ebbesen & Hope 2013).

The inclusion of risk into the newest PMBOK Project Management constraints is of most interest to this project. The effect of other elements of the project on risk identifies 5 categories of risk. Scope, quality, budget, resources and schedule can all effect the risk of the project and should be considered. Mulcahy (2004) also believes that risk management has a direct effect on the Iron Triangle is due to project managers needing to make adjustments to the elements of the Iron Triangle.

2.4.2 The Stiffler Hexagonal Constraint Method

The Stiffler Hexagonal Constrain Method uses the same constraints as the PMBOK 5th edition constraints however it links the outcomes with customer satisfaction. Stiffler (2010) believes that the constraints should be considered in a structured order to provide a process for customer satisfaction. Stifler's (2010) method begins with quality and works around in a clockwise order for each project, phase or deliverable.

Figure 11: The Stiffler Hexagonal Constraint Method (Stifler 2010)

2.5 Sub-contracting to reduce risk

The PMBOK risk management process identified risk transfer as a strategy to manage risk; however information is required to investigate the effects of this strategy. It is important to understand what is transferred to the subcontractor and how this is done. DBH Resources (2011) has identified the following common risks that are commonly transferred to the subcontractor:

- Scope of work
- Performance standards and construction quality
- Time for completion of the scope
- Insurance requirements

The transfer of risk has been identified to be very specific to the contractual agreements between the client, contractor and subcontractor. DBH Resources (2011) identified that the contractual agreements between the parties will best identify who the owner of the risks is. Figure 12 shows the process where risk is transferred from the owner (Client), to the contractor and the subcontractor.

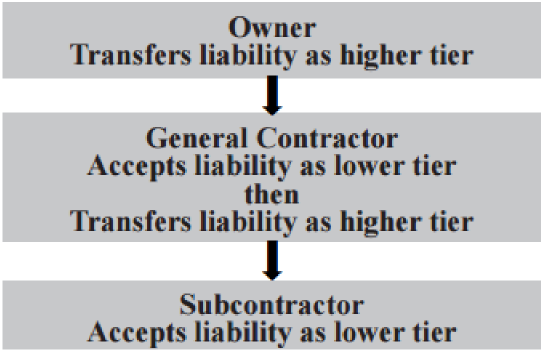

Figure 12: Risk Transfer Process (DBH Resources 2011)

2.6 Communication projects

2.6.1 Introduction

This section aims to identify the type of project that will be examined within the case study. The construction and upgrade of communication sites in Australia is increasing rapidly to meet the demands of population growth and increased use of technology solutions (Urgel, J 2016, pers.comm., 1 August). Communication sites have many different uses including providing: mobile phone services, private digital radio, microwave data transmission and data telemetry solutions. Australian Government projects including the NBN and Blackspot projects are aimed at increasing the coverage of the Australian communication networks (Urgel, J 2016, pers.comm., 1 August). These projects include the installation of towers and other structure types in remote locations where service coverage has not been reaching the population.

2.6.2 Telecommunications Act 1997

All works completed on a new or existing Telecommunications facility are to be completed within the requirements of the Telecommunications Act 1997. The Telecommunications Act is a legislation that includes regulation on many elements including the following:

- Land Access
- Quality
- Technology installation standards
- Record keeping
- EME Compliance

The Telecommunications Act has a large effect on the processes used in the site design, acquisition and EME compliance phases which will not be considered in the project. It is important that the land access and record keeping is in compliance with the Telecommunications Act within the construction phase.

2.6.3 Structure types

The sites selected can be categorised into several different types (Urgel, J 2016, pers.comm., 1 August):

- Self-supporting Lattice Towers
- Guyed masts

- Rooftop facilities
- Climbable and non-climbable monopoles
- Mounted to existing structures

Each structure is selected for a reason depending on the height requirements of the structure for coverage, the area where the construction is to be completed and the cost associated with achieving the desired outcome (Stottrup & Nielsen, 2006). Each different structure has different risks associated with their construction due to the different construction methodologies required.

2.6.3.1 Climbable and non-climbable monopoles up to 40m height

Concrete or steel monopoles are becoming one of the most popular types of structure utilised for telecommunication facilities. The structure can be erected onto the foundation within a day and does not require a large lay down area for construction (Urgel, J 2016, pers.comm., 1 August). The construction of a monopole is very cost effective; however the structures are limited to height of around 50m. Some of these structures have climbing pegs or ladders allowing them to be climbed for construction or maintenance; however some are constructed to be accessed by elevated work platform (EWP) only. Depending on the project scope, it can be advantageous to have a climbable structure to reduce the large cost associated with EWP hire or maintenance (Urgel, J 2016, pers.comm., 1 August). EWP's are prone to breaking down and this can cause delays and excess cost to the project.

Figure 13: Monopole (Adams 2016)

2.6.3.2 Guyed masts up to 100m height

Guyed masts are often used in regional areas where the need for height is important and the cost of land is less expensive (Stottrup & Nielsen, 2006). The guyed masts are cheap to fabricate and the foundations required are much cheaper than that used for self-supporting towers. In metropolitan areas, masts are not a viable option as they take up a large amount of space (Stottrup & Nielsen, 2006). Guyed Masts are generally a climbable structure due to their large height; however construction on the top of these structures is often difficult for the workers.

Figure 14: Guyed Mast (Adams 2016)

2.6.3.3 Self-supporting Towers up to 100m height

Self-supporting towers are the most expensive to construct, however they only take up limited space in comparison to guyed masts. Self-supporting towers are not as limited in height in comparison with monopole structures; however this comes with a longer construction time and increased costs (Urgel, J 2016, pers.comm., 1 August). Self-supporting towers are climbable structures for construction and maintenance (Stottrup & Nielsen, 2006). The structures are generally built on the ground in modules and assembled several modules at a time. The assembly process can be quite time consuming as the sections have a tendency to flex when lifted and it can be difficult for the structure to be realigned with the previous section for assembly (Urgel, J 2016, pers.comm., 1 August).

Figure 15: Self-supporting Tower (Adams 2016)

2.6.3.4 Rooftop facilities

Rooftop facilities allow the contractor to construct a facility without the cost of building a structure themselves. In metropolitan areas this ensures that there is no loss of space due to the construction of a structure and vacant rooftop space can be utilised. Constructing on rooftop locations often brings many challenges due to the logistics and getting materials to the rooftop, working along site the tenants and landlords to minimise disruption and the difficulties of arranging crane setup areas within built up or CBD areas (Urgel, J 2016, pers.comm., 1 August).

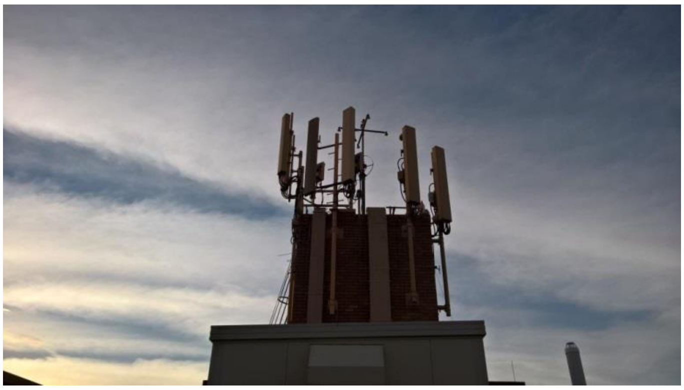

Figure 16: Rooftop site (Adams 2016)

2.6.3.5 Other

Telecommunications facilities can be constructed on top of billboards, grain silo's, water reservoirs and many other existing structures if it is deemed to be a cost effective option. Co-location on these structures can be cost effective to the client, however it generates different risks dependent on the structure type (Urgel, J 2016, pers.comm., 1 August).

Figure 17: Communications facility mounted to a grain silo (Adams 2016)

2.6.4 Site access/land access

Site access for a telecommunications facility is dependent on the ownership/leasing agreements in place for the facility area and its path of access. Depending on its location and path of access, the contractor may face complications. Site access can be difficult when the site is located on an existing structure due to (Urgel, J 2016, pers.comm., 1 August):

- Other parties working in the area or path of access
- Remote site location with weathered access tracks
- Pedestrian and road closures due to requirements for work at height exclusion zones
- Site specific access conditions

The construction of a new Greenfield site can have the same issues; however these issues are generally identified in the site selection phase to ensure the best candidate for property, design, construction and RF coverage is selected (Urgel, J 2016, pers.comm., 1 August). These requirements are generally identified on the access approval documentation or within the design documents.

2.6.5 Measuring project success

Project success can be measured by examining how well the final product has achieved the outcome desired by the client. The contractor also needs to measure its own project success to determine if they have achieved the desired outcome from the project. The outcomes expected by the client should be clearly identified within the contract and the project charter during the initiation phase of the project. Baccarini (1995, p 25) believes that the criteria for measuring project success should be identified prior to the beginning of the project, otherwise the project team will find themselves travelling in different directions which could lead to a project failure. Baccarini (1995, p 25) identified that there are two components where project success can be identified: Project Management Success and Project Success.

Baccarini (1995, p 25) found that project management success was focused on the success of the project process, particularly the objectives of time, cost and quality. Project management success is more related to how the project was conducted and only the achievements of the contractor. Project success is related to the outcome of the project and its final product. Baccarini (1995, p 25) identified that project management success does not consider the customer expectations which determine the success of a project. A project could be completed within time, cost and quality guidelines by the project management team, however if the final project does not provide the service or outcome required by the customer then I cannot be deemed to be a success.

2.6.6 Milestones

Milestones are an important part of measuring success of a project and reporting on the progress of each work package. PMI (2013, p153) define a milestone to be a significant point or event within the project. PIM (2013, p 153) suggests the miles stones are a project schedule event which has no duration. Milestones can be a contractual requirement or optional points within the project deemed to be important. Examples of milestones commonly used in Communications projects include the following:

- Construction start date
- Site on air date – The date when the technology system is operational and carrying traffic
- Construction complete date
- Practical Completion

(Urgel, J 2016, pers.comm., 1 August)

The clients are generally focused on the site-on-air date as the most important milestone as this is the time when they can begin to operate the communications system (Urgel, J 2016, pers.comm., 1 August). For some companies, this is the point when they can begin to provide a product to their customer, which in-turn provides them with the opportunity to increase their income. Where the technology solution is providing a service to the client, as soon as the site is on air they are able to increase the effectiveness of their service or operations.

CHAPTER 3 – METHODOLOGY

3.1 Introduction

The previous chapter investigated the industry risk management processes and the risks associated with different aspects of communication projects. This chapter will develop the criteria for the selection of the case study projects, the criteria that will be used to evaluate them and the execution of the case studies. In order to meet the specified project objectives, the following methodology has been proposed to be implemented in the project.

- Produce criteria for case study assessment
- Obtain sample data of real world projects for the purpose of case studies
- Gain approval from the contractors for the use of data in a case studies
- Complete case studies on each project
- Present the obtained data graphically and statistically analyse the data for each project
- Identify the key project characteristics to understand the sampled projects
- Develop strategies to minimise the impact of risk on future projects

Potential limitations include:

- Some project data may deemed to be confidential by the contractor or unavailable

3.2 Data Collection

Prior to the data collection phase, the following project documentations were identified as being available for viewing and analysis:

- For Construction and as built drawings
- Quotes and variations
- Financial summaries
- Schedule forecast and actual dates
- Risk registers
- Quality audit documentation
- And verbal consultation with members of the project team

The following documentation identified in the literature review was not available for viewing or analysis:

- Project management plans

- Risk management plans
- Project contracts
- Sub-contractor agreements

The available data was collected and pre-processed to determine it met the requirements of the project before being recorded for analysis.

3.3 Selection of Case Studies

With a large pool of sites available for selection it was important for the sites to be pre-processed to ensure those selected would be appropriate for the analysis. As often the sites would be awarded to the contractors under a program, each individual site was considered to be a separate project for the purpose of the analysis. The projects could have been selected from several separate programs provided they meet the pre-processing requirements. A selection of various projects will be used as part of the case study to ensure that the projects cover various risks involved across different situations. The pre-processing requirements will be discussed in the following sections.

3.3.1 Scope

It is important to consider the project type due to the different construction methodologies and procedures associated with the different works. The case studies to be selected will include the following scope:

- Construction of new structure
- Structural upgrades
- Technology upgrades

In some cases the projects could fall into several categories of work depending on the total scope that is to be completed. This scope has been selected to ensure that the analysis considers similar projects where works are completed on similar types of sites. If a larger quantity of case studies were to be considered, the scope could be expanded to cover larger scope.

3.3.2 Contract type

Throughout the literature review it was found that the type of contract selected for a project could be used be the client as a method of reducing risk. This was identified as an item that needed to be considered when evaluating the risk of specific projects. This was identified as an area that needed to be considered in the case studies to understand how this would impact on the project.

3.3.3. Project Type

It is important to consider the project type due to the different construction methodologies and procedures associated with the different works. The case studies available for use in the dissertation include the following project types:

- Structural upgrades
- Technology upgrades
- Construction of new greenfield sites
- Construction of brownfield sites
- Co-location onto existing structures

The project type selected will also need to consider the construction only element of the project, and will not consider the design, transmission, property or planning elements of the projects.

3.3.4 Project Value

Project value has not been deemed to have any effect on the project that would affect the completion of the case study. By not limiting the value of projects selected, this will ensure the data analysed will cover any project value and not affect the results of the analysis. Project value has not been found to be a cause of risk throughout the literature review.

3.3.5 Site location

The sites to be considered for this dissertation will be located in the states of Queensland or northern New South Wales in Australia. The contractors involved in this study are based in Brisbane and are required to mobilise from Brisbane to complete the works. This was not identified as a risk during the literature review; however it is clear that a different site location could impact on the project. Due to the position of Brisbane at the base of Queensland, the area contractors are required to cover is one of the largest in the country compared to the other sites. The area considered for this project is shown in figure 18.

Figure 18: Map of project area (Google, 2016)

3.3.6 Year of construction

Projects completed since 2013 have been selected to ensure that the project data is as new as possible and has been completed since the release of the PMBOK fifth editions release. Due to the considerations of the PMBOK processes it has been deemed to be important that the projects consider the most up to date methodology. Projects prior to 2013 are likely to use different risk management methodology which could impact on the results of this study.

3.3.7 Number of Projects

Ideally it would benefit the project to have a minimum of 10 case studies available to study for this project. Any less would not provide enough information for a complete analysis to be completed. It is important that the sites selected provide some versatility to ensure that the project data is not restricted to a single site type. By having a minimum of 10 case studies this will ensure that the data can be better analysed. If less than 10 case studies are available then the project will not have the accuracy or effectiveness that is being targeted.

3.5 Data Processing

The data processing stage required the raw data to be categorised and input into user friendly forms for the purpose of the analysis. The forms were developed to include the following key focus areas as have been identified through the literature review:

- Project summary
- Financial performance
- Schedule performance
- Quality Performance
- Scope Changes and Variations
- NTCP model of project complexity
- Project risk analysis

3.5.1 Project Performance Analysis Criteria

The project performance analysis criterions have been selected from the PMBOK 5th edition project management constraints and the NTCP model for measurement of project complexity. The constraints were found to have an impact on the other elements of the project and therefore needed to be considered to understand the risks associated with each project. The NTCP model is required to understand the project complexities and how they affect the risk during the completion of projects.

The development of a project performance data template was required to ensure the data could easily and clearly be recorded for the purpose of an analysis. During the literature review it was identified that the following criteria needed to be considered:

- Resources
- Scope
- Quality
- Budget
- Schedule
- Scope
- Elements of the NTCP Model
- Project location
- Structure details

All of the criteria selected have been inserted into the below template to ensure the data can be interpreted and analysed as shown in table 1.

The resources used to complete a project were found to be important to understand who owns the risks within a project. If the work has been subcontracted the risk is often transferred away from the contractor. This was evident throughout the literature review and has therefore been included as an important part of the project performance data template. The location of the project from Brisbane has been identified as an area of importance to understand the implications of remobilisation or when replacement materials will be required on site.

The literature review found that the scope of the project is important as it forms the basis for what most of the risk is for and defines the project. It has been identified that the project scope could be categorised into either Greenfield, brownfield or the upgrade of existing facilities to categorise the sites, before a brief scope would be beneficial for the comparison of the results. As identified in the literature review, there is a link between project complexity and risk.

Throughout chapter 2 it was found that different structure types and heights will have different risks associated when construction works are being completed. Weather the structure can be accessed by climbing or if it can only be accessed via EWP also needed to be considered as this could have significant impact on the costs and time required to complete a build. For this reason it was identified that the collection of project data regarding the structure type be considered for the purpose of the data analysis.

It has been identified that the year of construction will be important to understand if the project is relevant to the current PMBOK risk management procedures. Further to this it was identified that the contact type could have an impact on the severity and presence of a risk on a certain project. Further to this the collection of the scope changes and variations encountered on the project is important for the completion of the data analysis.

The literature review identified the impact of risk on the financial and schedule performance of a project as an area of interest. To analyse the impact of the project risks on the project it would be ideal to analyse the forecasted project performance against the actuals achieved. By recording this information and any other available schedule and financial information, this will assist to identify how these aspects of the project have performed.

The NTCP diamond approach is an effective method for understanding the project complexity which has been found to impact on project risk. The diamond approach was identified in the literature review to be a method that can be used to categories the novelty, technology, complexity and pace of a project. These elements will all be rated within the data template for investigation.

As a result of these findings throughout the literature review, the project performance data template was developed and is presented in table 1.

Table 1: Project Performance data template

Case Study Number: X	
Sub-contractor/ in-house resources:	
Project distance from HQ (km):	
Project type:	
Brief scope:	
Structure type:	
Structure Height	
Climbable or non-climbable structure:	
Contract type:	
Year of Construction:	
Financial Performance	
Quoted price:	
Approved Variations:	
Total Revenue:	
Forecast GM:	
Forecast Profit:	
Final GM:	
Final Profit:	
Notes:	
Schedule Performance	
Forecast start date:	
Actual start date	
Forecast finish date:	
Actual finish date:	
Notes:	
Quality Performance	
Quality Audit outcome:	
Scope Changes & variations	
Notes:	
NTCP Model	
Novelty	
Technology	
Complexity	
Pace	

3.5.2 Project Risk Analysis Criteria

The project risks were also recorded on a separate template to analyse the risks, the controls and the risks that were not identified until they were affecting the project performance. The project risks need to be recorded in a way that clearly shows the following steps as was identified within the literature review:

- Identify risks
- Qualitative risk analysis
- Quantitative risk analysis
- Risk responses
- Control of risks

To present the data clearly it was identified that a form should be developed to ensure the appropriate data is collected and could be clearly analysed for each case study. This form would be limited by the available data which found that there was no clear data available from a quantitative risk analysis. The Control of the risks is not something that could be clearly determined from the raw data and would need to be derived from the data through an analysis of the projects performance. This meant that the form was developed to present the identified risks, the qualitative risk analysis and the strategic actions used to respond to the risk. The form presented in table 5 was developed to ensure that all data can be presented clearly for analysis.

Table 2: Project Risk data template

Id	Description of Risk	Impact on Project	Probability Assessment	Impact Assessment	Strategic Actions
1					

3.5.3 Limitations

Throughout the project many limitations have arisen and been noted for further analysis in the results, discussion and conclusion sections of the project. These limitations include the following:

- Incomplete data available for some case studies
- Possible incorrect costs in financials
- Risk management and Project management plans not available for analysis in the project.
- Not enough data is available to complete effective quantitative risk analysis.

3.6 Summary

This chapter has been written to provide the reader with the understanding of the data collection process and the basis of the analysis phase of the project. It is important that the data collection phase aligns with the evidence presented within the literature review. This allows the data to be effectively analysed and discussed. This chapter will not consider the accuracy of the data; this will be discussed in chapters 5 and 6.

CHAPTER 4 – RESULTS

4.1 Introduction

The aim of this chapter is to present the results of the case studies conducted for this project. This chapter will highlight the results of the data collected from the 15 case studies within each of the focus areas identified in Chapter 3. The data found in chapter 4 has been derived from the data that has been displayed in Appendix B & C.

4.2 Results: Project details

Firstly it is important to understand the details of each individual project and how they differ from each other. The data sets collected for the analysis of project details were: sub-contractor/in-house resources, project type, distance from office, brief scope, structure type, structure height, climbable/non-climbable structures, year of construction and contract type/ the following findings were clear from the initial analysis:

- 100% of projects were completed under a unit price D&C contract

This dissertation will not consider the risks involved with the design phase, however the impacts of design on the construction process will be considered. It can be hypothesised that the client has engaged the contractor on a unit priced contract to reduce their risk on the project. An analysis of the project contract is outside of the project scope and will not be considered any further in the project.

4.2.1 Subcontracted vs in-house resources

The selection of projects analysed in the case study have been completed by either in-house resources or subcontractors. The literature review identified that the subcontracting of work could be beneficial in reducing the risk that the contractor is exposed to. The breakdown of the selected projects is shown below in figure 19.

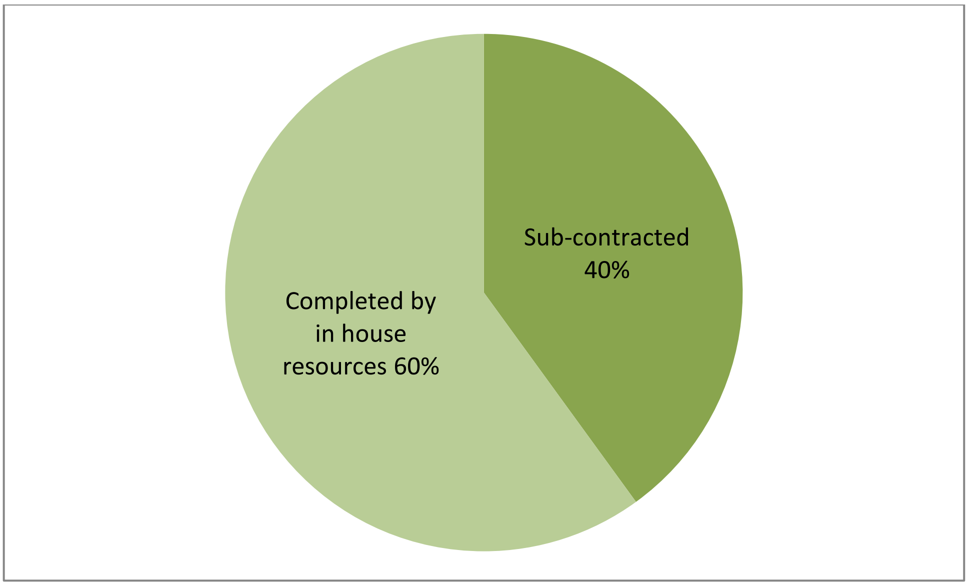

Figure 19: Subcontractor vs in-house resources comparison

As per figure 19 a total of 9 projects were completed by in-house resources where a further 6 were completed by subcontractors. Table 3 shows the breakdown of which sites were subcontracted.

Table 3: Works allocated to sub-contractors

Case Study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sub-contracted	No	Yes	No	Yes	No	No	Yes	Yes	No	Yes	No	No	Yes	No	No

4.2.2 Site location

During the data collection phase it was identified that the site location could have an effect on the risks associated with the projects. Figure 20 displays the distances of the projects from the mobilisation location of Brisbane.

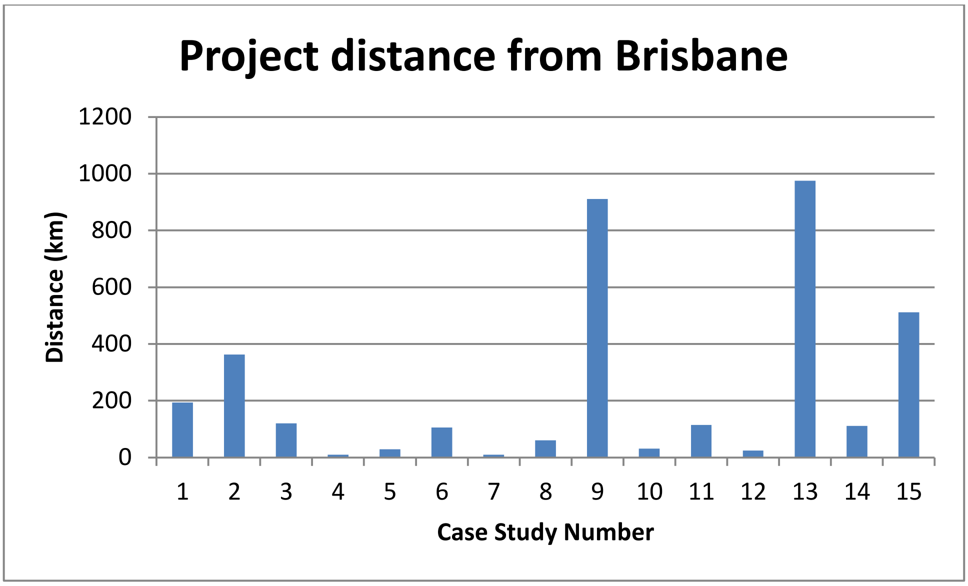

Figure 20: Project distance from Brisbane

The average distance of the site locations from figure 9 has been calculated to be 237.93kms. The results show four outliers, Case studies: 2, 9, 13 and 15 where the sites are all located more than 300km from Brisbane. The effect of the site location will be further analysed in chapter 5.

4.2.3 Project type and scope

The project type and scope is important to understand the type of works being completed in each case study. Figure 21 shows the percentages of the projects sampled that are brownfield, greenfield and upgrades of an existing facility.

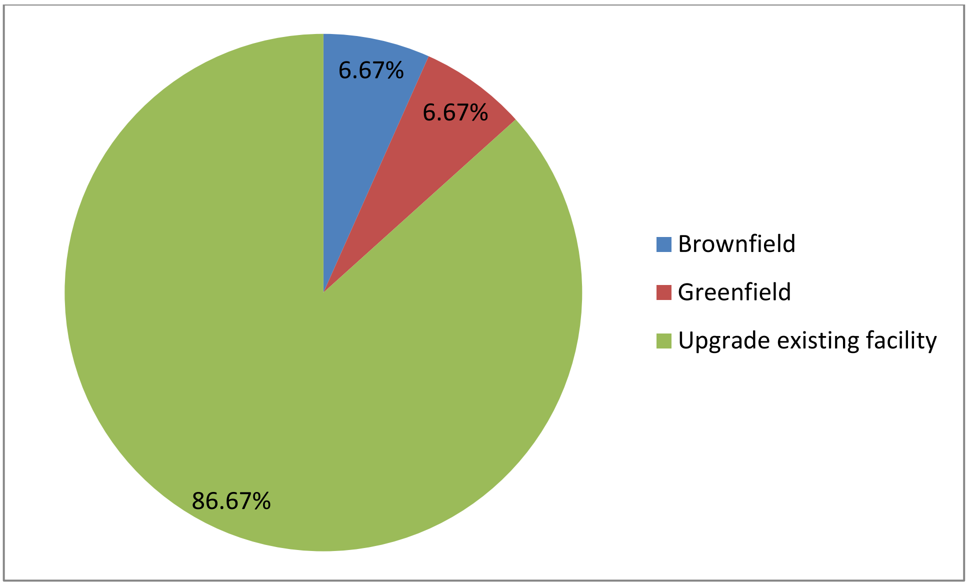

Figure 21: Percentages of project types

The breakdown of site types presented in figure 21 can be further broken down as shown in table 4.

Table 4: Breakdown of Project types

Case Study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Brownfield								X							
Greenfield		X													
Upgrade existing	X		X	X	X	X	X		X	X	X	X	X	X	X

The project scope has been broken down into each discipline as shown in table 5.

Table 5: Breakdown of project scope

Case Study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Technology Installation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Civil works		X						X							
Pole install		X						X							
Electrical		X													
Structural upgrade			X				X		X	X			X		X

4.2.4 Structure details

The completion of the literature review identified that different structure types, heights and weather the structure is climbable can impact on the construction process. Figure 22 shows the breakdown of structure types in all of the selected case studies.

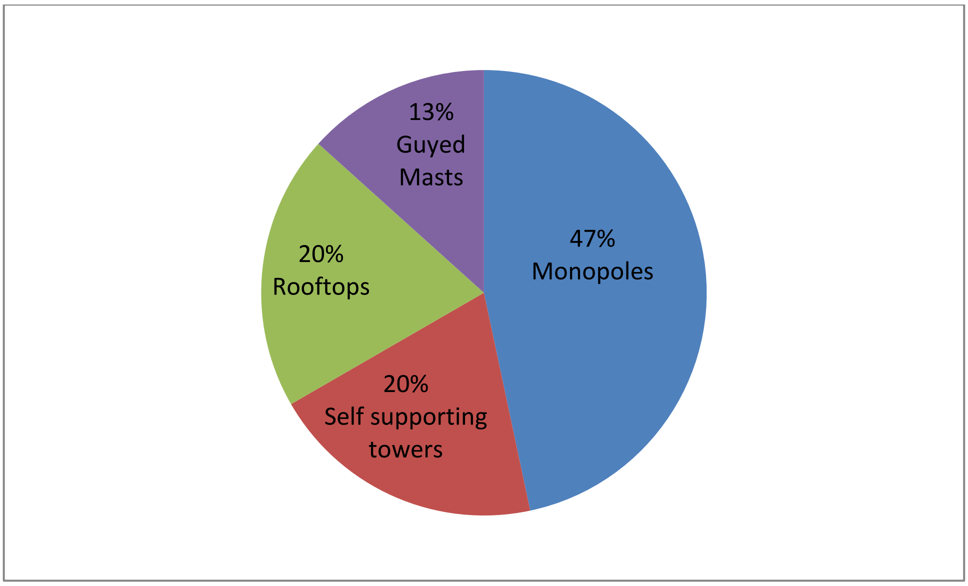

Figure 22: Breakdown of structure types

The structure heights were found to have an effect on the construction methodology and schedule when completing works. A further breakdown of the figure 22 can be seen in table 6.

Table 6: Breakdown of structure types

Case Study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Monopole	X	X	X		X			X			X			X	
Guyed Mast													X		X
Rooftop						X	X					X			
Tower				X					X	X					

Figure 23 shows a breakdown of the structure heights for all of the sites included in the case studies.

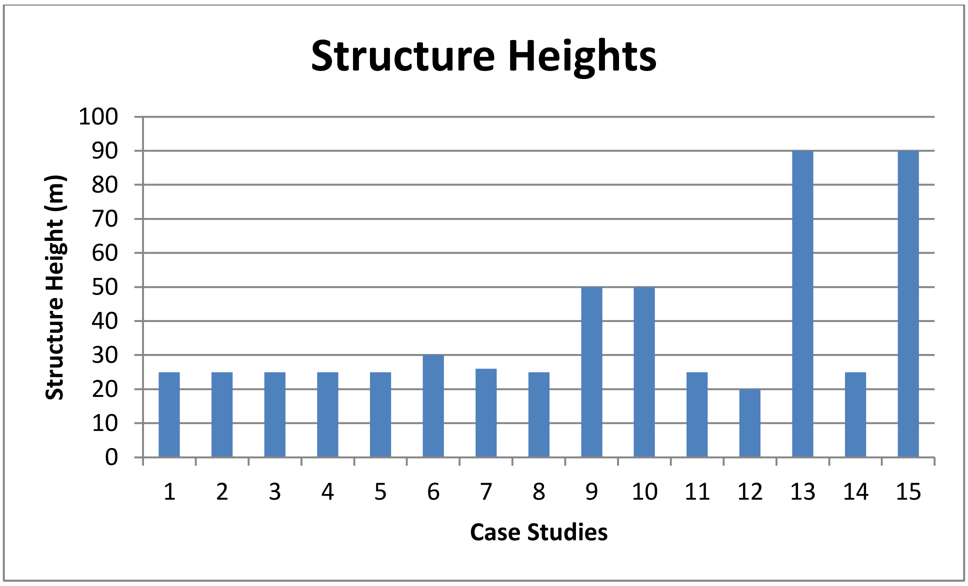

Figure 23: Structure heights of case studies

The results of the case study identified an almost even split between structures that were climbable, and non-climbable as shown in table 7.

Table 7: Percentage of climbable and non-climbable structures

Percentage of climbable structures	Percentage of non-climbable structures
53%	47%

4.3 Results: Financial performance

The financial performance of the projects takes into account the forecasted and final financial performance. A difference between forecast and actual can indicate that risks were not accounted for or managed effectively, or that the forecast was not completed accurately. Figure 24 shows a comparison between the forecast and actual gross margin achieved in all of the case studies.

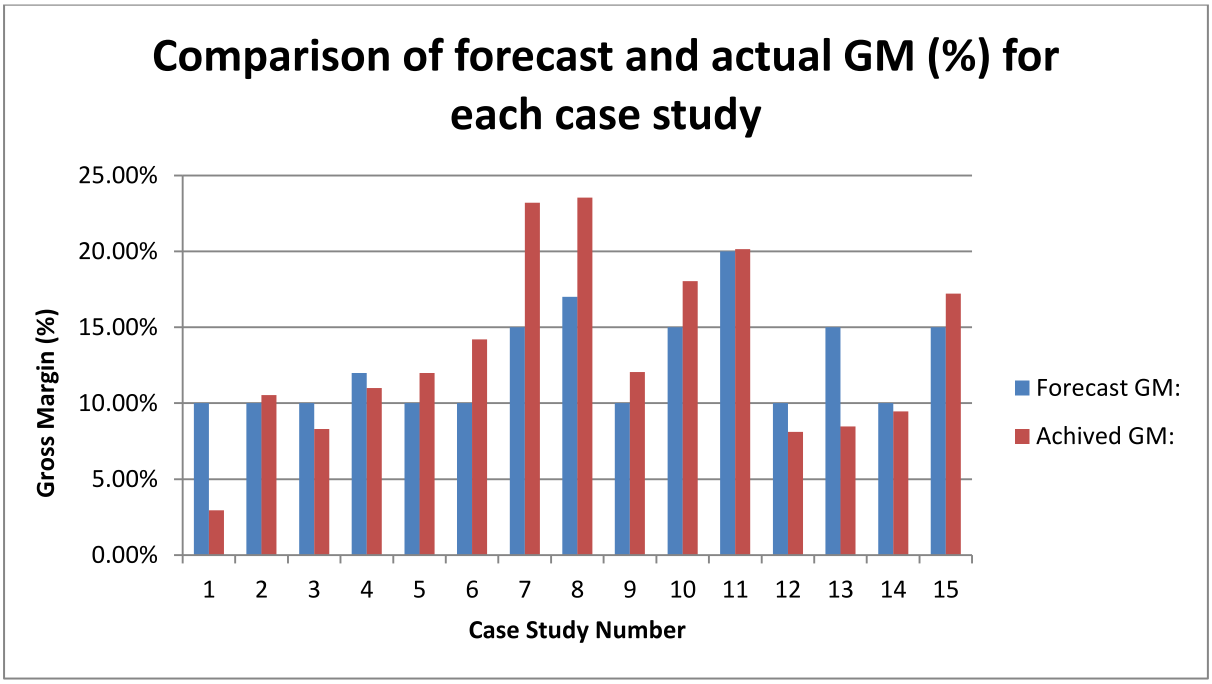

Figure 24: Comparison of forecast and actual GM (%) for each case study

Figure 25 illustrates the comparison between sites that achieved the forecasted gross margin against those who did not.

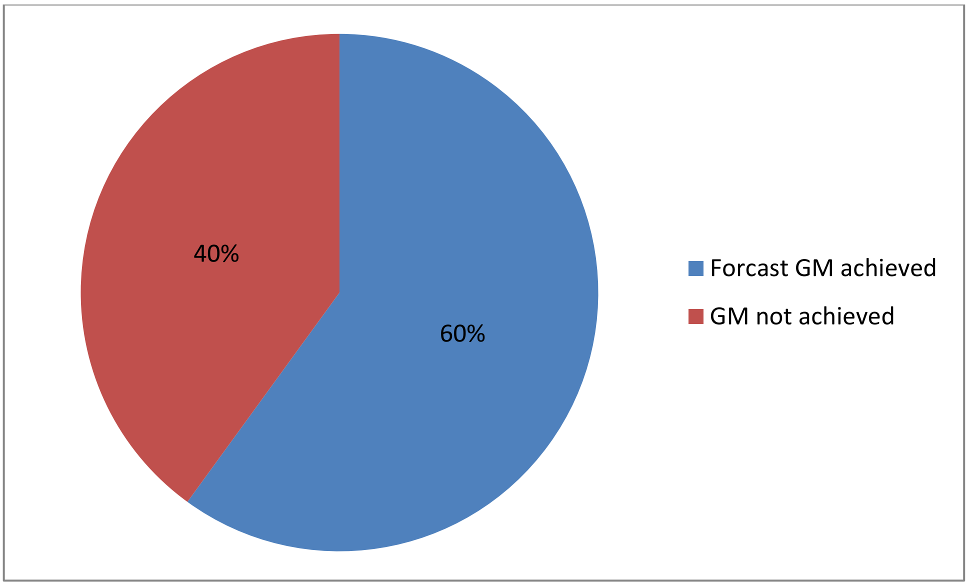

Figure 25: Comparison of Gross Margin Performance

Table 8 shows the total revenue achieved in the selected case studies.

Table 8: Total revenue of all case studies

Quoted price (total):	$912,192.90
Approved Variations (total):	$230,336.41
Total Revenue:	$1,142,529.31

4.4 Results: Schedule performance

The schedule performance takes into account the forecasted start and finish dates compared to the final finish dates. In some cases the project has been extended due to client delay, and these instances have been captured where the risk of delay is the client's responsibility. Figure 26 shows a comparison of projects completed early, on time or after the forecast date.

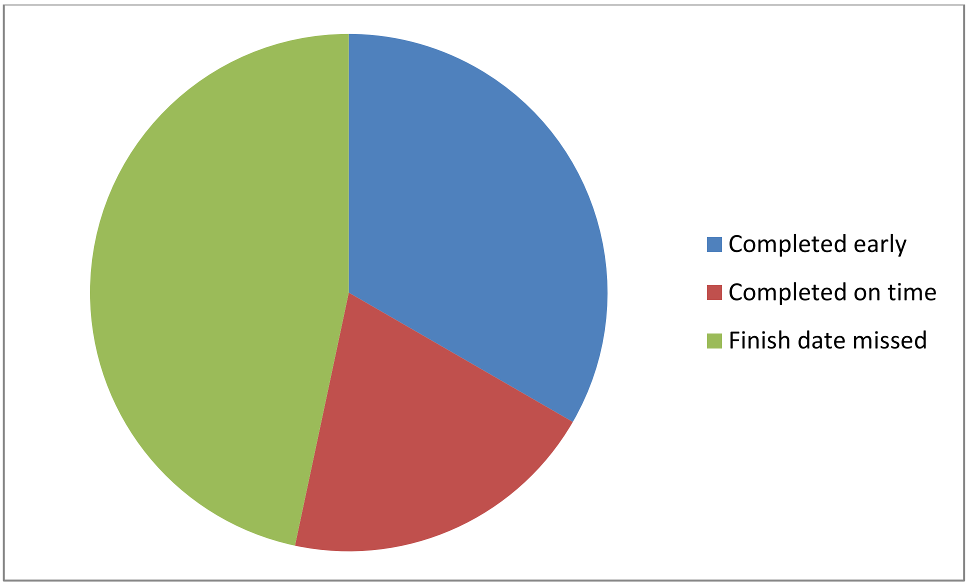

Figure 26: Analysis of schedule performance

The projects that were not completed within the forecasted dates were case studies; 2, 3, 5, 10, 12, 14 & 15. The reasons for these projects missing the forecast dates will be further considered in chapter 5.

4.5 Results: Quality performance

The quality performance refers to the results of quality audits completed post construction or where incorrect procedure during construction has affected the works. Figure 27 shows the percentages of projects that were affected by quality issues with no cost, those that incurred additional costs to rectify and projects where no quality issues were encountered.

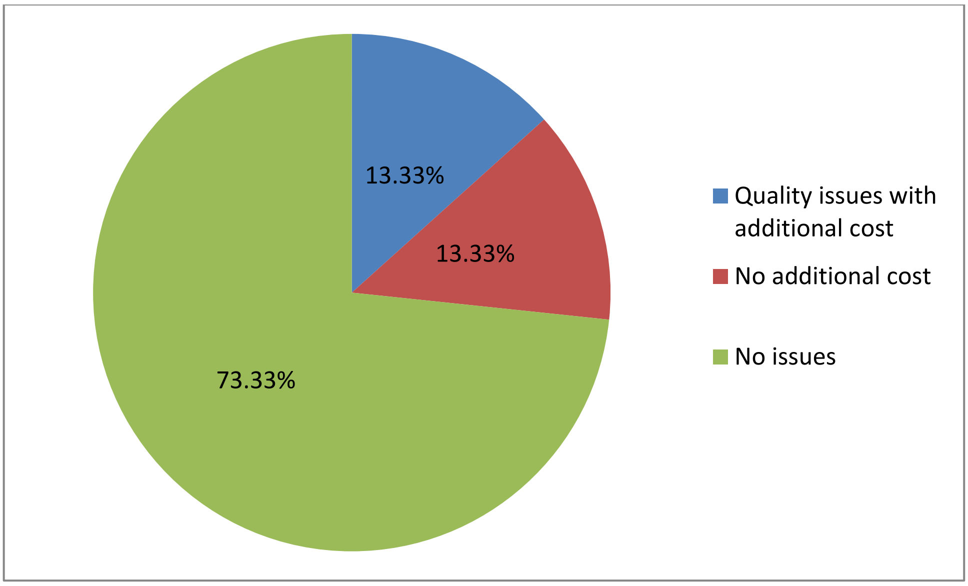

Figure 27: Quality issues from case studies

The two sites that experience quality issues when completed by the internal team were case studies 1 & 9. Case Studies 2 & 8 experienced quality issues that were rectified by the subcontractor at their cost. These will be further investigated in chapter 5. It should be noted that case study 15 involved a health and safety incident, however for the purpose of the analysis this will not be considered to be a quality issue.

4.6 NTCP Model Analysis

The NTCP Model analysis is used to understand the complexity of the project to better understand the risks faced during the construction phase. The initial findings from the project data are as follows:

- 100% of sites were found to have a Derivative level of Novelty.
- 100% of sites were found to have a High level of technical work.
- 100% of sites were found to have a system level of complexity.

The differences in the sites were found when comparing the pace of the projects to each other. As shown in figure 28 more than half of the case studies were required to be completed at time-critical or blitz pace to meet the clients deadlines.

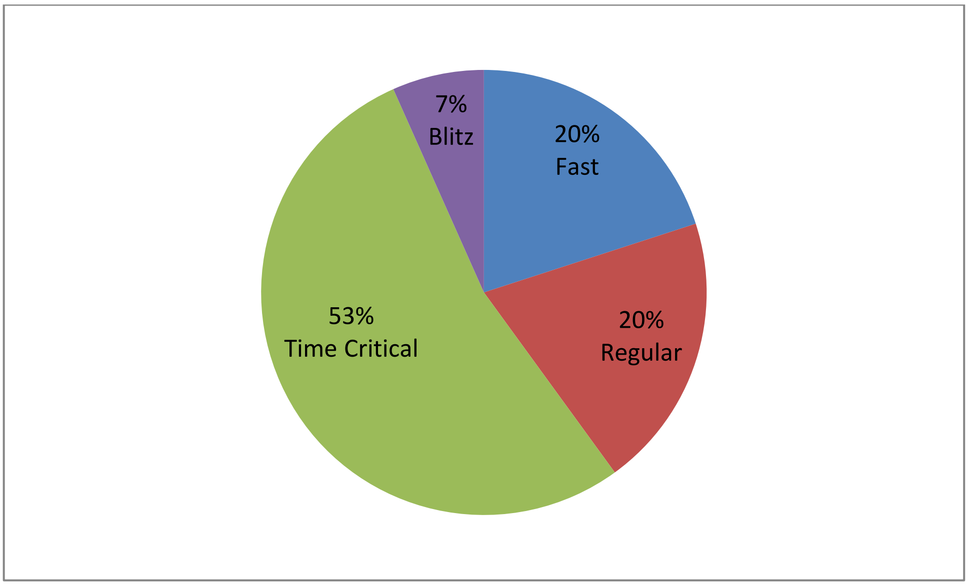

Figure 28: Comparison of pace between case studies

4.7 Results: Risk management

The analysis of the project risk registers provides results to show what risks were identified and how the risks were effectively managed for each project. The risk registers for all case studies can be located in Appendix C. The literature review identified that the strategies for controlling risk were important to understand the risk of a project. These will be considered within this section; however the risks themselves will be discussed further on a case by case basis in Chapter 5.

4.7.1 Case Studies

The analysis of case study 1 found that several risks impacted on the project performance. It was found that an incorrect procedure was used by field staff which required an additional day of rework to rectify. This also required an additional day of EWP hire which increased the costs required to complete the site. This delay also affected the project schedule which did not meet the forecasted completion date. Another contributing factor to the missed completion milestone is that a client supplied piece of equipment was found to be faulty and this needed to be urgently replaced to bring the site back on air. This caused a delay to the schedule, however all costs were claimable back to the client as a variation. Figure 29 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 1.

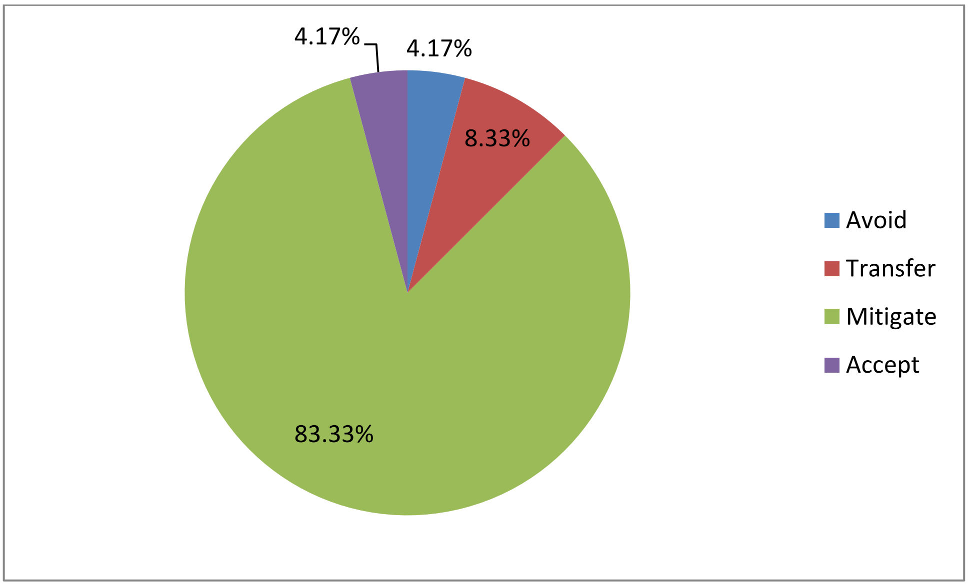

Figure 29: Case study 1 Risk Responses

The analysis of case study 2 found that risks several impacted on the project performance. The schedule was missed due to a power connection delay from the service provider. This delay caused additional mobilisation costs, however a contingency within the budget meant that the budget still met its target. During the quality audit phase there were several installation issues which were resolved by the subcontractor at their cost. Figure 30 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 2.

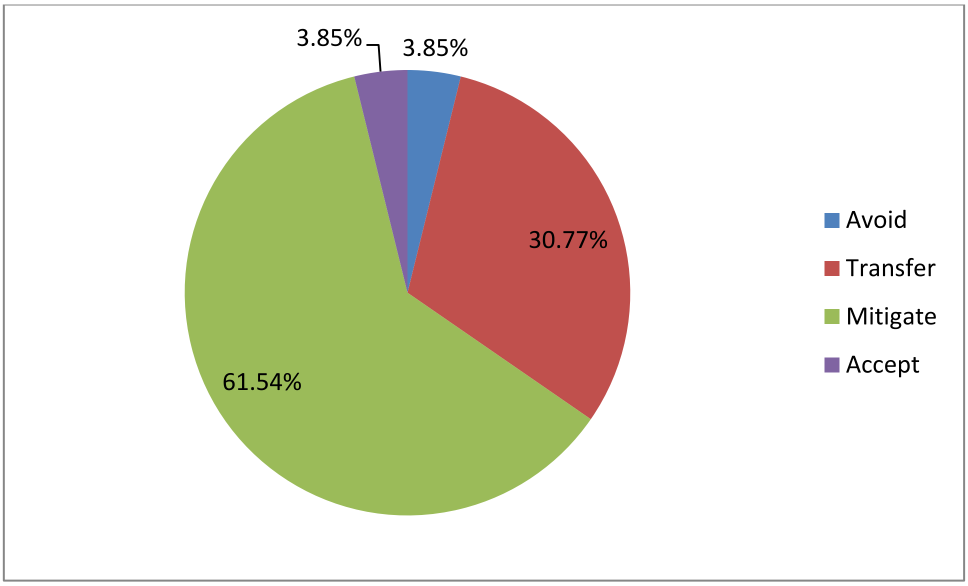

Figure 30: Case Study 2 Risk Responses

The analysis of case study 3 found that the main risk that impacted on the project performance was change management due to the huge amount of variations involved in the build. This was found to have been managed effectively and the huge schedule delays on this site were due to the client requiring time to source additional budget to meet the new project scope. Figure 31 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 3.

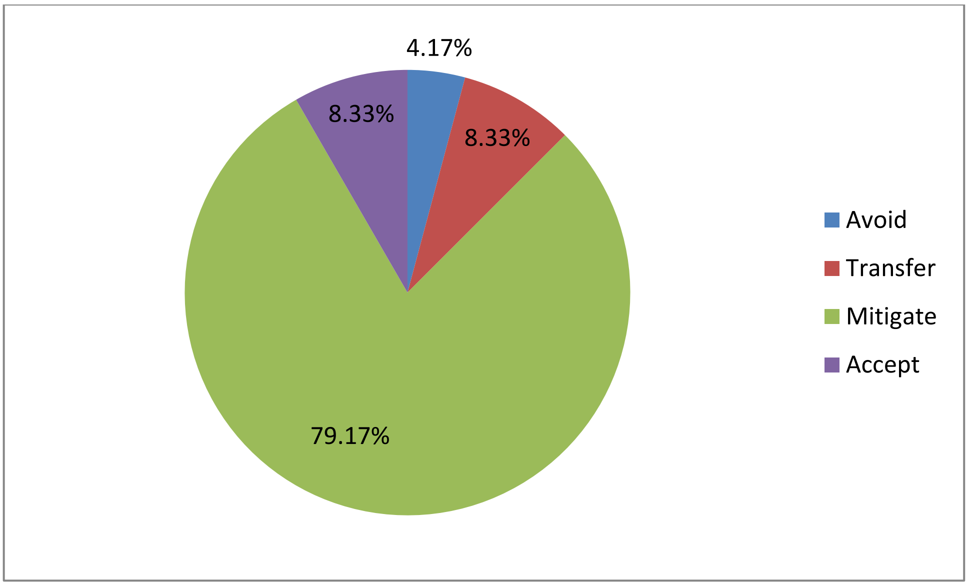

Figure 31: Case Study 3 Risk Responses

The analysis of case study 4 did not find that any risks impacted on the project performance. The project was completed on time, and only just missed achieving the forecasted gross margin for the site. Figure 32 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 4.

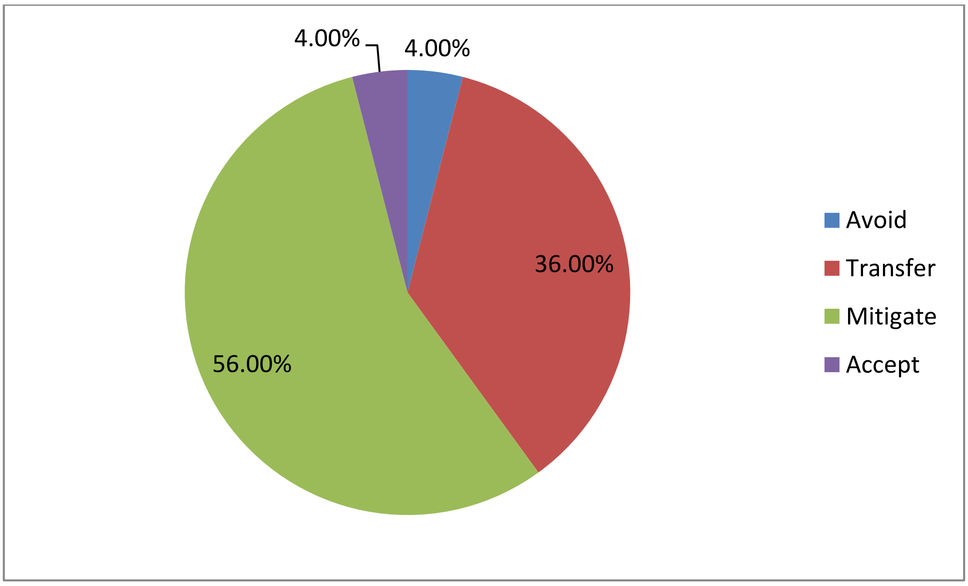

Figure 32: Case Study 4 Risk Responses

The analysis of case study 5 did not find that any risks impacted on the project performance. The project was completed on time, on budget and had no quality issues. Figure 33 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 5.

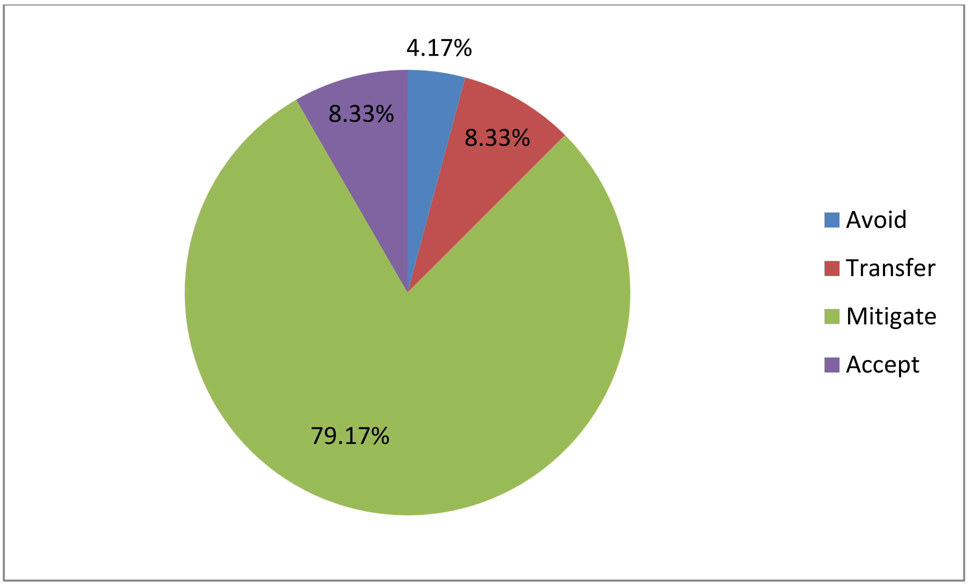

Figure 33: Case Study 5 Risk Responses

The analysis of case study 6 did not find that any risks impacted on the project performance. The project was completed on time, on budget and had no quality issues. Figure 34 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 6.

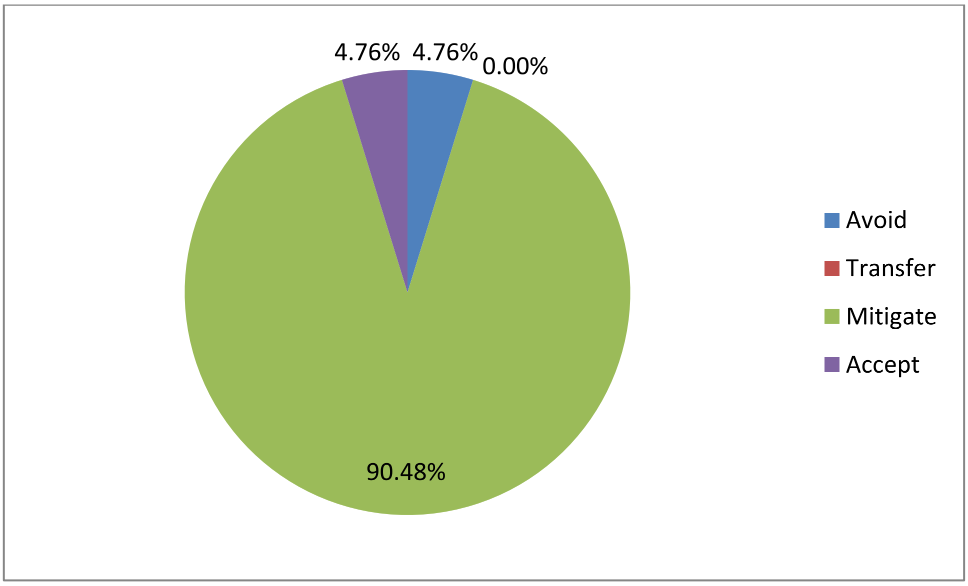

Figure 34: Case Study 6 Risk Responses

The analysis of case study 7 did not find that any risks impacted on the project performance. The project was completed on time, on budget and had no quality issues. Figure 35 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 7.

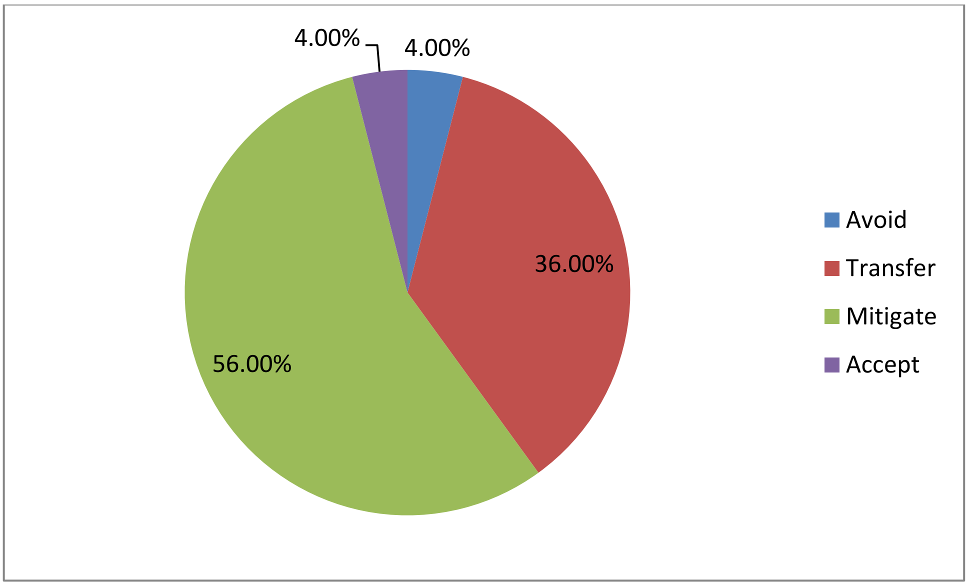

Figure 35: Case Study 7 Risk Responses

The analysis of case study 8 found that quality risks were managed very effectively on this site. The project was completed on time, on budget however the quality audit found that there were issues that required rectification. The rectification works were completed by the subcontractor at their cost and did not impact on the project budget or schedule. Figure 36 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 8.

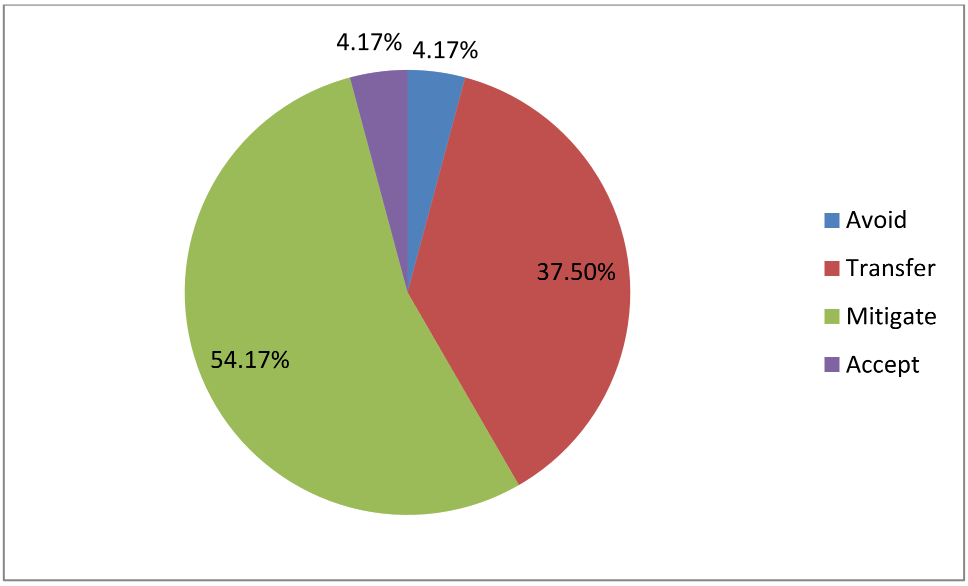

Figure 36: Case Study 8 Risk Responses

The analysis of case study 9 found that quality risks impacted on the project performance. Revisit was required to rectify incorrect installation which incurred additional costs. Figure

37 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 9.

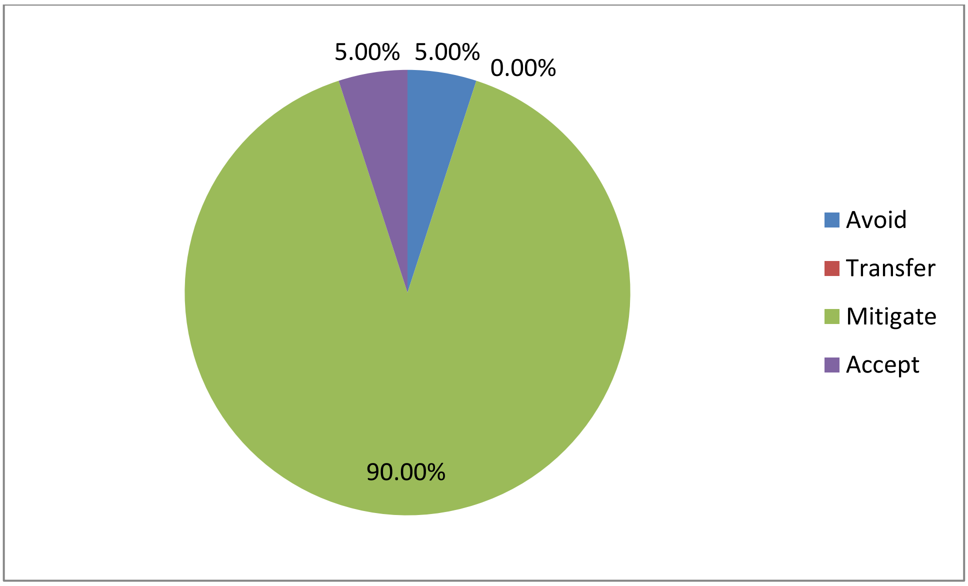

Figure 37: Case Study 9 Risk Responses

The analysis of case study 10 found that the schedule was impacted due to poor weather during the time of construction. Due to the sites proximity to Brisbane there was no budget impact to the project. Figure 38 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 10.

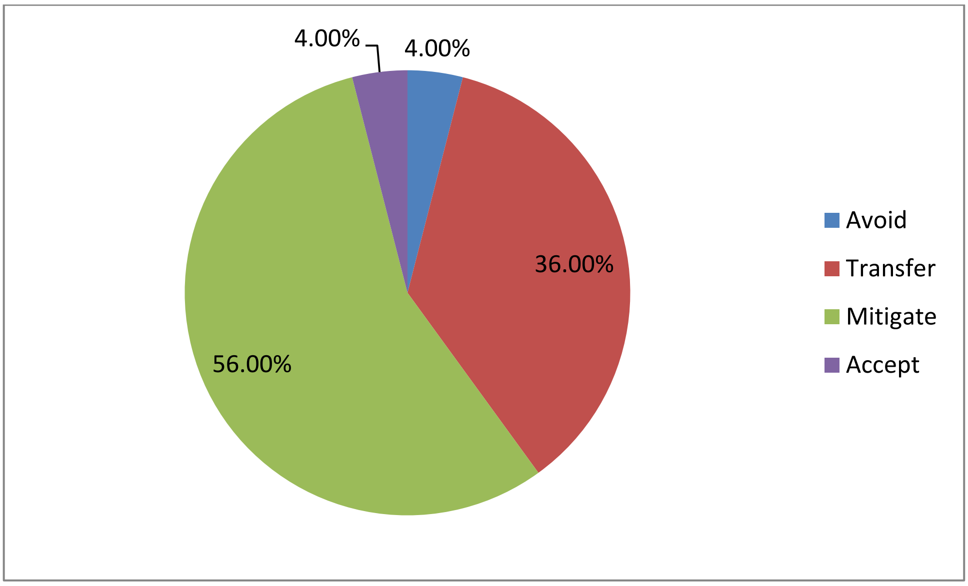

Figure 38: Case Study 3 Risk Responses

The analysis of case study 11 did not find that any risks impacted on the project performance. The project was completed on time, on budget and had no quality issues. Figure 39 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 11.

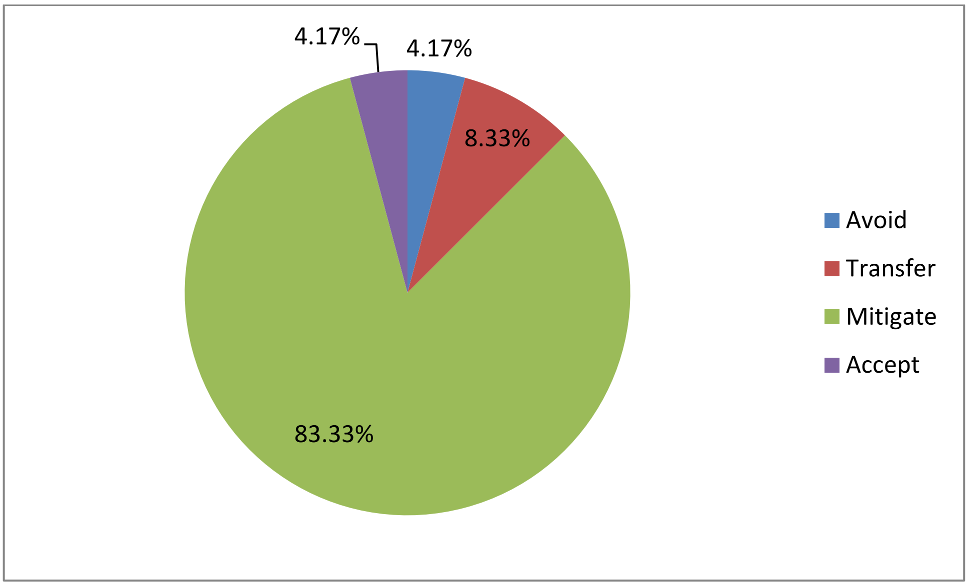

Figure 39: Case Study 11 Risk Responses

The analysis of case study 12 found that staff productivity was reduced and meant that additional resources were required to meet the project schedule. This meant that the project budget was impacted due to the additional costs. Figure 40 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 12.

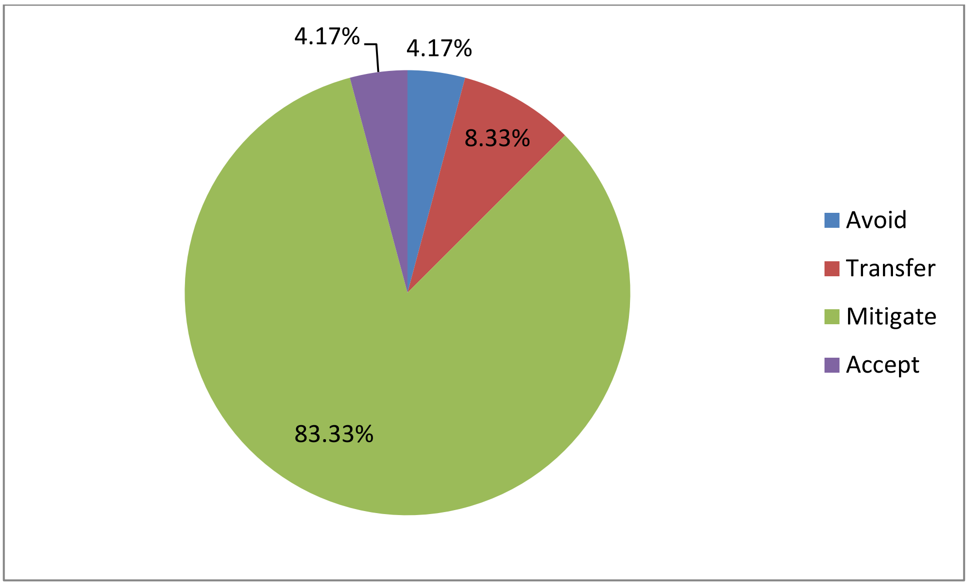

Figure 40: Case Study 12 Risk Responses

The analysis of case study 13 found that material delay caused additional shipping costs and a delay to the team on site. Due to the sites distance from Brisbane these additional costs impacted on the project budget. Figure 41 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 13.

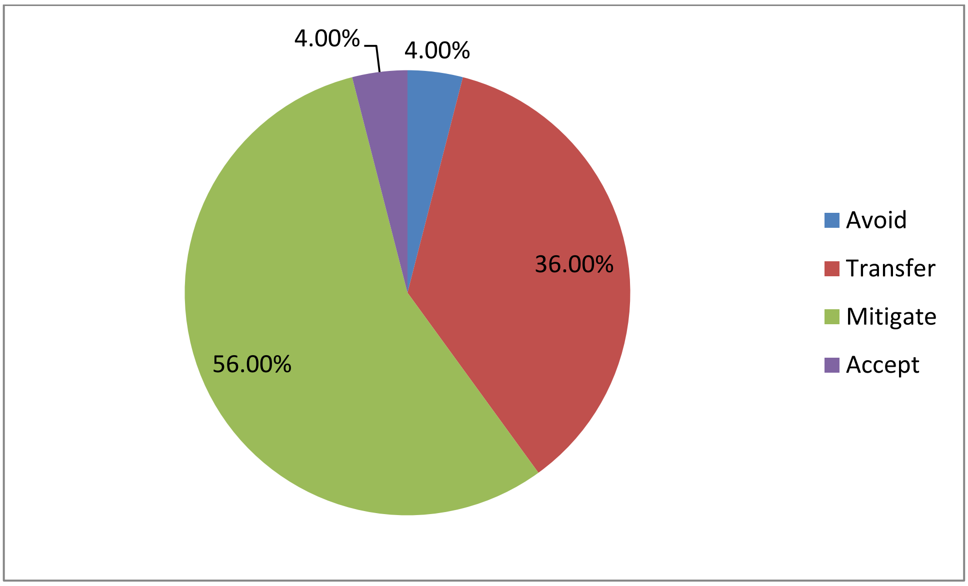

Figure 41: Case Study 13 Risk Responses

The analysis of case study 14 did not find that any risks impacted on the project performance. The project was completed on time and had no quality issues, however it marginally missed the targeted budget. Figure 42 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 14.

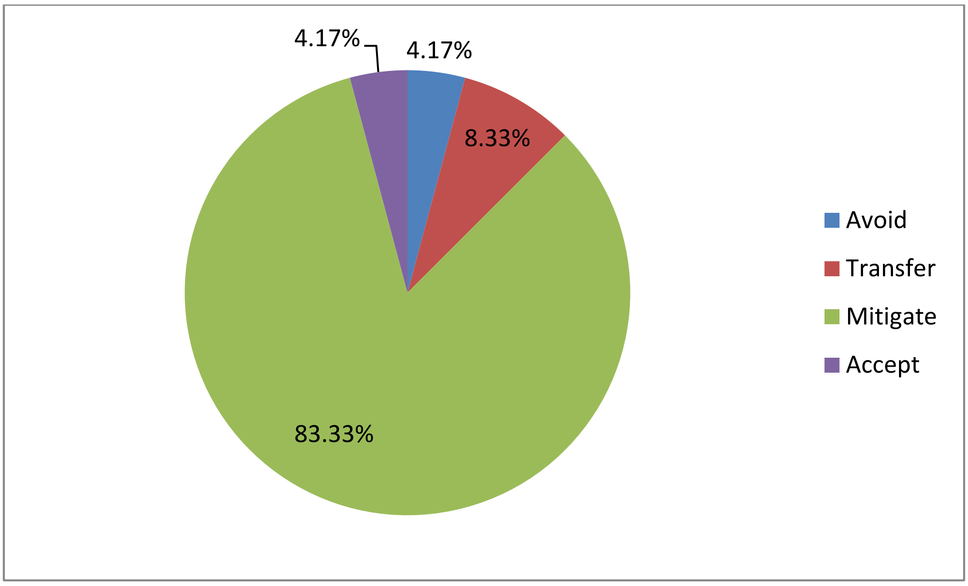

Figure 42: Case Study 14 Risk Responses

The analysis of case study 15 found that a health and safety incident occurred on site meaning that there was a delay to the project schedule. Figure 43 shows the breakdown of risk response strategies used to manage the negative risks associated with case study 15.

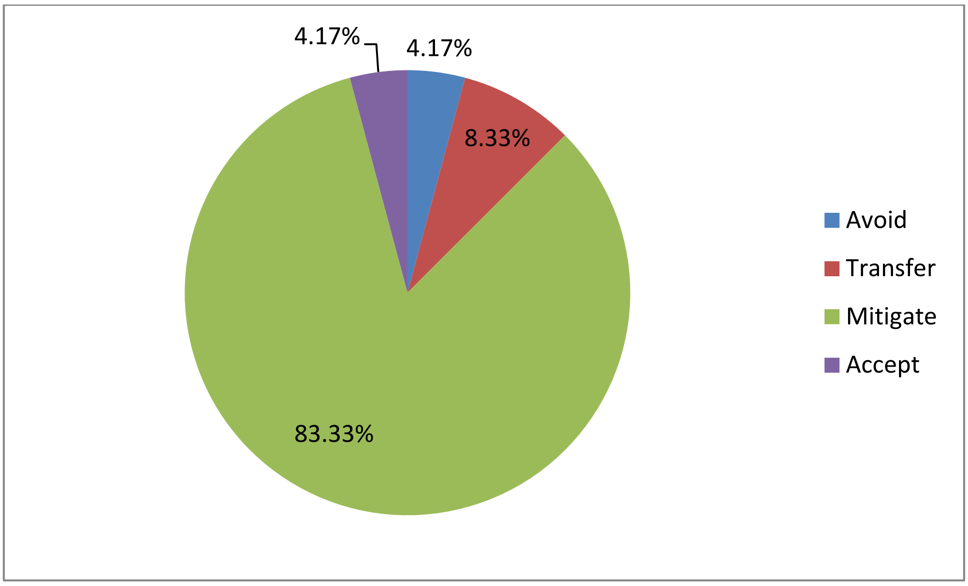

Figure 43: Case Study 15 Risk Responses

4.8 Risk Likelihood analysis

To analyse the likelihood of the identified risks of the projects they have been input into a table for ease of processing. To do this the risk severities were given the following ratings:

- Mild =1
- Medium=2
- High=3

From this, table 9 was developed where the average rate of severity has been calculated at the bottom of the matrix.

Table 9: Risk Likelihood Analysis

	Case Studies														
Risk no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1		1	1	1	1	1	1
22	1	1	1	1	1		1	1		1	1	1	1	1	1
23	1	1	1	1	1		1	1		1	1	1	1	1	1
24	1	1	1	1	1		1	1		1	1	1	1	1	1
25		1		1			1			1			1		
26		1													
Total	26	28	26	27	26	23	27	26	22	27	26	26	27	26	26
Average	1.08	1.08	1.08	1.08	1.08	1.10	1.08	1.08	1.10	1.08	1.08	1.08	1.08	1.08	1.08

4.9 Risk severity analysis

To analyse the severity of the identified risks of the projects they have been input into a table for ease of processing. To do this the risk severities were given the following ratings:

- Mild =1
- Medium=2
- High=3

From this, table 10 was developed where the average rate of severity has been calculated at the bottom of the matrix.

Table 10: Risk severity matrix

Risk No.	Case Studies														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	1	3	2	2	2	2	2	2
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	2	1	1	1	1	1	1	2	1	1	1	2	1	2
6	1	2	1	1	1	1	1	1	2	1	1	1	2	1	2
7	1	2	1	1	1	1	1	1	3	1	1	1	3	1	3
8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10	2	2	2	2	2	2	2	2	2	2	2	2	3	2	3
11	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
12	2	2	2	2	2	3	2	2	3	2	2	2	2	2	2
13	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
14	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
15	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
16	3	3	3	3	3	1	3	3	1	3	3	3	3	3	3
17	2	2	2	2	2	3	2	2	3	2	2	2	2	2	2
18	1	1	1	1	1	3	1	1	3	1	1	1	1	1	1
19	3	3	3	3	3	1	3	3	1	3	3	3	3	3	3
20	3	3	3	3	3	1	3	3	1	3	3	3	3	3	3
21	1	3	1	3	1	1	3	1		3	1	1	3	1	1
22	1	1	1	1	1		1	1		1	1	1	2	1	1
23	1	1	1	1	1		1	1		1	1	1	1	1	1
24	1	1	1	1	1		1	1		1	1	1	1	1	1
25		1		1			1			1			1		
26		2													
Total	43	52	43	46	43	38	46	42	42	46	43	43	52	43	48
Average	1.79	2.00	1.79	1.84	1.79	1.81	1.84	1.75	2.10	1.84	1.79	1.79	2.08	1.79	2.00

CHAPTER 5 – DISCUSSION

5.1 Introduction

This chapter aims to discuss the issues that were identified in this project and to further understand the data presented in Chapter 4. As stated in Chapter 3, a minimum of 10 projects would be required to allow for a comprehensive data analysis to be completed. Data from a total of 15 projects have been collected for the completion of an analysis. The data was collected from a contractor who was willing to supply the details however they requested that the specifics of the client, contractor and site names would remain confidential and not appear throughout the dissertation.

5.2 Data Collection and processing

It was identified in chapter 4 that the data collection and analysis was limited by the available data which is assumed to be accurate. Due to the time limitations of this project a sample of 15 case studies were collected and analysed. A larger sample size could be used in future studies to uncover further information which was not identified within this project. The following limitations have been identified throughout this project:

- Due to confidentiality, the Risk Management Plans and contracts were not available
- Potential for incorrect data to have been collected
- Potential that other risks that have impacted on the project were not documented

These limitations offer the potential for further studies to be conducted in the future to uncover further findings.

5.3 Project Details

5.3.1 Subcontracted vs in-house resources

During the literature review it was identified that the use of sub-contractors could transfer some risk away from the contractor. In some of the case studies shown in Chapter 4, as much as 30% of the risk could have been transferred to the subcontractor.

The results of the selected case studies showed that 60% of the projects were completed via in-house resources, and the remaining 40% were completed by sub-contractors. The analysis of the risk registers of the projects found that when the works had been subcontracted the ownership of risks for the contractor reduced significantly. By subcontracting the work the following risks have been transferred to the subcontractor creating certainty to the cost of the build:

- Plant failure
- Late arrival of plant
- Site security
- Damage to property
- Use of incorrect installation procedures
- Incorrect completion of as-built documentation

Examples of the benefit of subcontracting work can be identified when comparing the risk responses from case studies 4 & 6 shown in figures 32 & 34. Case studies 4 & 6 are sites with similar scope, however case study 6 was completed by an in-house team and case study 4 was sub-contracted. 90.48% of the risks in case study 6 were controlled by the use of mitigation strategies and none were transferred to a third party to manage. Case study 4 was subcontracted and 36% of the risk was transferred to the subcontractor to manage, leaving only 56% of the risks to be mitigated by the contractor.

The subcontractor will price these risks into their tender or quote which will increase the costs of the completion of the works, however it will provide a greater certainty that the work will be completed to budget and to the required quality standards. This shows that the subcontracting of work is an effective method to manage some select risks and provide cost certainty to a project. This will come at a price to the contractor and will need to be considered during the planning phase of the project.

5.3.2 Site location

During the data collection phase it was identified that the location of the construction sites could potentially bring additional risk to the project due to logistics complications. It was deemed to be an area where investigation was required to understand how the project location may affect the performance of a project. When all sites were compared it was found that the average distance between Brisbane and the site location is 237.93kms. Further analysis of the results indicated that there were 4 sites that stood out above the average with distances from Brisbane being 363kms, 512km, 911kms and 975kms. These four sites stood out to have an increased risk due to logistics issues associated with the site locations.

The risk of the location of the site is evident in case study 13 which is located 975kms from Brisbane. Correct planning was completed prior to mobilization, however some of the materials required for the build did not arrive on time and had to be shipped out to site during the construction works. This site incurred additional costs due to materials needing to be shipped to site and the delay experienced by the subcontractor. Due to the location of the site there was no express shipping option and general shipping took several days. Further to this example, if remobilisation was required for any reason, the cost would have been excessive which would have had a huge impact on the budget. The location of this site was found to have impacted on both the cost and schedule performance of the project. Further analysis of case study 13 shows that this risk was not recorded in the risk register shown in appendix C which suggests that the risk was not clearly identified or controlled. Failure to identify the risk means that there were no clear control measures in place that could clearly be understood by all of the project team.

The location of the sites was found to affect the impact of other risks on the project due to the costs associated with remobilisation. Evidence of its impact can be found when comparing the impact of the quality risks associated with Case Study 8 and 9. Case study 8 was found to be located only 60km from Brisbane, however case study 9 is located 911km's from Brisbane. Due to the quality audit process being completed post construction, remobilisation would be required to rectify any defects or issues found by the auditor. The impact of the quality risk increased from a low impact on Case study 8 to a high impact on case study 9. Case study 9 was impacted by this risk and the contractor required to pay the additional mobilisation costs. By subcontracting the works on remote sites the risk is then transferred away from the contractor to manage. This also happens on local sites; however there is a huge difference in the impact of the risk.

The analysis of the data also indicated that the location of a site does affect the impact of inclement on the project. Case study 10 was impacted due to inclement weather, however due to its proximity to Brisbane; there was no additional cost or stand down required for staff or plant. Remotely located sites would require either stand down of staff or demobilisation and remobilisation after the weather event was completed. In these remote locations the risk impact is found to be significantly higher

5.3.3 Project type and scope

As per the results the case studies selected include 13 upgrade projects, 1 Greenfield and 1 brownfield site. This selection of case studies skews the results more towards sites where upgrade works are being completed, rather than the Greenfield or brownfield type construction. This indicates that the results will favour the rigging and technical work rather than provide the opportunity to analyse the civil works in great detail or accuracy.

As the selected case studies were picked at random for pre-processing, it can be assumed that the pool of case studies was made up of a majority of sites where the scope was to upgrade an existing facility. This is likely to be due to a number of reasons including: the selected projects are based on a roll out of new technologies or there is a reduced construction cost compared to Greenfield construction. With case study 2 being a Greenfield and case study 8 being a brownfield these projects will likely have many different risks associated with them in comparison to the rest of the selected case studies.

The literature has identified that scope of a project has an impact on the project schedule. This is evident in the examples of the greenfield and brownfield sites in comparison to the sites where upgrade works were completed. This is due to the increased scope and different construction methods that are utilised in the construction of greenfield or brownfields. These sites have an increased schedule due to the additional works required for completion. Through the analysis it was found that the project scope will affect the likelihood of inclement weather impacting on the works due to the increased project duration.

5.3.4 Structure details

As per the results section 47% of the sites were constructed on monopoles with the remaining 53% of sites made up of guyed mast, self-supporting towers and rooftops. Out of all of the structures, 53% could be climbed for construction. Where the towers can be climbed the construction costs are reduced for the contractor. When working from a EWP the chance of an incident is reduced, this provides certainty to the project schedule and budget.

An investigation into the structure information for each site did not identify any links between the structure type and climb-ability to the project performance. It was hypothesised that this is likely due to these factors being considered when forecasting the works and therefore contingencies could already be in place. None of the structure details were found to be included on the risk registers and there were no findings to support the effect of the structure on risk. It is possible that a larger sample of projects could be studied in the future to understand if there are any trends in the data.

5.3.5 Average height of structures

Four of the case study sites stood out because they had heights of 50m and 90m, which were much larger than the common 25 and 30m structures. The literature review found that these structures are harder to work on due to the height of the workers above ground and the further distance materials are to be hauled for the completion of works. The data collected does not show any clear impact on the project performance on different structure heights. Again this is likely to be due to a contingency being built into the forecasts for these sites.

Case study 15 was a 90m structure and during the works a HSE incident occurred while a worker was hand hauling materials up to the workers up the guyed mast. While the specifics of the HSE incident are not within the scope of this dissertation it can be identified that there are additional HSE risks associated with larger structures which could impact on the projects performance. Due to the data only showing the single HSE incident it is not possible to conclude on this finding.

5.4 Financial performance

The financial results were based around the forecast and actual gross margin achieved on each site to understand how the project performed against its projected target. The analysis of the results found that the following case studies did not achieve the forecasted financial performance: 1, 3, 4, 12, 13 & 14. It was decided that each case should be investigated to understand the cause for the missed financial performance.

Case study 1 was found to have been impacted due to an incorrect testing procedure being used by the field team. This required an additional day of works on site including EWP hire and labour costs. A reason for case study 3 not achieving the forecasted gross margin could not be determined. The site was impacted by a massive increase in scope and it is assumed that the forecasted Gross Margin would have only considered the initial scope. With no way of confirming this hypothesis it is difficult to determine the root cause of the financial performance of case study 3.

Case study 4 missed its forecast Gross Margin by 0.99%, a value of less than $400.00. The reasons could not be determined and the impact on the project performance was extremely minor in this case. Case study 12 had a forecasted Gross Margin of 10% however it only achieved 8.12%. Due to the small revenue involved in the construction of this site, the value of additional expenditure is extremely minor. The reason for missing the forecast could not be determined from the project data available.

As previously discussed case study 13 was financially impacted due to materials arriving late and delaying the construction team on site. The impact of the risk was increased due to the sites remote location and the severity can be shown by the poor financial performance. The expected GM was 15% however at completion the site only achieved 8.48%. Case study 14 had a forecasted GM of 10% and achieved 9.47%. This site has only just missed the forecast and the reasons for this are unknown. It is possible that the forecasting could have been slightly out causing a difference in values.

A comparison between the financial performances of works completed by in-house resources in comparison to sub-contractors found that subcontracted works were more likely to achieve the forecasted Gross Margin. The analysis found that 66.67% of sites that were subcontracted achieved the forecasted Gross Margin. This is compared to 55.55% of sites completed by in-house resources achieved the forecasted Gross Margin. Although there is many other factors that impact on these figures, this result would be expected due to the transfer of risk to the subcontractor.

5.5 Schedule performance

Chapter 4 analysed the projects schedule performance compared to the dates that were forecast prior to construction. The following sites were not completed within the forecasted dates; 2, 3, 5, 10, 12, 14 & 15. It was decided that each case should be investigated to understand the root cause of the poor performance. Case studies 5, 10, 12 & 14 have no explanation as to why the schedule was not achieved.

Case study 2 was found to be delayed to a power connection delay by the power service provider. This example will be discussed further later in this chapter. Case study 3 was found to be delayed from its initial forecast due to a major change in scope during the construction phase. The site was found to have major issues with its existing configuration which required a complete redesign to rectify. For this reason the site was not completed until 6 months past its forecast completion date. It was found that during these works the issues with the existing site were raised to the client as an opportunity to add value to the project. Case study 15 was found to have delayed due to health and safety incident occurring on site. No further information about this incident is available, however it can be assumed that the process of resolving the incident was time consuming and caused an impact on the schedule.

5.6 Quality Performance

The results of the quality audits on the case study sites indicated that two sites required revisit to rectify at the contractors cost and two required revisit at the cost of a subcontractor to rectify. These instances of a poor quality product were found to impact on time and cost dependent on the control measures in place. The sites that were rectified by the contractor free of charge reinforce the advantages of transferring risk to a subcontractor. These two cases did not impact on the project performance due to the risk being owned by the subcontractor. The two sites that were rectified by the contractor impacted on the cost performance of the project.

5.7 NTCP Model Analysis

One of the key findings in the literature review was the potential link between project complexity and increased project risk. Chapter 2 identified the NTCP model for analysing project complexity and this was used to understand the novelty, technology, complexity and pace experienced within the project. This model was used to analyse all of the case studies to compare the differences of each. The results of this analysis were extremely similar for all sites that had the same results for the following criteria:

- 100% of sites were found to have a Derivative level of Novelty.
- 100% of sites were found to have a High level of technical work.
- 100% of sites were found to have a system level of complexity.

These results were considered to be likely due to the similarities of the project and the pre-processing procedure used for the case studies. The results do however indicate the level of complexity involved in communications projects in comparison to other industry projects. The results achieved show that the high technical nature and system level of complexity need to be considered to understand the risks involved in communication projects.

Further to these results, the pace required for completion of the case study sites varied a lot and included all levels of project pace from regular, fast, time-critical and blitz. The results indicated that more than 50% of sites are to be completed at a time-critical or blitz pace. This has not been found to impact on the schedule performance of the project.

The NTCP method has not been found to be very effective in understanding the risks or complexity of the communication projects. It does not differentiate between the differing scopes associated with the different case studies. An example of this is case study 3 which is the only site that includes a civil and electrical works. This site was not rated differently to any of the other sites showing that the model fails to differentiate this type of project.

5.8 Risk Likelihood and impact analysis

An analysis of the risk likelihood matrix shown in table 9 has found that all sites had 2 risks with a medium likelihood and the remainder were rated to be mild. The two risks with medium likelihood were found to be:

- Change management
- Supply of incorrect materials.

The analysis of the likelihood matrix did not have any other significant findings.

An analysis of the risk likelihood matrix shown in table 10 has found that there is a correlation between the site location and the average expected impact of the risk occurring. It was found that the 4 highest average impact ratings were for sites with the largest distance between Brisbane and the site location. It was hypothesised that this is due to the additional costs associated with remobilising to site to rectify quality issues. This is backed up by the data which shows that risks relating to quality have an increased impact compared to sites that are located in the vicinity of Brisbane. This finding shows that the further the site is located from Brisbane, the higher the impact quality risks could have on the project.

5.9 Selected Case Studies

The analysis of results collected in chapter 3 has identified several case studies that stand out and warrant further analysis. These case studies have been selected as they included risks that differ to other case studies or it has been identified that they were impacted by risks that were not identified prior to construction.

5.9.1 Case Study 5

Case study 5 was selected for further analysis because it was found to have been impacted by a quality issues that could have impacted on the reputation of the contractor. The relationship between the contractor and client is extremely important to the contractor and a good relationship can ensure that the contractor receives further work from the client in the future.

An analysis of this case study found that an incorrect Method of Procedure (MOP) was used by one of the field staff while completing a software upgrade for the client. This meant that the client's software engineers were delayed and were required to complete additional work to rectify the work. The client was disappointed with the work completed and very unhappy about the additional work they were required to complete to rectify. This instance damaged the reputation of the contractor and impacted on the relationship with the client. Instances like this have the potential to affect the sustainability of the contractor and impact on their opportunities for further work. To quantify the risk is difficult, however if the contractor was to lose all work from the client it could cause a loss of millions of dollars of revenue per year.

The scope of works completed at case study 5 involved the installation and commissioning of telecommunications equipment as part of a site upgrade. The site is located 29km from Brisbane meaning that there is minimal impact due to the location of the site in this case. The work is being completed by the contractor's in house resources.

5.9.2 Case Study 2

Case study 2 was selected for further analysis because it was identified to be the only Greenfield construction within the selected case studies. As this site differs significantly it was identified as a case study that would require further analysis to understand the additional risks associated with the civil and electrical works included in its scope. The site was also impacted by a delay due to the power authority not being able to connect power to the site in time. The scope of this case study includes the installation of a 25m monopole, construction of a steel platform, installation of a communications hut, connection of AC power, installation and commissioning of communications equipment. This site differs compared to the other case studies due to the earthworks, civil works and electrical scope required to complete the build. This information does not show up in the NTCP analysis as it does not breakdown the additional construction disciplines required, additional build time or scope size.

The case study site is located 363km from Brisbane in a regional town where a 25m monopole was constructed. As previously noted, the distance from Brisbane has a significant effect on the impact of some of the risks associated with the project. In this case study the site location has been found to affect the impact of the following risks:

- Inclement weather
- Supply of incorrect materials
- Incorrect completion of as-built documentation
- Incorrect access documentation
- Quality of work
- Site access issues

None of these risks occurred during this project due to effective control measures.

This case study performed financially as expected, achieving the forecasted GM% and expected profit. This suggests that the risks that have impacted on this case study have not impacted on the financial performance.

The construction of a Greenfield site has a larger construction window in comparison to the sites where upgrade works are completed. The forecasted schedule had allowed for a month to complete the full scope of works. This increases the likelihood of inclement weather impacting on the build. It is important for the project manager to liaise with the client about the impact of the weather on achieving their milestones. If a significant weather event was to occur there would be the potential that the team would need to either stand down from work, or remobilise once the weather event had passed. This incurs additional costs which need to be transferred to the client where possible.

The schedule for case study 2 was missed by 1.5 months due to a delay in the power connection from the service provider. This delay required a team to remobilise once the power was connected to complete the commissioning works. This risk is only present on

Greenfield and potentially brownfield sites however it is very much out of the control of the contractor. The only mitigation strategy that can be used is to ensure that the power application is submitted as soon as possible to provide the power provider with as much notice as is possible. The contractor must accept this risk and monitor throughout the construction phase to understand how it may impact on the project.

The quality audit at this site found several issues which required rectification by the subcontractor. This again highlights one of the major benefits of subcontracting the work in communications projects. Due to the site being located 363km from Brisbane, additional mobilisation costs would have applied to the subcontractor when they completed the revisit to rectify the issues. This risk was transferred effectively to the subcontractor.

The construction of a Greenfield site includes additional risk due to the amount of plant required for the construction. Excavators, augers, EWP's, cranes and franna's are required to complete the scope at this site and any additional plant time on site could impact on the project budget. In this case all of the plant hire has been subcontracted to provide cost certainty and transfer the risk. The subcontractor would then take ownership of this risk unless the delay was caused by the contractor.

An analysis of the site drawings found that the site was located on the edge of a flood prone creek where in serious flood events; the site could have been completely inundated. The design of the site has allowed for the potential flooding, however the risk register did not consider the potential impacts of this during construction. Natural catastrophes were assessed in the risk register however there was no specific mention of the risks associated with flooding. The risk could have been assessed as per table 5.

Table 11: Risk of Flooding at site

Description of Risk	Impact on Project	Likelihood	Seriousness	Strategic Actions
Flooding within the site area and construction zone.	Environmental impacts. Damage or loss of materials, plant or equipment. Cost, delay and rework impact.	L	H	Mitigate – security of site, planning and awareness during construction. Accept – react to the event if it happens.

The likelihood of a flood event occurring is still very low; however it could have a significant impact on the project and the community. Due to the unknown nature of a flood event it would be extremely difficult to quantify and would depend on the progress of the site at the time of the event. The best option would be to mitigate the risk be ensuring the project team is aware of the risks and provide a plan to minimise the impact if a flood event was to take place. By not having the risk listed in the risk register the project team do not have any visibility of the appropriate control measures.

5.9.3 Case Study 3

Case study 3 was selected for further analysis because it was identified as a project where the contractor presented an opportunity to add value to the work during the construction phase. During the first day of construction it was found that the site had major issues with the existing steelwork on the headframe of the pole and the cabling between the pole and communication hut was found to be severely damaged by birds. This site was found to involve positive risks by providing opportunities rather than threats to the project success.

The field team raised the issues immediately with the project manager who was able to provide the client with an opportunity to add value to the project. The project manager in this case was able to qualitatively and quantitatively analyse the risk where it was identified that the additional scope could be quite profitable to complete. The project manager decided that the best strategy would be to exploit the opportunity as the client would almost have no option but to have the issues rectified. The project manager developed a proposal and presented it to the client for consideration. The client accepted the opportunity and this increased the expected revenue of the project from $25,123.00 to a total of $107,060.00, more than 4 times the quoted value.

Discussions with one of the project team advised that due to how the design and construct telecommunications projects are completed, it is rare that the contractor has opportunity to add value to the client during the construction phase. The designer should have taken this into account previously unless there is an issue with the previous install at the top of the structure which was not investigated during the completion of a site design visit on an existing structure. The opportunities were not found to be listed on the project risk registers making it difficult to consider these within the project.

Throughout this dissertation the quantitative risk assessment has not been found to be effective to manage the threats present in the projects, however in the case of this opportunity it was the key in making the decision for the project manager. The additional scope could be quantified and costs could be forecasted prior to committing to the work.

Case study 3 was completed by an internal resource team who were able to communicate the opportunity to the project manager, we must consider if this would have occurred if the site was being completed by a sub-contractor. In this case the contractor could have potentially missed out on the opportunity to increase its revenue by $81,937.00. The risk of missed opportunities could be considered on sites where the works have been subcontracted. The risk could be considered for sites where works are subcontracted as per table 5.

Table 12: Risk assessment of missed opportunities

Description of Risk	Impact on Project	Likelihood	Seriousness	Strategic Actions
Missed opportunities to add value when works are subcontracted.	Loss of additional revenue and profit. Missed opportunity to impress the client.	L	H	Avoid – Never subcontract work. Mitigate – Training of subcontractor and providing incentives. Accept – acknowledge that by subcontracting out the work this risk could occur.

A strategy to avoid the risk entirely is not necessarily feasible to a contractor and could generate additional risks from using this strategy. Mitigation of the risk would be the best option to ensure that the subcontractor is attempting to identify the opportunities and present them to the project manager.

Schedule performance was found to be delayed from its initial forecast due to the major change in scope during the construction phase. The missing of milestones can often be seen as a negative performance by the contractor, however due to the opportunity presented to the client it is not the case for this site. The completion of this site did not have any negative implications with the client, they were extremely happy that the issues were presented to them for rectification. Further to this, at completion the site was not found to have any outstanding quality issues.

Financial performance was found to differ from the forecast due to the large scope change throughout the works. The initial targeted GM was 10% however the final completed scope only achieved 8.3%, slightly below the forecast. Due to the revenue increasing by more than 4 times the initial quote

The site was found to be located 120km from Brisbane which did not have any real impact to the project performance or the risks associated with the sites construction. The site is located within a town and was not found to have any access issues. The Structure on site is a 25m monopole which is only accessible via EWP. The contractor does not own an EWP and therefore was required to hire for the completion of the works.

CHAPTER 6 – CONCLUSIONS

6.1 Introduction

This chapter will focus on the conclusions and recommendations that have been identified throughout the completion of the project and suggest where improvements could be made for future studies. This section will also identify opportunities for future research which could compliment or add to the findings of this project.

6.2 Conclusions

The aim of the project was to investigate the risks involved in the construction and upgrade of mobile communications facilities. By reviewing the available literature it revealed that there was a lack of industry information and the literature was based around existing project management frameworks. The project has successfully analysed the risks involved in 15 separate case studies to understand how they have impacted on project performance. The findings were then compared to the literature and conclusions developed. The analysis has found the following conclusions.

Conclusion 1

The analysis identified that the risks that are transferred when work is subcontracted include the following:

- Quality
- Plant costs and failures
- Site security
- Productivity of labour
- Damage to property

These risks were found to contribute to up to 36% of the risks faced by the contractor.

Conclusion 2

The project has identified that site location has a huge effect on the impact of risks associated with the project. The further the project is located from Brisbane, the larger the impact of the following risks is:

- Inclement weather
- Supply of incorrect materials

- Logistics
- Incorrect access documentation
- Quality

When these findings are aligned with Conclusion 1, it further shows the benefit of subcontracting the works. This is because the risks have a higher impact, most of which could be transferred to the subcontractor.

Conclusion 3

The most commonly used risk management strategy is mitigation, which in all case studies was the most commonly used strategy.

6.3 Recommendations

The project has successfully analysed the risks involved in 15 separate case studies to understand how they have impacted on project performance. Following the completion of this project, the following recommendations can be made:

Recommendation 1

From the findings of this project it can be recommended that the further the site is located from Brisbane, the more beneficial it is to sub-contract the work. The increased impact associated with the site location encourages risk transfer to be used to ensure the project has the best opportunity of achieving a successful outcome. If the risks are to eventuate, there is the potential for the project to become a failure due to the high impact of the risks. Therefore it is recommended that these sites be sub-contracted.

Sites located closer to Brisbane have been identified to have a lower risk severity, and therefore it would be advantageous to complete these works with an internal resource team. This is dependent on the team's ability to complete the project scope and is subject to other considerations.

Recommendation 2

Client relationships and contractor reputation have both been identified as an area for consideration throughout the risk management process. It is recommended that client relationship and contractor reputation be included within the Risk Management Plan to ensure these form part of the baseline for the risk management process.

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APPENDIX A

Project Specification

ENG4111/4112 Research Project

Project Specification

For: Justin Adams

Title: Risk management during the construction of communication towers.

Major: Construction Management

Supervisor: David Thorpe

Confidentiality: Possible project data (refer to as Project A, etc.)

Enrolment: ENG4111 – EXT S1, 2016

ENG4112 – EXT S2, 2016

Project Aim: To investigate risks in the construction of communication towers and identify appropriate controls that could improve

Programme: Issue A 16th March 2016

1. Research background information relating to the risks involved in the construction of communication towers.
2. Identify a system of measurement that can be used to evaluate risk management in real world projects.
3. Gather data from real world projects using the system of measurement identified in step 2.
4. Evaluate the data for each project and identify contributing factors that have placed the contractor at risk in each project.

If time and resources permit

5. Develop a risk management procedure that can be trialled in a project.
6. Use the risk management procedure in a project environment to determine its effectiveness.
7. Evaluate results of trial project and refine the process.

Project Plan

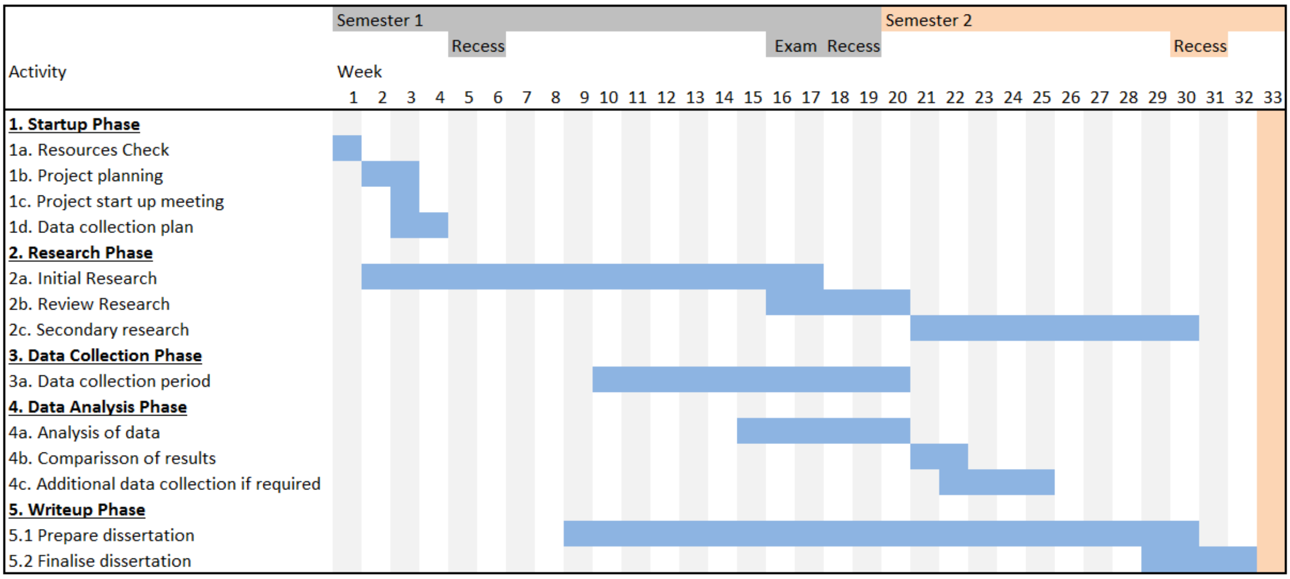

Figure 1: Project Plan

Project Resources

At this stage of the project not all resource requirements can be identified, however the resources required will be minimal due to the methods that will be utilised in this project. An estimated resources analysis can be seen below in table 1.

Table 1: Project resource analysis

Task	Item	Quantity	Source	Cost
1A, 1B	Literature – USQ online data bases	Unknown	USQ	Nil
1A, 1B	Literature – PMBOK 5th edition	1	Student	$90
1A-C, 4A-C	EndNote Software	1	USQ	Nil
1A-,3B-C, 4A-C	Microsoft Excel	1	Student	Nil
3B-C, 4A-C	Microsoft Word	1	Student	Nil
4C	Printer, paper and ink	1	Student	Minimal

APPENDIX B

Project Records

Case Study Number: 1	
Sub-contractor/ in-house resources:	In-house resources
Project distance from HQ (km):	193km
Project type:	Upgrade of existing site
Brief scope:	Installation of additional frequency band on existing communication pole.
Structure type:	Monopole
Structure Height	25m
Climbable or non-climbable structure:	Non-climbable
Contract type:	Unit Price
Year of Construction:	2016
Financial Performance	
Quoted price:	$38,611.52
Approved Variations:	$14,837.35
Total Revenue:	$53,448.87
Forecast GM:	10%
Forecast Profit:	$5,344.89
Final GM:	2.96%
Final Profit:	$1,584.67
Notes:	Additional day of EWP Required onsite due to incorrect testing procedure by rigging team. Additional costs include EWP @$2120/ day and 2x riggers at $600/day
Schedule Performance	
Forecast start date:	30/05/2016
Actual start date	30/05/2016
Forecast finish date:	4/06/2016
Actual finish date:	8/06/2016
Notes:	Client supplied antenna failed onsite delaying completion date. Remobilization costs and replacement works claimed as variation. Site was on air with partial service pending the replacement of antenna.
Quality Performance	
Quality Audit outcome:	Client identified incorrect test procedure was being used during commissioning. Rectification completed prior to demobilization from site at additional cost.
Scope Changes & variations	
Notes:	Additional scope claimed from client due to faulty equipment and items not covered under the unit price contract.
NTCP Model	
Novelty	Derivation
Technology	High tech
Complexity	System
Pace	Blitz

Case Study Number: 2	
Sub-contractor/ in-house resources:	Sub-Contractor
Project distance from HQ (km):	363km
Project type:	Greenfield site
Brief scope:	Construction of greenfield site. Civil, rigging, electrical and technical works. New pole installation.
Structure type:	Monopole
Structure Height	25m
Climbable or non-climbable structure:	Non-climbable
Contract type:	Unit Price
Year of Construction:	2016
Financial Performance	
Quoted price:	$323,564.57
Approved Variations:	$13,416.26
Total Revenue:	$336,980.83
Forecast GM:	10%
Forecast Profit:	$33,698.08
Final GM:	10.54%
Final Profit:	$35,517.78
Notes:	Nil
Schedule Performance	
Forecast start date:	15/03/2016
Actual start date	15/03/2016
Forecast finish date:	15/04/2016
Actual finish date:	28/05/2016
Notes:	Schedule missed due to delay in power connection.
Quality Performance	
Quality Audit outcome:	Quality issues rectified by subcontractor at their cost
Scope Changes & variations	
Notes:	Minor additional landscaping works required due to council requirements. Variation approved by client.
NTCP Model	
Novelty	Derivation
Technology	High tech
Complexity	System
Pace	Fast

Case Study Number: 3	
Sub-contractor/ in-house resources:	In-house resources
Project distance from HQ (km):	120km
Project type:	Upgrade of existing site
Brief scope:	Installation of additional frequency band on existing communication pole. Structural upgrades.
Structure type:	Monopole
Structure Height	25m
Climbable or non-climbable structure:	Non-climbable
Contract type:	Unit Price
Year of Construction:	2015/2016
Financial Performance	
Quoted price:	$25,123.00
Approved Variations:	$81,937.00
Total Revenue:	$107,060.00
Forecast GM:	10%
Forecast Profit:	$10,706.00
Final GM:	8.30%
Final Profit:	$8,885.98
Notes:	Huge scope change during construction impacted on project revenue.
Schedule Performance	
Forecast start date:	30/11/2015
Actual start date	30/11/2015
Forecast finish date:	4/12/2015
Actual finish date:	16/05/2016
Notes:	Due to large scope increase and redesign, schedule was forecasted.
Quality Performance	
Quality Audit outcome:	No issues
Scope Changes & variations	
Notes:	Issues with headframe condition and cabling between the pole and communications hut. Variation approved and completed.
NTCP Model	
Novelty	Derivation
Technology	High tech
Complexity	System
Pace	Regular

Case Study Number: 4	
Sub-contractor/ in-house resources:	Sub-Contractor
Project distance from HQ (km):	9.7km
Project type:	Upgrade of existing site
Brief scope:	Installation of additional frequency band on existing tower.
Structure type:	Self-Supporting Tower
Structure Height	25m
Climbable or non-climbable structure:	Climbable
Contract type:	Unit Price
Year of Construction:	2016
Financial Performance	
Quoted price:	$37,983.59
Approved Variations:	$1,275.00
Total Revenue:	$39,258.59
Forecast GM:	12%
Forecast Profit:	$4,110.03
Final GM:	11.01%
Final Profit:	$4,322.37
Notes:	Nil.
Schedule Performance	
Forecast start date:	11/04/2016
Actual start date	11/04/2016
Forecast finish date:	17/04/2016
Actual finish date:	14/04/2016
Notes:	Schedule achieved.
Quality Performance	
Quality Audit outcome:	No issues.
Scope Changes & variations	
Notes:	Existing signage covered in graffiti. Replaced and charged to the client as variation.
NTCP Model	
Novelty	Derivation
Technology	High tech
Complexity	System
Pace	Fast

Case Study Number: 5	
Sub-contractor/ in-house resources:	Internal Resources
Project distance from HQ (km):	29km
Project type:	Upgrade of existing site
Brief scope:	Installation of additional frequency band on existing communication pole.
Structure type:	Monopole
Structure Height	25m
Climbable or non-climbable structure:	Non-climbable
Contract type:	Unit Price
Year of Construction:	2016
Financial Performance	
Quoted price:	$16,637.00
Approved Variations:	$13,050.00
Total Revenue:	$29,687.00
Forecast GM:	10%
Forecast Profit:	$2,968.70
Final GM:	12%
Final Profit:	$3,562.44
Notes:	Nil.
Schedule Performance	
Forecast start date:	3/05/2016
Actual start date	3/05/2016
Forecast finish date:	6/05/2016
Actual finish date:	12/05/2016
Notes:	Nil.
Quality Performance	
Quality Audit outcome:	Nil.
Scope Changes & variations	
Notes:	Nil.
NTCP Model	
Novelty	Derivation
Technology	High tech
Complexity	System
Pace	Time-critical

Case Study Number: 6	
Sub-contractor/ in-house resources:	Internal Resources
Project distance from HQ (km):	106
Project type:	Upgrade of existing site
Brief scope:	Installation of additional frequency band on existing rooftop site.
Structure type:	Rooftop
Structure Height	30m
Climbable or non-climbable structure:	Climbable
Contract type:	Unit Price
Year of Construction:	2016
Financial Performance	
Quoted price:	$31,112.59
Approved Variations:	$11,667.50
Total Revenue:	$42,780.09
Forecast GM:	10%
Forecast Profit:	$4,278.01
Final GM:	14.21%
Final Profit:	$6,079.05
Notes:	Nil.
Schedule Performance	
Forecast start date:	5/03/2016
Actual start date	5/03/2016
Forecast finish date:	13/03/2016
Actual finish date:	13/03/2016
Notes:	Nil.
Quality Performance	
Quality Audit outcome:	No issues
Scope Changes & variations	
Notes:	Nil.
NTCP Model	
Novelty	Derivation
Technology	High tech
Complexity	System
Pace	Time-critical

Case Study Number: 7	
Sub-contractor/ in-house resources:	Sub-contractor
Project distance from HQ (km):	9.3km
Project type:	Upgrade of existing site
Brief scope:	Installation of additional frequency band on existing rooftop site. Structural steelwork upgrade.
Structure type:	Rooftop
Structure Height	15m
Climbable or non-climbable structure:	Climbable
Contract type:	Unit Price
Year of Construction:	2016
Financial Performance	
Quoted price:	$72,461.52
Approved Variations:	$4,071.10
Total Revenue:	$76,532.62
Forecast GM:	15%
Forecast Profit:	$11,479.89
Final GM:	23.20%
Final Profit:	$17,755.57
Notes:	Nil.
Schedule Performance	
Forecast start date:	18/06/2016
Actual start date	18/06/2016
Forecast finish date:	26/06/2016
Actual finish date:	26/06/2016
Notes:	Nil.
Quality Performance	
Quality Audit outcome:	No issues
Scope Changes & variations	
Notes:	Nil.
NTCP Model	
Novelty	Derivation
Technology	High tech
Complexity	System
Pace	Time-critical

Case Study Number: 8	
Sub-contractor/ in-house resources:	Sub-contractor
Project distance from HQ (km):	60km
Project type:	Brownfield
Brief scope:	Installation of new pole, removal of existing pole, introduction of new frequency band and civil works.
Structure type:	Monopole
Structure Height	25m
Climbable or non-climbable structure:	Non-climbable
Contract type:	Unit Price
Year of Construction:	2016
Financial Performance	
Quoted price:	$135,503.00
Approved Variations:	$33,986.09
Total Revenue:	$169,489.09
Forecast GM:	17%
Forecast Profit:	$28,813.14
Final GM:	23.54%
Final Profit:	$39,897.73
Notes:	Nil.
Schedule Performance	
Forecast start date:	16/05/2016
Actual start date	16/05/2016
Forecast finish date:	5/06/2016
Actual finish date:	1/06/2016
Notes:	Nil.
Quality Performance	
Quality Audit outcome:	Quality issues rectified by subcontractor at their cost
Scope Changes & variations	
Notes:	Nil.
NTCP Model	
Novelty	Derivation
Technology	High-tech
Complexity	System
Pace	Regular

Case Study Number: 9	
Sub-contractor/ in-house resources:	in-house resources
Project distance from HQ (km):	911
Project type:	Upgrade of existing site
Brief scope:	Installation of additional frequency band on existing tower. Structural upgrade.
Structure type:	Lattice Tower
Structure Height	50m
Climbable or non-climbable structure:	Climbable
Contract type:	Unit Price
Year of Construction:	2016
Financial Performance	
Quoted price:	$35,503.00
Approved Variations:	$7,709.41
Total Revenue:	$43,212.41
Forecast GM:	10%
Forecast Profit:	$4,321.24
Final GM:	12.06%
Final Profit:	$5,211.41
Notes:	Additional costs experienced due to revisit to rectify quality issues.
Schedule Performance	
Forecast start date:	22/03/2016
Actual start date	29/03/2016
Forecast finish date:	9/04/2016
Actual finish date:	7/04/2016
Notes:	Nil.
Quality Performance	
Quality Audit outcome:	Yes, revisit required to rectify incorrect installation.
Scope Changes & variations	
Notes:	Nil.
NTCP Model	
Novelty	Derivation
Technology	High tech
Complexity	System
Pace	Regular

Case Study Number: 10	
Sub-contractor/ in-house resources:	Sub-contractor
Project distance from HQ (km):	31
Project type:	Upgrade of existing site
Brief scope:	Installation of additional frequency band on existing tower. Structural upgrade.
Structure type:	Lattice Tower
Structure Height	50m
Climbable or non-climbable structure:	Climbable
Contract type:	Unit Price
Year of Construction:	2016
Financial Performance	
Quoted price:	$46,206.43
Approved Variations:	$10,409.50
Total Revenue:	$56,615.93
Forecast GM:	15%
Forecast Profit:	$8,492.38
Final GM:	18.04%
Final Profit:	$10,213.51
Notes:	Nil.
Schedule Performance	
Forecast start date:	25/04/2016
Actual start date	25/04/2016
Forecast finish date:	1/05/2016
Actual finish date:	3/05/2016
Notes:	Construction delayed due to inclement weather
Quality Performance	
Quality Audit outcome:	No issues
Scope Changes & variations	
Notes:	Nil.
NTCP Model	
Novelty	Derivation
Technology	High tech
Complexity	System
Pace	Fast

Case Study Number: 11	
Sub-contractor/ in-house resources:	In house
Project distance from HQ (km):	115
Project type:	Upgrade of existing site
Brief scope:	Installation of additional frequency band on existing communication pole.
Structure type:	Monopole
Structure Height	25m
Climbable or non-climbable structure:	Non-climbable
Contract type:	Unit Price
Year of Construction:	2016
Financial Performance	
Quoted price:	$25,123.59
Approved Variations:	$4,795.00
Total Revenue:	$29,918.59
Forecast GM:	20%
Forecast Profit:	$5,983.72
Final GM:	20.15%
Final Profit:	$6,028.59
Notes:	Nil.
Schedule Performance	
Forecast start date:	2/12/2016
Actual start date	2/12/2016
Forecast finish date:	18/12/2016
Actual finish date:	14/12/2016
Notes:	Nil.
Quality Performance	
Quality Audit outcome:	No issues
Scope Changes & variations	
Notes:	Nil.
NTCP Model	
Novelty	Derivation
Technology	High tech
Complexity	System
Pace	Time-critical

Case Study Number: 12	
Sub-contractor/ in-house resources:	In house resources
Project distance from HQ (km):	24
Project type:	Upgrade of existing site
Brief scope:	Installation of additional frequency band on existing rooftop site.
Structure type:	Rooftop
Structure Height	20m
Climbable or non-climbable structure:	Climbable
Contract type:	Unit Price
Year of Construction:	2016
Financial Performance	
Quoted price:	$13,233.50
Approved Variations:	$0.00
Total Revenue:	$13,233.50
Forecast GM:	10%
Forecast Profit:	$1,323.35
Final GM:	8.12%
Final Profit:	$1,074.56
Notes:	Nil.
Schedule Performance	
Forecast start date:	18/04/2016
Actual start date	18/04/2016
Forecast finish date:	23/04/2016
Actual finish date:	21/04/2016
Notes:	Nil.
Quality Performance	
Quality Audit outcome:	No issues
Scope Changes & variations	
Notes:	Nil.
NTCP Model	
Novelty	Derivation
Technology	High tech
Complexity	System
Pace	Time-critical

Case Study Number: 13	
Sub-contractor/ in-house resources:	Sub-Contractor
Project distance from HQ (km):	975
Project type:	Upgrade of existing site
Brief scope:	Extension of existing mast, upgrade of configuration and installation of new frequency band.
Structure type:	Guyed mast
Structure Height	90m
Climbable or non-climbable structure:	climbable
Contract type:	Unit Price
Year of Construction:	2016
Financial Performance	
Quoted price:	$50,503.00
Approved Variations:	$14,680.20
Total Revenue:	$65,183.20
Forecast GM:	15%
Forecast Profit:	$9,777.48
Final GM:	8.48%
Final Profit:	$5,527.53
Notes:	Late arrival of materials caused delay to the subcontractor on site.
Schedule Performance	
Forecast start date:	11/01/2016
Actual start date	11/01/2016
Forecast finish date:	21/01/2016
Actual finish date:	21/01/2016
Notes:	Nil.
Quality Performance	
Quality Audit outcome:	No issues
Scope Changes & variations	
Notes:	Nil.
NTCP Model	
Novelty	Derivation
Technology	High tech
Complexity	System
Pace	Time-critical

Case Study Number: 14	
Sub-contractor/ in-house resources:	in-house resources
Project distance from HQ (km):	111
Project type:	Upgrade of existing site
Brief scope:	Installation of additional frequency band on existing communication pole.
Structure type:	Monopole
Structure Height	25m
Climbable or non-climbable structure:	Non-climbable
Contract type:	Unit Price
Year of Construction:	2016
Financial Performance	
Quoted price:	$25,123.59
Approved Variations:	$8,942.00
Total Revenue:	$34,065.59
Forecast GM:	10%
Forecast Profit:	$3,406.56
Final GM:	9.47%
Final Profit:	$3,226.01
Notes:	Nil.
Schedule Performance	
Forecast start date:	2/11/2016
Actual start date	2/11/2016
Forecast finish date:	10/11/2016
Actual finish date:	25/11/2016
Notes:	Nil.
Quality Performance	
Quality Audit outcome:	No issues
Scope Changes & variations	
Notes:	Nil.
NTCP Model	
Novelty	Derivation
Technology	High tech
Complexity	System
Pace	Time-critical

Case Study Number: 15	
Sub-contractor/ in-house resources:	in-house resources
Project distance from HQ (km):	512
Project type:	Upgrade of existing site
Brief scope:	Extension of existing mast, upgrade of configuration and installation of new frequency band.
Structure type:	Guyed mast
Structure Height	90m
Climbable or non-climbable structure:	climbable
Contract type:	Unit Price
Year of Construction:	2016
Financial Performance	
Quoted price:	$35,503.00
Approved Variations:	$9,560.00
Total Revenue:	$45,063.00
Forecast GM:	15%
Forecast Profit:	$6,759.45
Final GM:	17.21%
Final Profit:	$7,755.34
Notes:	Nil.
Schedule Performance	
Forecast start date:	1/02/2016
Actual start date	1/02/2016
Forecast finish date:	10/02/2016
Actual finish date:	18/02/2016
Notes:	Schedule impacted due to health and safety incident.
Quality Performance	
Quality Audit outcome:	Health and safety incident on site caused delay to works.
Scope Changes & variations	
Notes:	Nil.
NTCP Model	
Novelty	Derivation
Technology	High tech
Complexity	System
Pace	Time-critical

APPENDIX C

Project Risk Registers

Project 1

Id	Description of Risk	Impact on Project	Probability Assessment	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire, and labour.	L	M	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (internal resources)	Potential delay or requirement for additional materials. Increase of costs, delayed schedule. Possible remobilisation to rectify.	L	M	Training of staff and contractors. Sub-contract work.
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, and PM. Completion of daily site reports by field staff
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	L	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	L	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	L	Training of staff. PM to allow appropriate time within the schedule.
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Limited EWP Access	Delay, stand down of staff and increased cost of plant hire.	L	M	PM to investigate prior to mobilisation. To be investigated during design visit.
10	Quality of work	Potential revisit to rectify, damaged reputation with client	L	M	Training off staff and review of photos and as-built documents after completion.

11	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.
12	Additional EWP cost	Budget is impacted	L	M	Training of field staff and monitoring of progress.
13	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to plan as per access conditions supplied by the client. PM to variate any additional cost due to incorrect information.
14	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
15	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
16	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
17	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
18	Productivity of labour	Budget and schedule impact	L	L	Planning, monitoring and adjusting resources to meet schedule.
19	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access.
20	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
21	Late delivery of materials	Budget and schedule impact	L	L	PM planning and allowing float in schedule if possible.
22	Late arrival of plant	Budget and schedule impact	L	L	PM to liaise clearly with plant provider.
23	Plant failure	Budget and schedule impact	L	L	Monitor and adapt if required.
24	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.

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Project 2

Id	Description of Risk	Impact on Project	Probability Assessnent	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire.	L	H	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (sub-contractor)	Potential delay. Revisit may be required at contractors cost	L	M	Training of sub-contractors. Sub-contract work.
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, and PM. Completion of daily site reports by sub-contractor. Subcontractor to substantiate any out of scope works.
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	M	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	M	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	M	Subcontract works
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Limited EWP Access	Delay, stand down of staff and increased cost of plant hire.	L	M	PM to investigate prior to mobilisation. To be investigated during design visit.

10	Quality of work	Potential revisit to rectify, damaged reputation with client	L	M	Training off staff and review of photos and as-built documents after completion.
11	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.
12	Additional EWP cost	Budget is impacted	L	M	Request subcontractor to supply EWP at fixed cost.
13	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to plan as per access conditions supplied by the client. PM to variate any additional cost due to incorrect information.
14	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
15	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
16	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
17	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
18	Productivity of labour	Budget and schedule impact	L	L	Subcontract works. Monitor schedule.
19	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access. Subcontract works.
20	Insolvency of subcontractor	Budget impact	L	H	Procurement team to have appropriate contract in place.
21	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
22	Late delivery of materials	Budget and schedule impact	L	L	PM planning and allowing float in schedule if possible.
23	Late arrival of plant	Budget and schedule impact	L	L	PM to liaise clearly with plant provider.

24	Plant failure	Budget and schedule impact	L	L	Subcontractor to supply at fixed cost.
25	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.
26	Delay due to power provider	Potential revisit to site to complete works	L	M	Submission of power application as soon as possible prior to beginning of construction.

Project 3

Id	Description of Risk	Impact on Project	Probability Assessment	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire.	L	M	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (internal resources)	Potential delay or requirement for additional materials. Increase of costs, delayed schedule. Possible remobilisation to rectify.	L	M	Training of staff and contractors. Sub-contract work.
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, and PM. Completion of daily site reports by field staff
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	L	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	L	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	L	Training of staff. PM to allow appropriate time within the schedule.
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Limited EWP Access	Delay, stand down of staff and increased cost of plant hire.	L	M	PM to investigate prior to mobilisation. To be investigated during design visit.
10	Quality of work	Potential revisit to rectify, damaged reputation with client	L	M	Training off staff and review of photos and as-built documents after completion.

11	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.
12	Additional EWP cost	Budget is impacted	L	M	Training of field staff and monitoring of progress.
13	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to plan as per access conditions supplied by the client. PM to variate any additional cost due to incorrect information.
14	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
15	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
16	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
17	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
18	Productivity of labour	Budget and schedule impact	L	L	Planning, monitoring and adjusting resources to meet schedule.
19	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access.
20	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
21	Late delivery of materials	Budget and schedule impact	L	L	PM planning and allowing float in schedule if possible.
22	Late arrival of plant	Budget and schedule impact	L	L	PM to liaise clearly with plant provider.
23	Plant failure	Budget and schedule impact	L	L	Monitor and adapt if required.
24	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.

Project 4

Id	Description of Risk	Impact on Project	Probability Assessment	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire.	L	M	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (sub-contractor)	Potential delay. Revisit may be required at contractors cost	L	M	Subcontract work.
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, and PM. Completion of daily site reports by field staff
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	L	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	L	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	L	Training of staff. PM to allow appropriate time within the schedule.
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Limited EWP Access	Delay, stand down of staff and increased cost of plant hire.	L	M	PM to investigate prior to mobilisation. To be investigated during design visit.
10	Quality of work	Potential revisit to rectify, damaged reputation with client	L	M	Subcontract works.
11	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.

12	Additional EWP cost	Budget is impacted	L	M	Subcontractor to provide for fixed cost.
13	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to plan as per access conditions supplied by the client. PM to variate any additional cost due to incorrect information.
14	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
15	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
16	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
17	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
18	Productivity of labour	Budget and schedule impact	L	L	Planning, monitoring and adjusting resources to meet schedule.
19	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access.
20	Insolvency of subcontractor	Budget impact	L	H	Procurement team to have appropriate contract in place.
21	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
22	Late delivery of materials	Budget and schedule impact	L	L	PM planning and allowing float in schedule if possible.
23	Late arrival of plant	Budget and schedule impact	L	L	Subcontractor to provide for fixed cost.
24	Plant failure	Budget and schedule impact	L	L	Subcontractor to provide for fixed cost.
25	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.

Project 5

Id	Description of Risk	Impact on Project	Probability Assessment	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire.	L	M	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (internal resources)	Potential delay or requirement for additional materials. Increase of costs, delayed schedule. Possible remobilisation to rectify.	L	M	Training of staff and contractors.
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, and PM. Completion of daily site reports by field staff
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	L	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	L	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	L	Training of staff. PM to allow appropriate time within the schedule.
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Limited EWP Access	Delay, stand down of staff and increased cost of plant hire.	L	M	PM to investigate prior to mobilisation. To be investigated during design visit.
10	Quality of work	Potential revisit to rectify, damaged reputation with client	L	M	Training off staff and review of photos and as-built documents after completion.

11	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.
12	Additional EWP cost	Budget is impacted	L	M	Training of field staff and monitoring of progress.
13	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to plan as per access conditions supplied by the client. PM to variate any additional cost due to incorrect information.
14	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
15	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
16	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
17	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
18	Productivity of labour	Budget and schedule impact	L	L	Planning, monitoring and adjusting resources to meet schedule.
19	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access.
20	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
21	Late delivery of materials	Budget and schedule impact	L	L	PM planning and allowing float in schedule if possible.
22	Late arrival of plant	Budget and schedule impact	L	L	PM to liaise clearly with plant provider.
23	Plant failure	Budget and schedule impact	L	L	Monitor and adapt if required.
24	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.

Project 6

Id	Description of Risk	Impact on Project	Probability Assessnent	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire.	L	M	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (internal resources)	Potential delay or requirement for additional materials. Increase of costs, delayed schedule. Possible remobilisation to rectify.	L	M	Training of staff and contractors. Sub-contract work.
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, and PM. Completion of daily site reports by field staff
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	L	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	L	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	L	Training of staff. PM to allow appropriate time within the schedule.
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Quality of work	Potential revisit to rectify, damaged reputation with client	L	M	Training off staff and review of photos and as-built documents after completion.
10	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.

11	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to plan as per access conditions supplied by the client. PM to variate any additional cost due to incorrect information.
12	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
13	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
14	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
15	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
16	Productivity of labour	Budget and schedule impact	L	L	Planning, monitoring and adjusting resources to meet schedule.
17	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access.
18	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
19	Late delivery of materials	Budget and schedule impact	L	L	PM planning and allowing float in schedule if possible.
20	Late arrival of plant	Budget and schedule impact	L	L	PM to liaise clearly with plant provider.
21	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.

Project 7

Id	Description of Risk	Impact on Project	Probability Assessment	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire.	L	M	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (sub-contractor)	Potential delay. Revisit may be required at contractors cost	L	M	Training of staff, and PM. Completion of daily site reports by field staff
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, contractors and PM.
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	L	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	L	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	L	Training of staff. PM to allow appropriate time within the schedule.
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Limited EWP Access	Delay, stand down of staff and increased cost of plant hire.	L	M	PM to investigate prior to mobilisation. To be investigated during design visit.
10	Quality of work	Potential revisit to rectify, damaged reputation with client	L	M	Training off staff and review of photos and as-built documents after completion.
11	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.

12	Additional EWP cost	Budget is impacted	L	M	Training of field staff and monitoring of progress.
13	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to plan as per access conditions supplied by the client. PM to variate any additional cost due to incorrect information.
14	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
15	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
16	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
17	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
18	Productivity of labour	Budget and schedule impact	L	L	Planning, monitoring and adjusting resources to meet schedule.
19	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access.
20	Insolvency of subcontractor	Budget impact	L	H	Procurement team to have appropriate contract in place.
21	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
22	Late delivery of materials	Budget and schedule impact	L	L	PM planning and allowing float in schedule if possible.
23	Late arrival of plant	Budget and schedule impact	L	L	PM to liaise clearly with plant provider.
24	Plant failure	Budget and schedule impact	L	L	Monitor and adapt if required.
25	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.

Project 8

Id	Description of Risk	Impact on Project	Probability Assessment	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire.	L	M	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (internal resources)	Potential delay or requirement for additional materials. Increase of costs, delayed schedule. Possible remobilisation to rectify.	L	L	Training of staff and contractors. Sub-contract work.
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, and PM. Completion of daily site reports by field staff.
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	L	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	L	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	L	Training of staff. PM to allow appropriate time within the schedule.
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Limited EWP Access	Delay, stand down of staff and increased cost of plant hire.	L	M	PM to investigate prior to mobilisation. To be investigated during design visit.
10	Quality of work	Potential revisit to rectify, damaged reputation with client	L	M	Training off staff and review of photos and as-built documents after completion.

11	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.
12	Additional EWP cost	Budget is impacted	L	M	Training of field staff and monitoring of progress.
13	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to plan as per access conditions supplied by the client. PM to variate any additional cost due to incorrect information.
14	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
15	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
16	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
17	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
18	Productivity of labour	Budget and schedule impact	L	L	Planning, monitoring and adjusting resources to meet schedule.
19	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access.
20	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
21	Late delivery of materials	Budget and schedule impact	L	L	PM planning and allowing float in schedule if possible.
22	Late arrival of plant	Budget and schedule impact	L	L	PM to liaise clearly with plant provider.
23	Plant failure	Budget and schedule impact	L	L	Monitor and adapt if required.
24	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.

Project 9

Id	Description of Risk	Impact on Project	Probability Assessment	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire.	L	M	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (internal resources)	Potential delay or requirement for additional materials. Increase of costs, delayed schedule. Possible remobilisation to rectify.	L	H	Training of staff and contractors. Sub-contract work.
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, and PM. Completion of daily site reports by field staff
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	M	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	M	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	H	Training of staff. PM to allow appropriate time within the schedule.
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Quality of work	Potential revisit to rectify, damaged reputation with client	L	M	Training off staff and review of photos and as-built documents after completion.
10	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.
11	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential	L	M	PM to plan as per access conditions supplied by the client. PM to variate any

		opportunity.			additional cost due to incorrect information.
12	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
13	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
14	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
15	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
16	Productivity of labour	Budget and schedule impact	L	L	Planning, monitoring and adjusting resources to meet schedule.
17	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access.
18	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
19	Late delivery of materials	Budget and schedule impact	L	L	PM planning and allowing float in schedule if possible.
20	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.

Project 10

Id	Description of Risk	Impact on Project	Probability Assessment	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire.	L	M	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (sub-contractor)	Potential delay. Revisit may be required at contractors cost	L	M	Training of sub-contractors.
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, and PM. Completion of daily site reports by field staff
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	L	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	L	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	L	Training of staff. PM to allow appropriate time within the schedule.
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Limited EWP Access	Delay, stand down of staff and increased cost of plant hire.	L	M	PM to investigate prior to mobilisation. To be investigated during design visit.
10	Quality of work	Potential revisit to rectify, damaged reputation with client	L	M	Training off staff and review of photos and as-built documents after completion.
11	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.

12	Additional EWP cost	Budget is impacted	L	M	Training of field staff and monitoring of progress.
13	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to plan as per access conditions supplied by the client. PM to variate any additional cost due to incorrect information.
14	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
15	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
16	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
17	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
18	Productivity of labour	Budget and schedule impact	L	L	Planning, monitoring and adjusting resources to meet schedule.
19	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access.
20	Insolvency of subcontractor	Budget impact	L	H	Procurement team to have appropriate contract in place.
21	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
22	Late delivery of materials	Budget and schedule impact	L	L	PM planning and allowing float in schedule if possible.
23	Late arrival of plant	Budget and schedule impact	L	L	PM to liaise clearly with plant provider.
24	Plant failure	Budget and schedule impact	L	L	Monitor and adapt if required.
25	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.

Project 11

Id	Description of Risk	Impact on Project	Probability Assessment	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire.	L	M	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (internal resources)	Potential delay or requirement for additional materials. Increase of costs, delayed schedule. Possible remobilisation to rectify.	L	M	Training of staff and contractors. Sub-contract work.
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, and PM. Completion of daily site reports by field staff
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	L	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	L	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	L	Training of staff. PM to allow appropriate time within the schedule.
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Limited EWP Access	Delay, stand down of staff and increased cost of plant hire.	L	M	PM to investigate prior to mobilisation. To be investigated during design visit.
10	Quality of work	Potential revisit to rectify, damaged reputation with client	L	M	Training off staff and review of photos and as-built documents after completion.

11	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.
12	Additional EWP cost	Budget is impacted	L	M	Training of field staff and monitoring of progress.
13	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to plan as per access conditions supplied by the client. PM to variate any additional cost due to incorrect information.
14	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
15	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
16	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
17	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
18	Productivity of labour	Budget and schedule impact	L	L	Planning, monitoring and adjusting resources to meet schedule.
19	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access.
20	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
21	Late delivery of materials	Budget and schedule impact	L	L	PM planning and allowing float in schedule if possible.
22	Late arrival of plant	Budget and schedule impact	L	L	PM to liaise clearly with plant provider.
23	Plant failure	Budget and schedule impact	L	L	Monitor and adapt if required.
24	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.

Project 12

Id	Description of Risk	Impact on Project	Probability Assessment	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire.	L	M	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (internal resources)	Potential delay or requirement for additional materials. Increase of costs, delayed schedule. Possible remobilisation to rectify.	L	M	Training of staff and contractors. Sub-contract work.
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, and PM. Completion of daily site reports by field staff
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	L	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	L	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	L	Training of staff. PM to allow appropriate time within the schedule.
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Limited EWP Access	Delay, stand down of staff and increased cost of plant hire.	L	M	PM to investigate prior to mobilisation. To be investigated during design visit.
10	Quality of work	Potential revisit to rectify, damaged reputation with client	L	M	Training off staff and review of photos and as-built documents after completion.

11	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.
12	Additional EWP cost	Budget is impacted	L	M	Training of field staff and monitoring of progress.
13	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to plan as per access conditions supplied by the client. PM to variate any additional cost due to incorrect information.
14	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
15	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
16	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
17	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
18	Productivity of labour	Budget and schedule impact	L	L	Planning, monitoring and adjusting resources to meet schedule.
19	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access.
20	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
21	Late delivery of materials	Budget and schedule impact	L	L	PM planning and allowing float in schedule if possible.
22	Late arrival of plant	Budget and schedule impact	L	L	PM to liaise clearly with plant provider.
23	Plant failure	Budget and schedule impact	L	L	Monitor and adapt if required.
24	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.

Project 13

Id	Description of Risk	Impact on Project	Probability Assessment	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire.	L	M	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (sub-contractor)	Potential delay. Revisit may be required at contractors cost	L	M	Training of sub-contractors.
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, and PM. Completion of daily site reports by field staff
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	M	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	M	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	H	Training of staff. PM to allow appropriate time within the schedule.
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Limited EWP Access	Delay, stand down of staff and increased cost of plant hire.	L	M	PM to investigate prior to mobilisation. To be investigated during design visit.
10	Quality of work	Potential revisit to rectify, damaged reputation with client	L	H	Training off staff and review of photos and as-built documents after completion.
11	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.

12	Additional EWP cost	Budget is impacted	L	M	Training of field staff and monitoring of progress.
13	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to plan as per access conditions supplied by the client. PM to variate any additional cost due to incorrect information.
14	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
15	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
16	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
17	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
18	Productivity of labour	Budget and schedule impact	L	L	Planning, monitoring and adjusting resources to meet schedule.
19	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access.
20	Insolvency of subcontractor	Budget impact	L	H	Procurement team to have appropriate contract in place.
21	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
22	Late delivery of materials	Budget and schedule impact	L	M	PM planning and allowing float in schedule if possible.
23	Late arrival of plant	Budget and schedule impact	L	L	PM to liaise clearly with plant provider.
24	Plant failure	Budget and schedule impact	L	L	Monitor and adapt if required.
25	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.

Project 14

Id	Description of Risk	Impact on Project	Probability Assessment	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire.	L	M	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (internal resources)	Potential delay or requirement for additional materials. Increase of costs, delayed schedule. Possible remobilisation to rectify.	L	M	Training of staff and contractors. Sub-contract work.
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, and PM. Completion of daily site reports by field staff
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	L	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	L	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	L	Training of staff. PM to allow appropriate time within the schedule.
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Limited EWP Access	Delay, stand down of staff and increased cost of plant hire.	L	M	PM to investigate prior to mobilisation. To be investigated during design visit.
10	Quality of work	Potential revisit to rectify, damaged reputation with client	L	M	Training off staff and review of photos and as-built documents after completion.

11	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.
12	Additional EWP cost	Budget is impacted	L	M	Training of field staff and monitoring of progress.
13	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to plan as per access conditions supplied by the client. PM to variate any additional cost due to incorrect information.
14	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
15	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
16	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
17	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
18	Productivity of labour	Budget and schedule impact	L	L	Planning, monitoring and adjusting resources to meet schedule.
19	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access.
20	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
21	Late delivery of materials	Budget and schedule impact	L	L	PM planning and allowing float in schedule if possible.
22	Late arrival of plant	Budget and schedule impact	L	L	PM to liaise clearly with plant provider.
23	Plant failure	Budget and schedule impact	L	L	Monitor and adapt if required.
24	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.

Project 15

Id	Description of Risk	Impact on Project	Probability Assessment	Impact Assessment	Strategic Actions
1	Incorrect design	Potential delay or requirement for additional materials. Increase of costs and delayed schedule.	L	M	Complete review of design prior to mobilisation. Review existing site configuration at time of arrival to site.
2	Inclement weather	Delay, stand down of staff and increased cost of plant hire.	L	H	Request approval from client prior to mobilisation in inclement weather.
3	Use of incorrect installation procedures (internal resources)	Potential delay or requirement for additional materials. Increase of costs, delayed schedule. Possible remobilisation to rectify.	L	M	Training of staff and contractors. Sub-contract work.
4	Change Management	Failure to identify out of scope works. Loss of revenue for works completed.	M	L	Training of staff, and PM. Completion of daily site reports by field staff
5	Supply of incorrect materials	Delay of teams on site, schedule delay, additional transport costs.	M	M	Site team to check materials before mobilisation. PM to review materials prior to mobilisation. Field team to mobilise with additional emergency spares.
6	Failure to secure network outages	Delay of schedule. Potential remobilisation.	L	M	PM to complete adequate planning prior to mobilisation.
7	Incorrect completion of as-built documentation	Revisit to site to rectify before RPC can be achieved.	L	H	Training of staff. PM to allow appropriate time within the schedule.
8	Incorrect access documentation	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to arrange prior to mobilisation and seek information from client where required.
9	Limited EWP Access	Delay, stand down of staff and increased cost of plant hire.	L	M	PM to investigate prior to mobilisation. To be investigated during design visit.
10	Quality of work	Potential revisit to rectify, damaged reputation with client	L	H	Training off staff and review of photos and as-built documents after completion.

11	Schedule slip	Effect on client, customer relationship	L	M	Appropriate planning and monitoring of progress.
12	Additional EWP cost	Budget is impacted	L	M	Training of field staff and monitoring of progress.
13	Site access issues	Delay for construction access. Stand down of team awaiting resolution of access. Potential opportunity.	L	M	PM to plan as per access conditions supplied by the client. PM to variate any additional cost due to incorrect information.
14	Stakeholder requirements	Bad reputation as outcome does not meet client's needs.	L	H	PM to refer to project charter and to request input from client where opportunities arise.
15	Tight project schedule	Potential of effect on time, cost and quality	L	M	Planning, monitoring and adjusting resources to meet schedule.
16	Accidents or incidents	Potential damage to plant, material, staff or public. Additional costs, delays and damaged reputation.	L	H	Planning, training of staff and supervision of high risk activities.
17	Damage to property	Budget impact	L	M	Planning, training of staff and supervision of high risk activities.
18	Productivity of labour	Budget and schedule impact	L	L	Planning, monitoring and adjusting resources to meet schedule.
19	Site security	Potential damage or theft of material on site. Safety of general public	L	H	Securing site and fencing off public access.
20	Natural Catastrophes	Potential damage to site and reduced safety to the public and workers.	L	H	PM to monitor weather and adjust schedule where possible.
21	Late delivery of materials	Budget and schedule impact	L	L	PM planning and allowing float in schedule if possible.
22	Late arrival of plant	Budget and schedule impact	L	L	PM to liaise clearly with plant provider.
23	Plant failure	Budget and schedule impact	L	L	Monitor and adapt if required.
24	Incorrect site investigation	Potential revisit to site or redesign required.	L	L	Review of design throughout planning phase.