

**Management blindness leading to black swan events: An
analysis of decision-making styles of key decision-
makers in the Pike River coal mining disaster**

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Abstract

Management blindness leading to black swan events: An analysis of decision-making styles of key decision-makers in the Pike River coal mining disaster.

This research investigates decision-making under uncertainty, and the possible reasons decision-makers fail to foresee, or are blind to the potential for black swan events, that is consequential surprise events. Three types of blindness were identified: the illusion of certainty; inductive cognitive biases; and a single unquestioned top-down reference narrative.

The research ties all these different threads together in two ways, First, by developing an uncertainty spectrum chart, which describes the different ways of understanding the uncertainty spectrum of the physical environment, through existing frameworks, such as the Snowden's Cynefin framework and the states of knowing. The second thread focuses on understanding the two broad types of decision-makers, and this is done through the use of Tetlock's fox/hedgehog framework. In using this framework, emphasis is placed on the different fox/hedgehog attitudes to uncertainty are highlighted or emphasized. Hedgehog cognitive thinkers focus predominantly on the known and certain. This makes them very susceptible to being blindsided by Taleb's black swan events when dealing with complexity and uncertainty. By contrast, Kay and King believe foxes have greater awareness of their lack of knowledge in situations of high uncertainty, where they prepare for the unexpected by having multiple options of the future.

The case setting examined in this study is the New Zealand 2010 Pike River coal mine explosion. This was selected from historical Royal Commission inquiries that had national and local significance, high degrees of complexity and uncertainty. The Pike River explosion resulted in the loss of 29 lives and all funds invested in the mine (being over \$300m). The primary source of information for the case study was documents aligned to the subsequent Royal Commission of Inquiry, and the case analysis undertaken was qualitative in nature, using a variety of complementary lenses and methodological approaches.

The weaving of many methodological practices used in this complex case study can be viewed as bricolage or quilt making, using whatever strategies, methods, empirical materials that were available. Throughout the case study, the ex-ante public statements and attitudes of three key decision-makers (i.e., board chair, CEO, and General-Manager Mines, supported by the 'in-group') were compared to the actor-critics, whose views only became public at the RCI hearings.

Overall, the research found that Pike River Coal Ltd's three key decision-makers (and supporting in-group) had adopted the overconfident attitudes reflective of a hedgehog cognitive thinking style. This included underestimating and oversimplifying the inherent uncertainty; oversimplifying the inherent complexity, through the use of inductive cognitive biases; and strongly defending their collective reference narrative, which they believed was compelling and robust, from actor-critics who unsuccessfully challenged it. These behaviours limited Pike's collective intelligence to the small in-group at a time when opportunity was available to increase Pike's collective intelligence by drawing on the intelligence of other actors.

The hedgehog cognitive thinking style and reference narrative of Pike's three key decision-makers was in hindsight, flawed. That thinking style was not appropriate for a complex situation of radical uncertainty where they experienced one unexpected surprise after another, leading up to the methane explosion(s) that they didn't believe was likely to happen. It was a black swan event for the key decision-makers and all those who relied on them, such as workers, shareholders and the general community.

This study makes theoretical, methodological and practical contributions, for example, by: developing a new conceptual framework and related perspective; by providing new insights into the Pike River coal mine disaster as a black swan event; and it provides a new framework for managers to use; and for Commissions of Inquiry to use ex-ante or ex-post, when dealing with potential black swan situations that are highly uncertain and complex.

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List of abbreviations

Abbreviation	
ABM20	ABM20 continuous mining machine
BDA	Behre Dolbear Australia, coal mine consultants
BHP	BHP Billiton Ltd, an Anglo-Australian multinational mining, metals and petroleum company
CEO	Chief Executive Officer
DIA	Department of Internal Affairs
DOC	Department of Conservation. They owned the reserve land that the Pike mine went under.
DOL	Department of Labour. This department included health and safety inspectors as well as specialist mine inspectors.
GM	General Manager
JORC Code	The Australasian code for reporting of exploration results, mineral resources and ore reserves. It sets minimum standards for public reporting.
IPO	The initial public offer, enables a private company to be a publicly listed one.
NZ	New Zealand
NZO&G	New Zealand Oil and Gas Ltd. It was a publicly listed company that set up Pike.
OECD	Organisation for Economic Co-operation and Development
Pike	Pike River Coal Ltd. It was a publicly listed company.
Royal Commission or RCPRCMT	A New Zealand Royal Commission on the Pike River Coal Mine Tragedy. This was established on 29 November 2010.
SIMTARS	The Safety in Mines Testing and Research Station. This organisation was established by the Queensland Government following a number of coal mine tragedies.
Solid Energy	A state-owned enterprise (SOE), owned by the New Zealand Government. It was the largest coal mining company in New Zealand.
WYSIATI	What You See Is All There Is (Kahneman, 2011)
3D	Three-dimensional

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1. Introduction

1.1 Background to the case study, research question and contribution

This research investigates the problem of surprise black swan events occurring outside an organisation's collective reference narrative and the frameworks that support that view. Examples of black swan surprises at a national level include the Global Financial Crisis (GFC) and the great recession of 2007-2009 and the COVID19 pandemic of 2020. In New Zealand, the Pike River coal mine disaster was a black swan event for the decision-makers and other stakeholders of the Pike mine and this was selected as the case study for this research.

1.1.1 Overview of the case study

An explosion at the Pike River coal mine, near Greymouth, on the west coast of the South Island on 19 November 2010 'killed 29 miners. A Royal Commission of Inquiry into the Pike River Coal Mine Tragedy (RCPRCMT) was subsequently established. The commission found the immediate cause of the tragedy was a large methane explosion, with a number of potential ignition sources, that include arcing in the mine electrical system, a diesel engine overheating, and the use of electric motors in the non-restricted part of the mine (RCPRCMT, 2012).

The commission (RCPRCMT, 2012) endeavoured to establish both operational factors and systemic reasons that contributed to the tragedy. The inquiry was not limited to events at the mine, but extended its scope to the actions of the mining regulators and the effectiveness of mine industry regulation and practice in New Zealand. Some of the major themes that became apparent during the inquiry, were:

- This was a 'process safety accident', being an unintended escape of methane into the mine tunnels followed by an explosion in the mine. It occurred during a drive to initiate actual coal production in a mine experiencing problems in leadership, operation al systems and culture.

- Such problems coincided with inadequate oversight of the mine by a health and safety regulator that lacked focus, resourcing and inspection capacity.
- The legal framework for health and safety in underground mining was deficient.

The mine was new and the owner, Pike River Coal Ltd (Pike), had not completed the systems and infrastructure necessary to safely produce coal. Pike was still in start-up mode and was considerably behind in its development schedule. Its health and safety systems were inadequate. Market credibility, capital-raising, higher coal production, increased ventilation capacity, methane management and upskilling the workforce were significant challenges facing the company. Development delays meant cash flow was an issue. Pike's ventilation and methane drainage systems could not cope with everything the company was trying to do: driving roadways through coal, drilling ahead into the coal seam and extracting coal by hydro-mining, a method known to produce large quantities of methane. There were numerous warnings of a potential catastrophe at Pike River, but these were not heeded (RCPRCMT, 2012).

The commission (RCPRCMT, 2012) recommended a wide range of changes. These included:

- A better resourced and focused Crown entity to oversee health and safety in New Zealand.
- A strengthened regulatory framework for underground coal mining.
- A strengthened regulatory oversight, especially around the duties of statutory mine managers, worker participation, mine qualifications, and emergency management.
- The need to develop a code of good practice for directors and a separate one for managers, on how good governance practices can be used to manage health and safety risks.

- The need for managers in underground coal mines to be appropriately trained in health and safety.
- To require operators of underground coal mines to have modern equipment and facilities, and to support effective emergency management.

1.1.2 Research question and the importance of this research

Research questions

Why did the key decision-makers in Pike River Coal Ltd fail to foresee, listen to or act upon the black swan event?

Pike was a large complex organisation. Because a multimethod approach was used, and different approaches had different data sources and focus, it was found helpful in the case study phase to break the question down into three parts:

- ***What*** did they fail to foresee, listen to or act upon? I.e., the context.
- ***Who*** failed to foresee the black swan event?
- ***Why*** did they fail to foresee, listen to or act upon the black swan event?

From the answers to these questions comes a consequential objective:

- ***To develop a conceptual framework to assist key decision-makers and other stakeholders to better manage their organisation's approach to identifying and addressing potential black swan events.***

To answer these questions the research builds on four key foundational constructs being, strategic drift and the reference narrative; black swan events; uncertainty; and three common organisational forms of bounded rationality. These are described in Section 1.1.4.

The underlying importance of the research question

The world of economics, business and finance is non-stationary, being periodically turbulent and disruptive, and not predicted by scientific law. An important challenge in this world is to identify and respond to unique complex events, and because what is observed is not the outcome of a stationary statistical process, conventional statistic inferences (such as subjective Bayesian approaches) rarely apply and forecasts are often based on 'shifting sands'. When confronting an unknown future, optimisation models can fail to capture the disruptive behaviour that results (Kay & King, 2020). A key feature of the business and finance world when operating under such uncertainty, is surprise events, which Schiller (2019) notes when he observes that *'We can think of history as a succession of rare big events that no economist forecast'*.

The implications of this research are potentially significant. It is about how real people make choices in a radically uncertain world, in which probabilities cannot meaningfully be attached to alternative futures. This research considers the options that decision-makers have in relation to decision-making when there is poor knowledge of what is going to happen next, both individually and collectively. The research also considers decision-maker's attitudes to uncertainty and how they wittingly or unwittingly seek to simplify or oversimplify complexity through different cognitive biases and their reference narrative (Kay & King, 2020).

The COVID-19 pandemic is the latest surprise big event, perhaps being the greatest economic (and social/health) disrupter of this generation. Together with other complex challenges like climate change, this pandemic will ensure the economic and business environment will remain in the realm of an unknown future of radical uncertainty. This research seeks to develop a conceptual framework to help decision-makers make better decisions in this environment of radical uncertainty, where surprise events will keep on occurring. This makes this research very relevant, valuable and timely.

1.1.3 Researcher's background

The researcher is a mature student who has come from a policy/strategy/governance role in the public sector and has had experience in preparing technical reports across a range of subject and policy areas, including reports to Royal Commissions. The researcher is a chartered accountant (CA) member of the Chartered Accountants of Australia and New Zealand (CA ANZ), a Fellow and chartered member of Governance New Zealand, and an associate member of the New Zealand Institute of Directors.

This PhD research builds on his Master of Strategic Studies (MSS) at VUW's School of Government and his subsequent Master of Commerce and Administration (MCA), where his two Theses were titled, '*Picking the best strategic forecasting tool for the job at hand*' and '*Forecasting, when power law distributions apply*'. This research builds on aspects of complexity not able to be considered in earlier research projects.

1.1.4 Base theory, constructs and the research gap

This research discusses and critiques ideas, notions and frameworks drawn from four key sets of constructs. These are:

- **Black swan events**, being defined as, '*surprising extreme events relative to one's knowledge/beliefs*' (Aven, 2015). This definition was adopted at the final stage of this research to make explicit which interpretation of a black swan event was being applied. Refer Section 3.3.1 for an explanation of the research journey from the original definition from Taleb (2008a) to the one suggested by Aven (2015) above.
- **Uncertainty**, being defined as resolvable/radical as outlined by Kay and King (2020). Refer Section 2.2.1.5. This is overlaid with the Cynefin framework of Kurtz and Snowden (2003) which explicitly adds the complex and chaotic dimensions with their distinct and sometimes overlooked characteristics. The Cynefin framework can be simplified from four domains to just two, being

ordered and unordered and this is useful to overlay on the resolvable/radical categorisation. Refer Section 2.2.2. The Cynefin framework was adopted as a construct half way through the research project, whereas the Kay and King (2020) uncertainty definition was adopted late in the research period and after its 2020 publication. Whilst the uncertainty construct provides an important overview, it also helps explain one of the common forms of bounded rationality being the illusion of certainty.

- **Three common forms of bounded rationality** relating to organisational decision-making under uncertainty. These are, being blinded by a single top-down reference narrative, being blinded by inductive cognitive biases, and being blinded by the illusion of certainty. Refer Section 2.3.1.6. Individually each simplification may be valid, for example, it is common for CEO's to be extremely confident with a clear narrative. The three forms of bounded rationality are interdependent, so collectively form a cocktail of simplifications that can cause decision-makers to fail to see potential black-swan events. For all stakeholders (except the whistle-blowers) financial collapses like Enron (2001), Theranos – Elizabeth Holmes (2018) or Carillion plc (2018) were black-swan events. The illusion of certainty (Gigerenzer, 2014) and inductive cognitive biases (Kahneman, 2011) were developed from the start of the research, whilst being blinded to a single top-down reference narrative was introduced late in the research after reading Kay and King (2020).
- **Strategic drift and the reference narrative**
Strategic drift is described in Sammut-Bonnici (2015) as a gradual deterioration of a competitive action that results in the failure of an organisation to acknowledge and respond to changes in the business environment. Drift is a reflection of a static outlook, which over time becomes more distant from the reality of shifting conditions in the economy, technology, and consumer demand. Strategic drift is a form of cognitive sloth in the ability to meet the original objectives of an organisation. Symptoms include, homogeneous mind set at managerial and board levels, preservation of the status quo mind set, lack of focus on the external environment and decline in

performance (Sammut-Bonnici, 2015). In this research, the collective management/board mindset is called the 'reference narrative' as described by Kay and King (2020). Including the construct of strategic drift was woven into the research at the examination stage as an important and relevant foundational construct.

The research joins these constructs together. This starts with strategic drift where the organisational reference narrative becomes increasingly distant from the reality, causing a reality check, known as a surprise black swan event to occur. The ways to avoid this situation include encouraging diverse perspectives, championing innovation, promoting an external focus, industry benchmarking and market research and monitoring performance (Sammut-Bonnici, 2015). The gap in the research is not what happens when strategic drift connects with a black swan event but why do otherwise good boards and management teams get into this state of 'cognitive sloth'. The research question asks why key decision-makers failed to foresee, listen to or act upon a black swan event? The answer lies in the three types of organisational bounded rationality which this research explores. All three forms of organisational bounded rationality actively work to make a fixed and time bound organisational reference narrative, which causes strategic drift and therefore the potential for a black swan event to occur and not be anticipated.

1.1.5 The researcher's contribution

This research does not attempt to undertake an ex-post risk management assessment of the Pike River coal mine explosion, based on the similarly ex-post collective wisdom of the Royal Commission of Inquiry (i.e., with perfect hindsight). Instead, the research examines Pike's approach and the key decision-makers' responses, given what was known to them at the time of making their decisions. It does this by using the ex-post information to identify actor-critics who in their different ways, did their own ex-ante risk assessments and critiques various aspects of the Pike River mine operations, which assessment, differed materially from the official narrative of the key decision-makers. The research identifies the associated ex-ante reaction from the key decision-makers to these assessments. Based on those

critiques and the associated management reactions, the research aims to identify underlying patterns of decision-making behaviour and potential reasons for why the key decision-makers appeared blind to the possibility of a surprise black swan event, especially as ex-post, it is clear they actively disregarded the many warnings. These findings relating to decision-making behaviour may usefully inform other decision-makers operating in highly uncertain and complex/chaotic environments.

As such, this research potentially contributes to both theoretical and applied aspects of decision-making under uncertainty, in as much as it seeks to describe and explain the underpinnings of decision-making behaviour.

Theoretical contribution:

The research question places this research within the qualitative aspects of complexity and business decision-making under ‘uncertainty’, rather than the inherently quantitative nature of ‘risk’. It takes a different approach to the extant risk management approaches to surprise events that cause death. It examines uncertainty in two ways, first in an overall context, related to its position in the ‘uncertainty spectrum’ and the second reflecting the decision-makers’ perspective related to the use of the four states of knowing. Onto these four states is overlaid the fox/hedgehog categorisation of good and bad expert forecasters (Tetlock, 2005). These two simple frameworks were useful in tying together a range of related concepts and frameworks: such as black swan events (Taleb, 2008a), radical/resolvable uncertainty (Kay & King, 2020), the Cynefin framework (Snowden & Boone, 2007), the illusion of certainty (Gigerenzer, 2014), inductive cognitive biases (Kahneman, 2011), as well as objective or subjective probabilities and induction/deduction.

The individual conceptual threads or lines of thinking used in this research have been developed and explored by others. They come from a range of different literatures. What is unique with this research is that these different conceptual threads have been woven together into a flexible conceptual meta-framework. The resulting framework allowed the researcher to develop insights that would not have been possible by following just the different individual conceptual threads, as the

framework is a sum of the parts. Also, some of the threads are novel for different disciplines (i.e., economics or risk analysis) such as reference narratives and radical uncertainty. This is discussed further in Section 2.2.1.7.

A major finding from this approach, is that decision-makers who use a hedgehog cognitive thinking style that predominantly focuses on the known and certain (i.e., known, knowns) are especially prone to surprise black swan events when operating under high complexity/uncertainty. This finding runs counter to the standard risk-based approach which may apportion blame for prioritising production over safety. Both conclusions are valid, but the approach of this study helps explain why the conclusions from hindsight reviews of black swan disasters about what could or should have been done are often so different from what the decision-makers were thinking ex-ante and it helps explain why they were thinking like that.

In particular, this study identified three forms of bounded rationality or cognitive biases or blindnesses that lock decision-makers to the known and certain. These are:

- Blinded to a single top-down 'reference narrative'.
- Blinded by induction, which includes being blinded by induction and inductive cognitive biases.
- Blinded by the illusion of certainty.

Using the practical guide for theory contribution developed by Makadok, Burton, and Barney (2018), this research contributes in two ways to theory development. First, it introduces new causal cognitive blindnesses (i.e., the three forms of bounded rationality listed above) and secondly, it synthesizes these multiple causal blindnesses. Results are derived from a combination of causal blindnesses that could not be derived from any one of them (Makadok et al., 2018). Both these contributions address a 'why?' question, rather than the alternative questions of how, who, where, what or when?

Applied contribution:

The framework described above was applied to a business disaster, being the Pike River coal mine disaster 2010. The research found that the key decision-makers adopted an approach reflecting a hedgehog cognitive thinking style that focussed on the 'known, known' state of knowing. From public documentation, it was clear that the key decision-makers were affected by the three types of blindness listed above. These findings are a useful addition to the Royal Commission's findings which emerged using the 'Swiss Cheese Model' of analysis, which described numerous errors by numerous stakeholders (RCPRCMT, 2012). Early in the research this model was considered a possible approach to apply to the research, but the Swiss Cheese model is like a photograph in time, showing the holes in the control systems at the time of the disaster, rather than what this research was trying to understand was the dynamics over time, which is more like a film. Over time the holes would be changing and evolving shape and position within each slice of cheese as new situations arose and new controls added or removed. The drift over time approach used by Dekker (2011) was deemed more appropriate.

The findings of this research have a broader implication than just understanding the failings of the decision-making at the Pike mine. The research may have implications for all decision-making under high uncertainty and complexity, where there is a high potential risk of unexpected events occurring.

1.1.6 Where in the literature is this research situated?

This is a cross-disciplinary approach as evidenced by the sources of literature for the four foundational constructs. (Refer Section 1.1.4) For example, the term strategic drift comes from management/strategy literature; reference narratives and black swan events comes mainly from risk analysis/strategy literature; uncertainty mainly comes from risk analysis/economic literature; and the three forms of organisational bounded rationality (later called hedgehog blindnesses) come mainly from behavioural economic/risk analysis literatures. The research starts and ends with a

management/strategy research lens, since the research question and case study are essentially about the effectiveness of governance structures and processes.

This research is situated in the literature within decision-making under uncertainty. There are two main strands in this research. Both relate to uncertainty, but with a different focus. One uses the uncertainty spectrum as a means of situating the problem in an overall context of uncertainty and the other is decision-making based on the decision-maker's apparent preferred state of knowing. Each of these has a slightly different set of supporting literature. Uncertainty is a topic that does not fall neatly within a single discipline. Instead, it is spread across a variety of academic disciplines, professional contexts and problem domains. Consequently, some contend that there is no cogent, readily identifiable body of literature on uncertainty (Bammer & Smithson, 2009).

The uncertainty spectrum

The uncertainty spectrum diagrams summarise a wide set of literature that includes; the resolvable/radical definitions of uncertainty (Kay & King, 2020), the Cynefin sensemaking framework (Snowden & Boone, 2007), and the black swan concept (Taleb, 2008a). These aspects and their different supporting literature is described in Chapter 2, section 2.1: Introduction.

Decision-making based on the decision-maker's preferred state of knowing

This strand of the research literature draws together a number of different elements that relate to the behavioural aspects of organisational decision-making under uncertainty and the multi-disciplinary threads that make it up. There are strong links and overlaps to descriptive decision theory, behavioural decision theory and behavioural economics. In all these areas, the focus is on analysing how agents actually make decisions. Such analysis is mindful of psychological, cognitive, emotional, cultural and social factors on the decisions of individuals and organisations. Typical concepts reviewed included: the four states of knowing, reference narratives (Kay & King, 2020), various inductive cognitive thinking and biases, under/over-weighting of probabilities (Kahneman, Slovic, & Tversky, 1982);

inside-outside view/planning fallacy (Kahneman, 2011; Kahneman & Lovallo, 1993), looking forward and looking back (Dawes, 1999; Watts, 2012); and the fox/hedgehog cognitive thinking styles (Tetlock, 2005).

1.1.7 Structure of thesis

There are six chapters in this thesis. Chapter 1 provides an overview of the case study; background to the research and the research question; base theory, constructs and the research gap; as well as the potential theoretical/applied contributions to be made.

Chapter 2 outlines the literature review and the development of the conceptual framework used throughout the research, first with a discussion on uncertainty and risk and then moving on to the decision-maker's preferred state of knowing. It ends with a review of three 'hedgehog' or boundedly rational blindnesses that inadvertently or unwittingly keep the decision-makers cognitive focus solely on the known and certain, which is a blindness if the environment is complex and uncertain.

Chapter 3 outlines the research methodology used, and its rationale and appropriateness. This chapter covers the ontological and epistemological assumptions, the research design, research methods, the bricoleur's research journey, analysis of that journey and an introduction to emergent drift over time charts to understand accident investigations.

Chapter 4 is an analysis of the case-study, being the decision-making around the Pike River coal mine disaster in 2010, which involved a subsequent Royal Commission of Inquiry. Different methods of analysis are used to provide different lenses for learning, including analysing the Royal Commission final report, using the emergent drift charts, understanding the ownership/shareholding/power structures, using a 'forced scenario process lens' and analysing the various surprises to key decision-makers over the three years leading up to explosion.

Chapter 5 outlines the synthesis sections. Each of the three hedgehog blindnesses is considered in detail against the ex-ante/ex-post publicly available information of Pike's key decision-makers.

Chapter 6 includes the conclusion, research boundaries, research contribution and future research opportunities.

2. Literature review and conceptual framework construction

2.1 Introduction

2.1.1 Conceptual framework construction

Chapter 2 explores, builds on and weaves together the four foundational constructs. These are, black swan events, uncertainty, three common forms of organisational bounded rationality, and strategic drift and the reference narrative (Refer 1.1.4). The gap in the research is not what happens when strategic drift (Sammut-Bonnici, 2015) connects with a black swan event but why do otherwise good boards and management teams get into the cognitive sloth that causes their blindness. The research question asks why key decision-makers failed to foresee, listen to or act upon a black swan event? The answer lies in the three types of organisational bounded rationality which this research explores. All three forms of organisational bounded rationality actively work to make a fixed and time bound organisational reference narrative (i.e., mindset), which causes strategic drift and therefore the potential for a black swan event.

Chapter 2 deals with both a review of the literature and the building of a conceptual framework. The conceptual framework is based on a wide range of cross-disciplinary literature on decision-making under uncertainty, especially involving disasters. While the framework is not New Zealand-specific, it has been developed and applied (much later in the Thesis) to a single New Zealand case study. The framework that is developed provides the lens for examining the case study, for developing alternative perspectives and interpretations of events.

With the focus on developing a general conceptual framework, the specific problems of the decision-makers in the Pike River case study are not addressed in this chapter, but were always in mind when developing the framework. The theory development was always in parallel with the case study as both were emergent and related. The process of conceptual framework analysis was iterative, *'requiring a steady movement between concept and data, as well as comparative, requiring a*

constant comparison across types of evidence to control the conceptual level and scope of the emerging theory' (Orlikowski, 1993).

The literature review, as provided has an inherent focus on uncertainty involving two sets of metaphors, being surprise black swan events (Taleb, 2008a) and the fox/hedgehog cognitive thinking styles (Tetlock, 2005). While these metaphors are widely used, especially in literature and politics, they are mostly used as descriptors. Most studies merely quote the various definitions without much analysis of the metaphors themselves. For the fox/hedgehog distinction, many studies use the high-level definition outlined by Berlin (1953), that a hedgehog knows one big thing. This research, however, puts emphasis on the decision-maker's attitude to uncertainty, which builds on the wider description of a fox/hedgehog coming out of the empirical work of Tetlock (2005). This is a significant shift in application and usage and may result in different perspectives and findings relative to the earlier literature.

2.1.2 The purpose of having a literature review/conceptual framework construction section

O'Leary (2014) defines a literature review as a critical review of a body of knowledge including findings and theoretical and methodological contributions. It is a very specific piece of argumentation that acts to create a 'space' for the research study. This is pre-existing research that has already been conducted in the areas that directly relates to or complement the Thesis research question.

According to Miles and Huberman (1994), a conceptual framework '*lays out the key factors, constructs, or variables, and presumes relationships among them*'. A conceptual framework is not merely a collection of concepts but, rather, a construct in which each concept plays an integral role. A conceptual framework provides a means of developing an interpretative approach to social reality, rather than necessarily a causal/analytical setting. Conceptual frameworks can provide understanding, rather than just offering a theoretical explanation, as may quantitative models. Conceptual frameworks can be developed and constructed through a process of qualitative analysis (Jabareen, 2009).

This chapter follows with two major sections relating to the uncertainty spectrum (Section 2.2) and decision-making based on the decision-maker's preferred state of knowing (Section 2.3). A brief overview of these sections are outlined below, before the sections are developed in more detail.

The uncertainty spectrum

Section 2.2.1 considers decision-making under uncertainty and complexity. The historical context of decision-making under uncertainty is reviewed, outlining Knightian uncertainty, bounded rationality, and the value of diversity of thinking in decision-making. It then considers decision-making in a complex world by outlining the implications of complexity, the statistical and temporal aspects of decision-making, and it introduces the concepts of radical/resolvable uncertainty, objective and subjective probabilities, and the importance of the reference narrative and how organisations should ensure it is robust by constantly challenging it. From these different strands, a descriptive conceptual framework is developed which is termed as the uncertainty spectrum.

Section 2.2.2 describes the categorisation of uncertainty using the simplified Cynefin sense-making framework (Snowden & Boone, 2007) of ordered/unordered domains to give an additional lens for viewing and describing radical/resolvable uncertainty. These strands are also added to the uncertainty spectrum framework. The purpose of the uncertainty spectrum is to reflect and visually convey the complete spectrum of uncertainty, which is not always apparent, with matching elements from the different approaches. This helps the decision-maker understand what approaches are appropriate at different levels of uncertainty. This is especially important if decision-making is operating in a complex and dynamic environment that is outside the known and certain.

Decision-making based on the decision-maker's preferred state of knowing

Section 2.3 seeks to bridge the gap between the decision context and individual decision-makers' conscious/unconscious decision choices drawing on the four states of knowing and the level of awareness/uncertainty from Boschetti (2011). Decision-makers' preferences are examined, then drawing on frameworks of decision-making bias from Kahneman (2011), Gigerenzer (2014), and Taleb (2008a). These are then overlaid onto the fox/hedgehog categorisation of cognitive thinking styles provided by Tetlock (2005). These strands are also added to the uncertainty spectrum framework.

Throughout the development of the conceptual framework, a bricoleur process (Denzin & Lincoln, 2008) was used to weave together anything that was relevant, and this can be likened to making a quilt to produce an emergent overall pattern from all the individual parts used. Framework development evolved through the study, in what may be described as an iterative and emergent process.

2.2 Understanding the uncertainty spectrum

2.2.1 Decision-making under uncertainty and complexity

2.2.1.1 Assuming radical or Knightian uncertainty when decision-making

The distinction between risk and uncertainty and their implications for economic analysis and decision-making was first documented in the inter-war period. Economists Frank Knight and John Maynard Keynes defined risk as akin to predictable games of chance with probability distributions known at the outset, which could be represented probabilistically. This definition has come to be known as 'Knightian risk', which they distinguished from 'radical uncertainty'. Radical uncertainty, with unknown probability distributions, is not amenable to the same mathematical treatment/modelling as statistically quantifiable risk. Instead, it presumes some fundamental degree of ignorance, a limit to knowledge, and an essential unpredictability of future events (Kay & King, 2020).

"Uncertainty must be taken in a sense radically distinct from the familiar notion of risk, from which it has never been properly separated.... The essential fact is that 'risk' means in some cases a quantity susceptible of measurement, while at other times it is something distinctly not of this character; and there are far-reaching and crucial differences in the bearings of the phenomena depending on which of the two is really present and operating.... It will appear that a measurable uncertainty, or 'risk' proper, as we shall use the term, is so far different from an unmeasurable one that it is not in effect an uncertainty at all" (Knight, 1921).

"Uncertain' knowledge...about these matters there is no scientific basis on which to form any calculable probability whatever. We simply do not know" Keynes (1937).

For both Knight and Keynes, recognition of the pervasive nature of radical uncertainty was essential to an understanding of how a capitalist economy functioned. Knight asserted that radical uncertainty led to profit opportunities for

entrepreneurs, as their skill and luck in navigating it necessitated technical change and thereby drove economic progress. Both Keynes and Knight denied that probabilities could be applied outside the realm of known or knowable frequency distributions. While the Knightian distinction between risk and uncertainty is widely acknowledged, it relies largely on narrative analysis and this presented a problem for classical economics and its equilibrium framework, as uncertainty without a known probability distribution could not be modelled (Kay & King, 2020).

2.2.1.2 Assuming an ‘as if’ simplification of reality of perfect knowledge and rationality when decision-making

Friedman and Savage (1948) moved away from Knightian definitions when introducing the value of subjective probability, which paved the way for developing the elegant mathematical models of the equilibrium framework. Savage was modest about the scope of his approach, i.e., that it was only applicable to the small world of gambles, but Friedman had few doubts. The Friedman-Savage utility function asserts that individuals, when making decisions, behave ‘as if’ they calculated and compared expected utility and ‘as if’ they knew the odds. Like any model, this simplification of reality can be a useful first order approximation.

Savage (1954) proposed that the notion of probability included more than just the strictly objective and repetitive events based on past data with a well-defined sample space (called objective or frequentist probability, applicable to Knightian risk). He also included what he called personalistic probability (now called subjective). These probabilities are not objectively known, but are interpreted as reasonable expectations representing a state of knowledge or as a quantification of a personal belief. This subjective approach is used where there is incomplete knowledge or partial ignorance, but this approach becomes problematic if not enough information about what is known, is known. Savage’s subjective approach challenged the dominant frequentist school, as Savage (1954) notes about his approach, ‘*the foundations are the most controversial parts of many, if not all, sciences.*’ In statistics, the foundation of probability is ‘*as controversial a subject as one could name.*’

Savage's subjective probability theory has become the standard approach to modeling uncertainty in the social sciences and this has proved productive, especially through the use of Bayesian reasoning. Now probabilities could be attached to every conceivable event and decisions spelt out as a choice from a set of mutually exclusive alternatives, influenced only by the probabilistically-defined conceived events.

The subjective interpretation of probability does not draw a distinction between risk and a wider concept of uncertainty; so, this approach denies the existence of Knightian uncertainty. For example, Friedman (2007, p. 282) wrote, '*Knight drew a sharp distinction between risk, as referring to events subject to a known or knowable probability distribution, and uncertainty, as referring to events for which it was not possible to specify numerical probabilities. I've not referred to this distinction because I do not believe it is valid. I follow L.J. Savage in his view of personal probability, which denies any valid distinction along these lines. We may treat people as if they assign numerical probabilities to every conceivable event*'. Adopting this approach meant that radical uncertainty had effectively been tamed by subjective or personal probabilistic reasoning and radical uncertainty was no longer at the heart of economic analysis, as suggested by Knight and Keynes (Kay & King, 2020).

Friedman (1953) argued that if the economy behaves 'as if' people were perfectly rational, then it really does not matter whether people are perfectly rational or not. For example, '*It is frequently convenient to present such hypothesis by stating that the phenomena it is desired to predict behave in the world of observation **as if** they occurred in a hypothetical and highly simplified world containing only the forces that the hypothesis asserts to be important.*' Assumptions need no further justification as long as the results are correct. This significantly simplified the assumptions made, and now the economic models could be mathematical. People were assumed to have perfect rationality, i.e., they know everything possible about the future and can crunch all the information to make rational decisions. This worked well for population samples, but not so well for unique one-off events (Beinhocker, 2006).

More recently, Aven (2010) claimed Knightian risk is an empty phrase, because, *'It is difficult to find any good argument for using this terminology. It is not in line with the common risk language. Referring to risk only when we have objective distributions would mean excluding the risk concept from most situations of interest. If we adopt the subjective or Bayesian perspective on probability, Knight's definition of risk becomes empty. There are no objective probabilities. Given these observations, it is hard to understand why the definition is still being used. In my view we should abandon the Knight nomenclature once and for all... The scientific risk fields cannot be based on a terminology that simply restricts itself to a set of more or less trivial situations and excludes the majority of cases.'*

2.2.1.3 Behavioural aspects of decision-making

Simon (1957), after observing managers in their work places, put forward his competing theory of decision-making under uncertainty to Friedman and Savage. This introduced the concept of bounded rationality. Simon's theory took into account people's lack of perfect information, the large but still finite processing power of human brains, and the costs (in time and money) of information acquisition and processing. Simon proposed that people, instead of being perfectly rational and optimising, 'satisfice', i.e., take the information available and look for an answer that is 'good enough' rather than the absolute best possible. Kahneman (2011) regards Simon as foundational to the study of contemporary decision-making. However, the inability to mathematically model uncertainty limited his contribution to neoclassical economic theory (Beinhocker, 2006). Nevertheless, Simon's contribution is foundational to thinking about risk and uncertainty in transaction cost economics (Williamson, 1986, 2010) and behavioural economics.

Behavioural economists Kahneman and Tversky (1979) also offered an alternative account of behaviour under uncertainty to the conventional 'rational' view based on the Friedman-Savage axioms. Uncertainty was 'coded' relative to a reference point around which gains were valued less than losses of similar amounts were resented. Kahneman and Tversky differed from Simon by making the decision-maker the subject of interest rather than the model of decision-making. They questioned the

predictable determinism of the mechanistic models of decision-making proposed by the economists seeking to maximise system-wide outcomes by allowing for idiosyncratic differences in decisions made by individuals of different capacities in different circumstances. Real people are also fallible and subject to biases in their decision-making. Despite these advances, economic models that incorporate this realistic environment have remained elusive (Beinhocker, 2006; Kay & King, 2020). One of the problems for decision-making in applying this approach is that for most ordinary circumstances, Type 1 heuristic shortcuts (defined as fast, intuitive, unconscious thought, and being prone to cognitive biases, as opposed to Type 2 thinking which is slow and requires conscious effort, but is more resistant to cognitive biases), do lead to reasonable judgements (Kahneman, 2011). It is only in non-standard situations that biased and seriously flawed answers are produced (Mercier & Sperber, 2018).

2.2.1.4 Decision-making in a complex world

During the latter half of the twentieth century scientists became interested in dynamic systems that never settled into a rest (equilibrium) state (Beinhocker, 2006). They called these complex systems. A complex system is a system of many dynamically interacting parts or particles. In such systems the micro-level interactions of the parts or particles lead to the emergence of macro-level patterns of behaviour. A complex adaptive system is when the parts/particles/agents have the ability to process information and adapt their behaviour (Beinhocker, 2006).

Complexity is an interdisciplinary domain, and it draws contributions from many different fields. These include the study of self-organization from physics (Bak, 1996; Gell-Mann, 1994), that of spontaneous order from the social sciences, path-dependency from chemistry (Prigogine & Stengers, 1984), chaos and nonlinear dynamics from mathematics (Mandelbrot, 2001), adaptation from biology, the butterfly effect from meteorology (Lorenz, 1995) and network theory. Complexity, therefore builds on a long and rich intellectual history that includes figures in management-related areas, such as game theorists (Von Neumann & Burks, 1966); economists (Hayek, 1962); behavioural economists (Kahneman & Tversky, 1979;

Simon, 1982); institutional economists (North, 2005); evolutionary economists (Nelson & Winter, 1982); political scientists (Axelrod, 1997; Schelling, 1958); and computer scientists (Holland, 1998). These different inputs provided new tools for analysis that supported this new understanding of how complex systems worked. The rise of complexity therefore followed the rise in the processing power of computers (Beinhocker, 2006; Colander & Kupers, 2014).

In complexity theory, social systems such as the economy are viewed as complex adaptive (constantly changing) dynamic systems (Beinhocker, 2006). For example, the economy is too complex, interdependent, nonlinear, dynamic, and sensitive to the twists and turns of chance to be amenable to predictions over anything but the very shortest of terms. The complexity viewpoint therefore questions many of the standard assumptions of the traditional economic models. Even if humans were as rational as possible and had all the necessary information, the computational complexity of the economy is such that the future would happen before they would have time to predict it. In radical uncertainty we cannot know which bits of information are useful. Uncertainty is inherently intrinsic to complex systems with its interdependent parts, so those dealing with complex systems always need to be aware of the inherent limitations of their knowledge (Beinhocker, 2006).

Beinhocker (2006) states that organisations are complex adaptive systems nested within the larger complex adaptive system of the economy. Organisations are made up of individual agents and groups who dynamically interact with each other; agent rules of behaviour and networks of interactions change in response to changes in the environment; and agents' interactions produce emergent macro-level patterns of behaviour (Beinhocker, 2006).

An analysis of a complex system must consider the interconnectedness of the parts together with the parts themselves, which implies that in a complex system the whole is not necessarily equal to the sum of the parts (Colander & Kupers, 2014). Each component is ignorant of the behaviour of the system as a whole, and does not know the full effects of its actions either. Components respond locally to information presented to them there and then. The knowledge of each agent is limited and local (Dekker, 2011).

Beinhocker (2006) notes that managing a complex environment needs an adaptive mindset, which mirrors the approach of venture capitalists who use their portfolios to learn their way into the future. Instead of taking one big, risky bet to innovate, they take many small ones and only bet big on something that works. Adaptive mindsets are highly pragmatic, valuing tangible facts about today more than guesses about the future, assuming that not everything will work out as planned and preferring lots of small failures to big ones. They are willing to change course when the circumstances change. The result of adaptive thinking is more of a zig-zag rather than the straight line of many conventional strategy approaches which forecast the future, devise a strategy and then action it (Beinhocker, 2006).

Schneider (2001, 2004, 2010) suggests that in reality, complete or perfect knowledge of complex systems, which would permit the credible calculation of objective or frequentist probabilities rarely exists and experiments on the future are impossible. In such an environment (like the study of climate change), prediction is wholly a subjective Bayesian exercise, but with the proviso that these non-linear systems, with unbounded complexity of causal chains and open networks, are especially subject to unexpected behaviours and surprises. These surprises include extreme outcomes or tipping points which lead to unusually rapid changes of state and irreversible events (Schneider, 2001, 2004, 2010).

The ‘bad news principle’ and other timing aspects of decision-making

The timing of decision-making is important. Decision-makers are more sensitive to changes in a ‘bad news’ payoff state and are less responsive to changes in the high-payoff state. The threshold price that warrants immediate investment depends on the size of the downward movement, not of the upward movement size. Waiting, rather than deciding now, keeps other options open and may give the investor more information (Bernanke, 1983; Dixit & Pindyck, 1994). In the computer world this is called premature optimization (Epstein, 2019).

Another aspect around timing of decision-making under uncertainty is how decision-makers change can change their views ex-ante to ex-post. For example, health

insurance decisions made by an individual in the ex-ante uncertain or uninformed state may differ from those made by the same individual in the ex-post certain or informed state. The level of knowledge differs considerably between those two points of time (Danzon, 1997).

Statistical aspects of decision-making

There can be a statistical aspect of decision-making, which revolves around people's understanding of different statistical/causal effects of population versus individual results. Blastland (2019) states that people make causal links and assume regularity in the way that one thing leads to another. But there is a disruptive power of irregularity that periodically frustrates people's plans and purposes, and limits their power. This irregularity is often caused by subtle and hard-to-detect-or-predict factors. Often it is due to the way some people think about probabilities. Much of life is probabilistic, but this requires an understanding that what is a valid probability in large-scale populations (i.e., an average result) will not always be valid at the individual level (i.e., especially an outlier). As with the Type 1 cognitive thinking of Kahneman (2011), it is not the normal that is a problem, but the infrequent outliers that the averaging or our thinking has eliminated (Blastland, 2019).

Colander and Kupers (2014) suggests that diversity plays a different, more central role in complex systems than it does in simple systems. In practice, policy makers deal with diversity by looking at averages, which is appropriate for simple linear systems, rather than at distributions or patterns of diversity which are important in complex systems. In a complex system with feedback systems, averages can often be inappropriate or make the analysis completely meaningless. Diversity of responses strengthens systems-level resilience – to avoid the system being fragile and unable to handle external shocks. The standard policy frame has diversity framed as a symptom of inefficiency. In the complexity frame, it is an essential ingredient of innovation and resilience (Colander & Kupers, 2014; Page, 2007).

2.2.1.5 Decision-making in a complex world involves recognising radical uncertainty

Subjective probabilities reflect individual judgement, and indeed different people may attach different probabilities to the same past, present or future events. The probability expresses their confidence in their opinion of what may happen. This is not a calculation of probabilities but a weighing up of the credibility and coherence of competing narratives. Hence, there is a strong need for more humility in presenting this information (Kay & King, 2020).

Kay and King (2020) note that while extreme and unique events are the most important challenge in the world of economics, business and finance, they were mostly not captured or reflected in existing models. They do not believe Knightian uncertainty has been tamed by probabilistic reasoning and suggest that conventional thinking, which focuses almost exclusively on risk and probability and not uncertainty, should be reversed. They believe we should replace the distinction between risk and uncertainty with resolvable and radical uncertainty (Kay & King, 2020).

Kay and King (2020) suggest that resolvable uncertainty is uncertainty which can be removed by further research or which can be represented by a known stationary probability distribution of outcomes, e.g., a games of chance which are repeatable and repeated. Probability has a clear and objective meaning. This is called a 'small world' which fits into the state of knowing called 'known, knowns', in which we can then solve problems by maximising expected utility. This is very useful, but it is a very limited class of applications. This compares to the large world in which we actually live. Only in small worlds are right and wrong answers clearly identified in advance (Kay & King, 2020).

Resolvable uncertainty can be thought of as puzzles. A puzzle has well-defined rules and a single solution, and we know when we have reached that solution. Puzzles deliver the satisfaction of a clear-cut task and a correct answer. Even when the puzzle-player cannot find the right answer, they know it exists. Puzzles can be solved; they have answers. But the solutions may be difficult to find (Kay & King, 2020).

Kay and King (2020) offer a view that radical uncertainty has many dimensions; obscurity; ignorance; vagueness; ambiguity; ill-defined problems; and a lack of information. These aspects of uncertainty make up everyday experience. Radical uncertainty cannot be described in the probabilistic terms applicable to a game of chance. Most events are not a random drawing from a well-defined and stationary probability distribution. There is no stable structure of the world about which we could learn from past experience and use to extrapolate future behaviour. Under radical uncertainty most decision-makers cope rather than optimise. It is not just that they do not know what will happen. They often do not even know the kinds of things that might happen. This is a world of uncertain futures and unpredictable consequences. There will be differences of views, as there is no objective right answer, either before or after the event. This world of radical uncertainty is the world most decision-makers live in, both in their individual and collective decisions (Kay & King, 2020).

Kay and King (2020) state that radical uncertainty can be thought of as a mystery. Mysteries offer no clarity of definition, and no objectively correct solution: they are imbued with vagueness and indeterminacy. When approaching a mystery the decision-maker needs to ask 'What is going on here?', and recognise that even afterwards our understanding is likely to be only partial. They provide none of the comfort and pleasure of reaching the 'right' answer. A mystery can only be framed by identifying the critical factors and applying some sense of how these factors have interacted in the past and might interact in the present or future. Mysteries require acknowledgement of ambiguities and to resolve them sufficiently to clarify the decision-maker's thinking. Real life offers mysteries, either because the outcome is unknowable or because the issue itself is ill-defined (Kay & King, 2020).

Gigerenzer (2014) suggests that most of the time people live in a changing world of radical uncertainty of unknown risks. Uncertainty refers to more than unknown probabilities ('ambiguity'); it can extend to not knowing all the alternatives and consequences. The world of uncertainty is huge compared to that of risk. Whom to marry? Whom to trust? Where to go on holiday? There are unknown unknowns and surprises. In an uncertain world, not everything is known, and it is beyond probability theory. Optimization (finding the best course of action) is by definition unfeasible in

an uncertain world; therefore, the goal is to find a robust course of action, one that has a good chance of surviving in the unknown future. Here, good rules of thumb and intuition are required (Gigerenzer, 2014).

2.2.1.6 The importance of the reference narrative when dealing with high uncertainty/complexity

To cope with resolvable uncertainty quantitative approaches are ideal, but to cope with radical uncertainty decision-makers also need qualitative approaches. They try to form a coherent and credible answer to the question 'What is going on here?' They cope with the future by organising their lives around reference narratives. A central element of this ability is people's capacity for, and pleasure in storytelling. People change the reference narrative in response to disconfirming events, but infrequently and discontinuously. And they do not construct these narratives in isolation. They discuss them with family and friends. They take advice from professionals and they benefit from the collective intelligence accumulated and readily available in the various communities in which they live. This collective reference narrative helps decision-makers understand the environment and to answer the question, 'What is going on here?' Risk is defined as the failure to achieve the reference narrative of a successful mission, derived from realistic expectations, to unfold as envisaged (Kay & King, 2020).

The value of narratives to understand significant surprise events is especially relevant to economics, since economists tend to rely on quantitative, rather than qualitative, observations. This has resulted in good very short-term forecasts, but as Schiller (2019) observes, '*We can think of history as a succession of rare big events that no economist forecast.*' Understanding the economic narratives surrounding these events is essential to understanding these events.

Reference narratives change and evolve over time, so they need to be constantly challenged. Risk-averse individuals are defined as those who are reluctant to move outside the comfort zone of their established reference narrative. They seek certainties in a world of radical uncertainty by trying to limit themselves to a small,

stationary world. They 'defend' their reference narrative. Risk lovers are defined as those who are constantly seeking a new reference narrative, and through that search change, for better and worse, the reference narrative of everyone else. The risk lovers are the creative individuals of history and business and they actively try to 'extend' the reference narrative (Kay & King, 2020).

2.2.1.7 Building the uncertainty spectrum

This chapter has covered many of the key viewpoints on uncertainty developed over the twentieth century and it highlights the major differences that are still evident, for example, the novelty of adopting the Kay and King (2020) radical/resolvable uncertainty framework, as this research does. The use of an extant "Narrative" as a frame, framework or construct is common in the social sciences or in futures research (Dillon & Craig, 2021), but in economics/management reference narratives (being a collective organisational mindset) is a novel concept, since economics has traditionally assumed that preferences are located exclusively with the individual, which ignores the influence of social groups on individual preferences (Akerlof & Snower, 2016). Another important reason for the absence of narratives in mainstream economics is that it deals almost exclusively with decision making under risk (whereby the probability distributions of all random variables are assumed to be known) rather than under uncertainty (whereby these distributions are unknown) (Akerlof & Snower, 2016).

Figure 2.1 combines the various approaches to uncertainty. The line between subjective probability (which attempts to have a probability for everything) and radical uncertainty is on an angle to indicate that radical uncertainty increases with higher uncertainty. Consequentially, the value of subjective probability declines, but both approaches will consider it valid to be in that uncertainty space.


Level of uncertainty	Approaches to uncertainty
<p>High</p>  <p>Low</p>	<p>Radical uncertainty</p> <p>Subjective</p> <p>Objective (e.g., frequentist)</p>

Figure 2.1: Understanding the uncertainty spectrum (1)

2.2.2 The categorisation of uncertainty using the Cynefin sense-making framework

This section describes the categorisation of uncertainty using the Cynefin sense-making framework (Snowden & Boone, 2007). Other frameworks considered were the Stacey matrix (Stacey, 1996), the simplified Stacey matrix, the Ashby Space diagram (Boisot & McKelvey, 2011b), the probable/preferable/possible/plausible framework and the aleatory/epistemic framework. Early in the study all these frameworks were used to show slightly different effects, but due to the relative similarity of the Cynefin/Stacey and Ashby frameworks, only the 'simplified' Cynefin framework is used or needed for this study. The simplified Cynefin framework provides an important distinction of unordered/ordered domains which gives an additional lens for viewing and supporting the description of radical/resolvable uncertainty and later, how decision-makers default to greater certainty. Using this framework means that situations that are complex or chaotic retain those features throughout the analysis, rather than having them downplayed. This downplaying of uncertainty is further developed in Section 2.3 with the identification of various forms of organisational bounded rationality which can cause this downplaying effect. A second reason for using the simplified Cynefin framework is that the framework clearly sets out different tools and methods for the two overall sets of domains. This is evidenced by a form of polarity of approaches across different management areas, such as for strategy, policy, futures, and risk management that all apply different tools and methods for situations of either low uncertainty or high uncertainty. It is essential then for the decision-maker to understand which overall Cynefin domain (which links directly back to radical/resolvable uncertainty) they are operating in and to be able to respond appropriately.

2.2.2.1 The Cynefin sense-making framework

Kurtz and Snowden (2003) state that the Cynefin framework was developed to reflect and describe the evolutionary nature of complex systems and their inherent uncertainty. The framework sorts the issues into five domains defined by the nature of the relationship between perceived cause and effect. Four of these relationships,

being simple/obvious, complicated, complex, and chaotic, require decision-makers to diagnose situations and to act in contextually appropriate ways. The fifth domain disorder, is the state of not knowing what type of causality exists, and is where people will revert to their own comfort zone in making a decision. No domain is more desirable than any other as it is not a value-based system. The framework is used to consider the dynamics of situations, decisions, perspectives, conflicts, and changes in order to come to a consensus for decision-making under uncertainty (Kurtz & Snowden, 2003; Snowden & Boone, 2007).

In Figure 2.2 below, the two right-side domains reflect a composite 'order' domain of what is known and what is knowable. This contrasts with the left-side domain of unordered, where distinctions of knowability are or may be less important than distinctions of interaction; that is, distinctions between what we can 'pattern' (complexity) and what we need to stabilise in order for patterns to emerge (chaotic) (Kurtz & Snowden, 2003).



Figure 2.2: The basic Cynefin framework

Source: Kurtz and Snowden (2003, p. 468), with updated headings from Snowden (2021)

The complex domain is much more prevalent in the business world than most leaders presume and this requires different, often counterintuitive, responses (Snowden & Boone, 2007).

The known 'Obvious' space is the realm of current scientific knowledge. The knowable 'Complicated' space is the realm of most scientific inquiry. The unknown and unordered 'Complex' space is the realm of social systems and the cause and effect can only be determined after the event. In the unknowable 'Chaotic' space no cause and effect is discernible (French, 2012).

The positive side of uncertainty is the potential for creativity/learning which by definition are in the unknown, inevitably outside of the present conceptual universe, since that universe is itself the result of acts of creativity. It is from the unknown that creativity is born (Byers, 2011).

2.2.2.2 Complex systems

Over time, most social systems have become complex with tight coupling (often through social media). Coupling is tightened with very tight schedules, new systems and no margin for error (Clearfield & Tilcsik, 2018). As systems add webs of interactions, relationships and interdependencies, complexity increases and positive/negative feedback loops emerge, creating non-linear effects (Dekker, 2011). Complex systems are varied and include future markets, entrepreneurial business, nations, stock markets, and international politics. Past a certain point, the internal dynamics of these systems is bewilderingly unknowable, with unsuspected risk. Complex adaptive systems do not just react, they learn (Ramo, 2009). Since most human ecosystems are complex and adaptive, we need to acknowledge and be tolerant of their inherent irreducible uncertainty (Bammer & Smithson, 2009). Most situations and decisions in organisations are complex because some major change such as a bad quarter, a shift in management, or a merger or acquisition, introduces unpredictability and flux (Snowden & Boone, 2007).

Clearfield and Tilcsik (2018) suggest it is hard to understand what is happening in complex systems because most of the direct/indirect interactions within the system or subsystem are hidden, like a black box, and there may only be indirect indicators to assess the situation. As such, the effects of our decisions are hard to understand and

learn from, and our intuition often fails us. There can be uncertain and often contradictory information. Tunnel vision may be manifest, and early evidence may be overlooked, disregarded or denied. (Clearfield & Tilcsik, 2018).

Before the black swan event, there are too many ‘dots’ to consider, yet after the event there is an emergent pattern of dots may be visible (retrospective coherence)

French and Niculae (2005) suggest that in the complex domain systems involve many interacting causes, effects and causal relationships. Typically, such complexity arises in social systems. Knowledge is at best qualitative: there are simply too many potential interactions to disentangle particular causes and effects. Unlike the precise models that may be developed in the known and knowable domains, under complexity there may be no comprehensive and accurate models to predict system behaviours. Analysis is still possible, but more macro in nature, with less emphasis on details. Decision support will be more focused on exploring judgement and issues, and on developing broad strategies that are flexible enough to accommodate changes as the situation evolves (French & Niculae, 2005).

The complex domain has cause and effect relationships between agents, but both the number of agents and the number of relationships can defy categorization or analytic techniques. Emergent patterns can be perceived but not predicted; this is called retrospective coherence. The mathematics of joining up the dots provides a simple answer. With four dots, there are six possible linkages between those dots and 27 possible patterns arising from those dots and linkages. If the number of dots rises to 10, then the number of possible patterns is over three trillion. Even if 99% of these links/patterns are harmless, no one can tell, up front, which ones are trivial and which are not. This is beyond our human capability. Speed in identifying the emerging pattern is key (Boisot & McKelvey, 2011b; Child & Ihrig, 2013; Kurtz & Snowden, 2003; Snowden, 2005).

Once an emergent pattern has stabilised, the path to that pattern appears logical, but only when looking backwards, since it is only one of many patterns that would appear

logical in retrospect. Patterns may indeed repeat for a time in this space, but no one can be sure that they will continue to repeat, because the underlying sources of the patterns are not open to inspection. Complex systems are emergent in nature, arising from the interactions of many agents, which are dynamic, so reliance on historical trends will not prepare decision-makers for the new unexpected patterns (Kurtz & Snowden, 2003; Snowden, 2005).

2.2.2.3 Cynefin's critical 'ordered'/'unordered' divide (two different worlds)

While all four of the quadrants of the Cynefin framework are different, this study focusses on Cynefin's important 'unordered' versus 'ordered' domain 'fault' line, and in particular the complex versus complicated domain divide which is where most strategic thinking/planning is situated. To match with other diagrams/tables in this study, the 'ordered' domains are placed on the left, and the 'unordered' are put on the right.

Table 2.1: A simplified version of the Figure 2.2 Cynefin framework showing the 'ordered'/'unordered' divide

Cynefin's 'ordered' domains <i>(Equivalent to resolvable uncertainty)</i>	Crossing the divide <i>Different thinking and action</i>	Cynefin's 'unordered' domains <i>(Equivalent to radical uncertainty)</i>
Complicated		Complex
Obvious		Chaotic

Understanding which domain that an issue in question fits into is extremely important. For the two ordered domains of obvious and complicated, analytical techniques are very effective. For actions in a complicated domain, the analytical-based 'predict, plan and control' are appropriate. It is a predictable world where causes and effects are considered repeatable. Checklists as a management tool are useful for the two ordered domains, as are searching for drivers of change.

Snowden and Boone (2007) suggest that for actions in the unordered complex domain, there is a need to act rather than analyse, to 'explore, experiment and learn',

as the intent is on letting things emerge. In this domain there is never enough information, even with its messy coherence, and outcomes are dynamic so that repeatability is not always possible or expected. The response needed is to avoid determining future steps, and to act now on what can be influenced, then amplify success. In this domain it is systemic change not individual change that matters. The complex domain is the domain of senior politicians, generals and key decision-makers. In this domain, aim for 'good enough', rather than the 'gold standard'. Complexity needs heuristics rather than rules and Snowden gives the example of Napoleon telling his generals that when they are unsure of what to do in battle, march towards the sound of gunfire. It is not effective to change people if the system does not support or accommodate them. The focus is on systemic change. Where there is a mood for system change, then change is possible. Complex systems are therefore managed as a whole, not in parts. Complexity is uncomfortable for decision-makers as there are always incomplete information, unintended consequences, continuous uncertainty and non-linear causality (Snowden & Boone, 2007).

In the ordered complicated domain, it is reasonable to use 'If, then?' statements, as deductive logic would apply. But in the unordered complex domain it is reasonable to use 'What, if?' counterfactual statements, as that is seeking possibilities, relationships and connections. 'What, if?' covers both novel possibilities and discoveries, as well as potential dangers and black swan events that no one has yet seen (Tetlock & Gardner, 2015).

Hasan (2012) suggests that while order is widely understood and valued, unordered is not always appreciated. Recognising unordered and choosing tools appropriate to help resolving unordered problems, is itself usually an unordered activity that can best be undertaken by those who appreciated the value of unordered. In most organisations a state of order, or at least a perception of order, seems to dominate and only a real crisis will change this (Hasan, 2012).

The Cynefin distinction of ordered and unordered is useful for making sense of traditional approaches for tame conditions and the complexity approaches for dynamic environments. Ali (2014) suggests the approaches that work for ordered

domains do not necessarily work in the complex domain, and vice-versa. The two approaches are radically different. Refer Table 2.2. Included in the second half of the table are examples of management styles for the two approaches, which use completely different thinking approaches, methods and tools. For example, whereas wicked problems clearly fit into the complex domain and tame problems fit into the complicated domain (Ali, 2014; Fodness, 2015).

Table 2.2: The Cynefin framework’s fault line between the ‘ordered’ versus ‘unordered’ domains, with different paradigms and different management practices/approaches that need to be used

Subject	Ordered domains (i.e., mostly complicated)	Unordered domains (i.e., mostly complex)	Source
Uncertainty/ knowledge	<ul style="list-style-type: none"> - Low uncertainty - ‘Obvious’ being knowns, i.e., mostly <i>known</i>, <i>knowns</i> - ‘Complicated’ being knowables, i.e., mostly <i>known</i>, <i>unknowns</i> 	<ul style="list-style-type: none"> - High uncertainty - ‘Complex’ being unknowns, i.e., mostly <i>unknown</i>, <i>knowns</i> - ‘Chaotic’ being unknowables, i.e., mostly <i>unknown</i>, <i>unknowns</i> 	Kurtz and Snowden (2003), Snowden and Boone (2007), McLeod and Childs (2013)
Cause/effect	<ul style="list-style-type: none"> - Clear cause and effect but sometimes separated over time and space - One or more right answers - Objective validation or refutation 	<ul style="list-style-type: none"> - No cause-and-effect relationship or only in retrospect - No right answer, but emergent patterns - Knowledge of conditions, but not outcomes 	Kurtz and Snowden (2003), Snowden and Boone (2007)
Techniques	<ul style="list-style-type: none"> - Fact-based management - Predict, plan and control - Analytical – reductionist 	<ul style="list-style-type: none"> - Pattern-based leadership - Explore, experiment and learn - Perspectives 	Kurtz and Snowden (2003), Snowden and Boone (2007)

Subject	Ordered domains (i.e., mostly complicated)	Unordered domains (i.e., mostly complex)	Source
	<ul style="list-style-type: none"> - Systems thinking - Organisational learning 	<ul style="list-style-type: none"> - Complex adaptive systems - Crisis management 	
Examples			
Strategy	<ul style="list-style-type: none"> - Deliberative, determine desired end state - Strategic planning - Exploit - Strategic planning that plans many steps ahead, in detail - Hedgehogs - Efficiency - Top-down management 	<ul style="list-style-type: none"> - Emergent - Strategic thinking - Explore - Strategic intuition and just take the next step - Foxes - Effectiveness - Bottom-up management 	<p>Mintzberg (1994)</p> <p>Liedtka (1998)</p> <p>Martin (2009)</p> <p>Duggan (2008)</p> <p>Tetlock (2005), Silver (2012)</p>
Policy	<ul style="list-style-type: none"> - Tame problems 	<ul style="list-style-type: none"> - Wicked problems 	Rittel and Webber (1973)
Futures/ scenario planning	<ul style="list-style-type: none"> - Historic determinism - Forecasting - Extrapolation - Detailed complexity 	<ul style="list-style-type: none"> - Future difference - Foresight - New patterns - Dynamic complexity 	<p>van Asselt, van' t Klooster, van Notten, and Smits (2010)</p> <p>Senge (2006)</p>
Risk management	<ul style="list-style-type: none"> - Tame – rationally extended - Standard/conventional risks (individual parts) - Normal distributions - Probabilities 	<ul style="list-style-type: none"> - Wild/feral, meta-rationality - Deals with systemic risk, where risk is greater than sum of the parts - Non-linear fat tails - Deep uncertainty 	<p>Ramírez and Ravetz (2011)</p> <p>Kupers (2014)</p> <p>Kupers (2014)</p> <p>Lempert (2002)</p>
Definition of black swans	<ul style="list-style-type: none"> - Black swans are observer dependent, 	<ul style="list-style-type: none"> - Black swans are unknown unknowns 	Taleb (2015)

Subject	Ordered domains (i.e., mostly complicated)	Unordered domains (i.e., mostly complex)	Source
	including unknown knowns and known unknowns		
Other/ science	- 'Normal' incremental science	- Transformational paradigm shifts	Kuhn (1962)

2.2.2.4 Different thinking styles are needed to match different levels of uncertainty

To understand the world, different thinking styles, i.e., deductive, inductive and abductive reasoning are needed for different levels of uncertainty (Arthur, 1994). For 'small worlds' (i.e., the world of objective/frequentist probability, as per Savage (1954)), deductive reasoning is essential as it reaches logical conclusions from stated premises. Deduction cannot have information missing or ambiguity otherwise it is inherently brittle. Computers are very good at deduction. The historical view of classical economics is to assume that humans are rational, i.e., perfect, logical, and having deductive rationality, which enabled economists to generate solutions to theoretical problems (Arthur, 1994).

Moving to 'larger' worlds (Savage, 1954), the role of the inductive and abductive reasoning increases relative to deductive thinking. For subjective probability (especially with Bayesian approaches), inductive reasoning is needed. Inductive reasoning likes to analyse data and it seeks to generalise from observations. Kahneman (2011) believes that humans are inductively rational pattern recognisers who are able to make decisions in ambiguous and fast-changing environments and to learn over time. Humans may not be brilliant at calculating long equations, but they are amazing storytellers and story listeners. Stories and storytelling are vital to us because the primary way we process information is through induction. Induction is essentially reasoning by pattern recognition. It draws conclusions from a

preponderance of evidence (Beinhocker, 2006; Kahneman, 2011; Kahneman et al., 1982).

Beinhocker (2006) believes that humans excel at two aspects of inductive pattern recognition. The first is relating new experiences to old patterns through metaphor and analogy making (Lakoff & Johnson, 1980). Second, humans are not just good pattern recognizers, but also very good pattern-completers. Humans are experts at filling in the gaps of missing information. The ability to complete patterns and draw conclusions from highly incomplete information enables people to make quick decisions in fast-moving and ambiguous environments. Sometimes in their inductive haste, people make mistakes and miss logical connections. Pattern recognition and storytelling are so integral to human cognition that people will even find patterns and construct narratives out of perfectly random data (Beinhocker, 2006; Kahneman, 2011).

For radical uncertainty, abductive reasoning, being a special form of induction, is essential (Kay & King, 2020). Abductive reasoning may yield a plausible explanation or conclusion but cannot logically verify it, so the results need to be qualified as having a remnant of uncertainty or doubt, which is expressed in terms such as "best available" or "most likely". Abductive reasoning seeks to filter disparate evidence to provide the best explanation or narrative account of a unique event. When events are essentially one-of-a kind, which is often the case of radical uncertainty, abductive reasoning is indispensable (Kay & King, 2020; Sober, 2013).

2.2.2.5 The uncertainty spectrum

Figure 2.3 integrates the various approaches to uncertainty in Figure 2.1, with the Cynefin sense-making domains, states of knowing and the matching thinking style. It is considered that most business decision-making is done in the complicated/complex domains where subjective probability/induction and radical uncertainty co-exist.

Level of uncertainty	Cynefin domains	State of knowing	Approaches to uncertainty	Matching thinking style
<div>High</div> <div>↑</div> <div>Low</div>	<i>Unordered domains</i> <ul style="list-style-type: none"> - Chaotic - Complex <i>Ordered domains</i> <ul style="list-style-type: none"> - Complicated - Obvious 	Unknown, unknowns Unknown, knowns Known, unknowns Known, knowns	Radical uncertainty Subjective Objective (e.g., frequentist)	Abductive Inductive Deductive

Figure 2.3: Understanding the uncertainty spectrum (2)

There is a practical problem in dealing with different uncertainty levels, with different approaches, since it implies that the decision-makers know what the real level of uncertainty actually is and therefore when to switch approaches. Sometimes it is clear what the uncertainty level is. At other times it is not. The dominant and default business decision-making approach is the one suited to the ordered domains, especially the complicated domain (Snowden & Boone, 2007). This approach will be supported by the organisation's management information systems and models. This approach is used by organisations on most occasions, but with decreasing relevance as the uncertainty increases. One reason why this approach is used in that way is the fact that we do not know what we do not know, and we favour what is known and certain. This will potentially understate the uncertainty and make it more likely that the decision-makers stick with ordered approaches when they should switch to approaches better suited to the unordered domains. Figure 2.4 tries to avoid the switch effect of Cynefin's four or two levels, by having both approaches applying at any time, on an increasing/decreasing scale. In the next section, this balancing of different approaches helps explain why it is important decision-makers with cognitive diversity, such as fox-like cognitive thinkers, who are good at balancing different approaches and ideas, in key decision-making processes.


Level of uncertainty	Cynefin domains	Both approaches apply at any time	Determining the approach to apply
<p>High</p>  <p>Low</p>	<p><i>Unordered domains</i></p> <ul style="list-style-type: none"> - Chaotic - Complex <p><i>Ordered domains</i></p> <ul style="list-style-type: none"> - Complicated - Obvious 	<p>Approaches relevant to the unordered domains</p> <p>Approaches relevant to the ordered domains</p>	<p>← Almost 100% - unordered</p> <p>← Weighted towards unordered</p> <p>← Both apply</p> <p>← Weighted towards ordered</p> <p>← Almost 100% - ordered</p>

Figure 2.4: Understanding how approaches to the ordered/unordered domains fit into the uncertainty spectrum

2.3 The hedgehog cognitive thinking and decision-making style

Section 2.3 considers the role that bounded and inductive rationality plays in decision-making under uncertainty and it uses Boschetti (2011) who has the four states of knowing put into a 3D diagram. The focus of this research is the cognitive default to what is known and certain (i.e., primarily the 'known, known' state) to the exclusion of the other more uncertain states of knowing. Three de-facto defaults or blindnesses have been identified as potentially locking the decision-maker to the 'known, known' space, when all four states of knowing should be considered and used. These defaults/blindnesses are:

- Blinded by a single top-down reference narrative.
- Blinded by induction and becoming a turkey.
- Blinded by the illusion of certainty.

The result of these biases or heuristic defaults and simplifications is to avoid or disregard, be ignorant or unaware of complexity and uncertainty, which increases the risk of a surprise black swan event.

2.3.1 Problems for decision-makers who stick only to the known and certain

2.3.1.1 Dealing with uncertainty in complex decision-making

Boschetti (2011) suggests that decision-making in complex settings can be considerably simplified by addressing three core ideas: a) the level of uncertainty, b) the awareness of uncertainty, and c) the framing or perception of a problem affecting uncertainty. None of these are binary variables: in real-world problems decision-makers are never either fully certain or fully uncertain, never fully aware or fully unaware of uncertainty; similarly, how many frames are used to perceive a problem depends on the problem as well as on the number of actors affected by it.

These ideas and their continuums can be represented in 3D graphical plot, in which each axis maps one of these dimensions. Figure 2.5 provides a geometrical

representation of uncertainty that incorporates key categories such as ‘known knowns’, ‘unknown knowns’, ‘known unknowns’, ‘unknown unknowns’ and ‘knowing too differently’; as well as showing axes for unaware/awareness, uncertainty/certainty and single/multiple frames. The X axis maps the level of uncertainty; the Y axis maps the awareness of uncertainty; the Z axis maps the number of different frames or interpretations of an issue, that is how ‘differently’ actors view the same problem, which leads to multiple, diverging views. Increasing the number of frames may widen the pool of knowledge available as well as make decision-makers aware of new aspects of uncertainty not previously considered. This representation can help monitoring and assessing the dynamics of knowledge and uncertainty during a project and how it affects decision-making. In complex projects different aspects of uncertainty could be moving in different directions within the level-awareness-framing plot and different actors could be in different squares, especially at the beginning of the project (Boschetti, 2011).

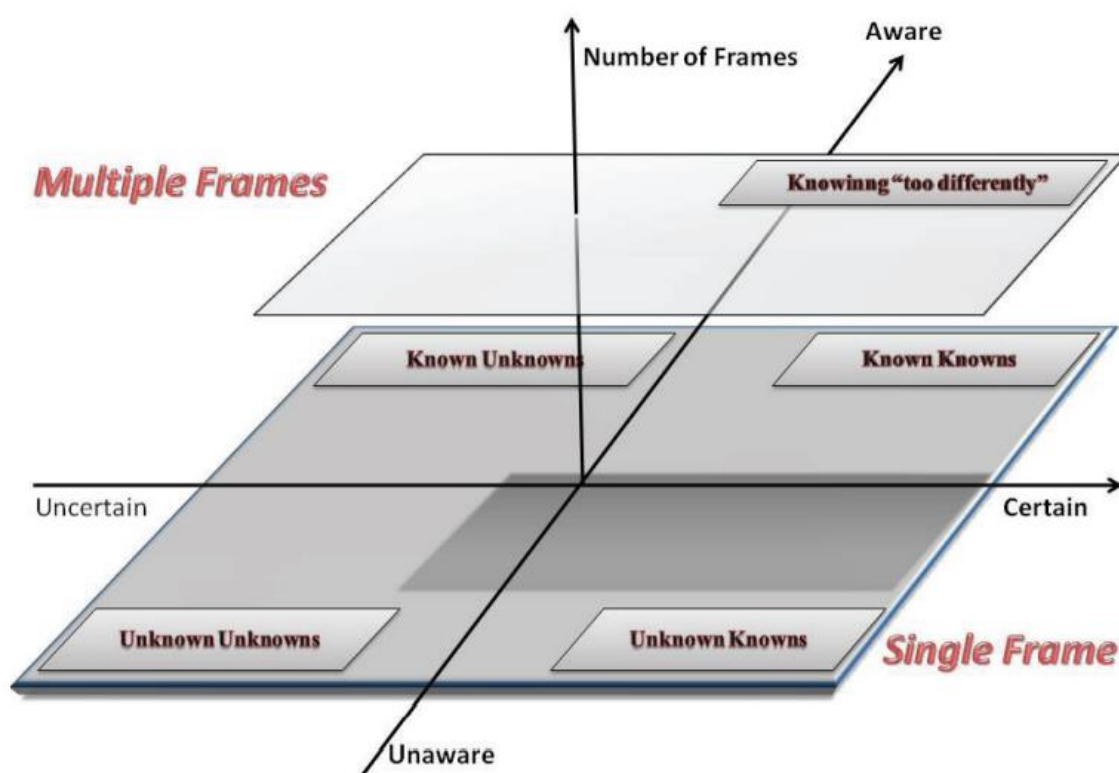


Figure 2.5: Boschetti's level-awareness-perception plot
Source: Boschetti (2011)

2.3.1.2 There is a strong tendency for decision-makers to stay with the known and certain

What is of critical importance in this research is the frontier between what the decision-maker is aware of (i.e., predominantly the 'known, knowns' and to a lesser degree the 'known unknowns' spaces) and what they are not aware of (i.e., the 'unknown, knowns' and the 'unknown, unknowns').

Taleb (2015) says that understanding all the risks (i.e., within the 'known, known' stage of knowledge) is not enough, as there is a need to understand Knightian uncertainty if decision-makers want to understand black swan events and their often-disastrous consequences. Taleb states that the world is inherently random, because decision-makers have incomplete information and understanding at some layer for decision-making at any point in time, even if some of the underlying processes are not truly unpredictable. He also suggests that a common feature of decision-making is to focus or 'tunnel' too much on the known, repeated and certain, rather than understanding what we do not know, and the unknown unknowns in particular. Living in this world of Knightian uncertainty makes it impossible to fully understand what is going on. Due to a world with unseen elements and properties, the random and the complex (with interdependencies between parts), make decision-making under uncertainty difficult. Taleb claims people suffer from epistemic arrogance or overconfidence, where they overestimate what they know, and underestimate uncertainty, by compressing the range of possible uncertain states (i.e., reducing the space of the unknowns). This overconfidence makes them very susceptible to black swan blindness (Kay & King, 2020; Taleb, 2008a, 2012).

Kahneman (2011) also states there is a serious problem of decision-makers overstating and being overconfident in the limited amount of what they know/understand and are aware of, or what he terms, WYSIATI or '**What You See Is All There Is**'. They understate or overlook what they do not know and are not aware of. Under situations outside of the 'known, known' space, where there is uncertainty and complexity, this results in inappropriate thinking and the actions being taken, which exacerbates the unrecognised uncertainty that potentially leads to surprise black swan events with 'non-trivial' impacts (Gigerenzer, 2014; Kahneman, 2011;

Taleb, 2008a). These mental shortcuts or heuristics create a serious problem in decision-making under uncertainty, since there is a mismatch between the ‘wicked’ problems that the world is facing which come from the unordered/complex domain and problem-solving approaches that fit into the ordered domain of the ‘known, known’ state of knowing.

2.3.1.3 Decision-makers have either a Tetlock (2005) fox or a hedgehog cognitive thinking style based on their preference of the states of knowing

Building on the preceding sections, the following sections overlay on top of the four states of knowing, the fox/hedgehog categorisation of Tetlock (2005), that he had used for better and worse forecasting. This study build’s on Tetlock’s generalisation that hedgehogs have a predominant focus on ‘known, knowns’ and foxes have a more holistic approach of giving attention to any state as they need to. This approach is summarised in Tables 2.3 and 2.4.

Table 2.3: The predominant state of knowing for a hedgehog-like cognitive thinker (1)

	Certain	Uncertain
Unaware	Unknown, knowns	Unknown, unknowns
Aware	Known, knowns	Known, unknowns

Table 2.4: The distributed states of knowing for a fox-like cognitive thinker (1)

	Certain	Uncertain
Unaware	Unknown, knowns	Unknown, unknowns
Aware	Known, knowns	Known, unknowns

Tetlock’s fox/hedgehog categorisation of expert political judgement

Tetlock based his categorisation on the philosopher, Isaiah Berlin’s story of a fox and a hedgehog, which was based on a fragment of a poem by the Greek poet Archilochus (c680 - c645 BC), via the writings of Erasmus (1466-1536), who wrote, ‘*The fox knows many little things, but the hedgehog knows one big thing*’. Berlin’s

prototypical fox sees the world in all its multi-level complexity, and the fox deals with this complexity by drawing from an eclectic array of traditions, often loosely connected (Gaddis, 2018; Tetlock, 2005).

Berlin's prototypical hedgehogs, on the other hand, live within one tradition and simplify the complex world into a single organising idea, a basic principle or concept that unifies and guides everything. It does not matter how complex the world; it is presumed that hedgehogs reduce all challenges and dilemmas to simple narratives. For a hedgehog, anything that does not somehow relate to their organising idea is discarded (Collins, 2001).

As the metaphor indicates, the hedgehog approaches its target directly, slowly, and without unnecessary detours, while the fox moves obliquely and swiftly, with an adaptive style of re-evaluation and small steps. The hedgehog knows the answers, often even before it encounters a situation, while the fox knows the limits of its knowledge. Whereas the hedgehog is considered less sensitive to the limits of knowledge, the fox has a sense for subtlety and appreciates ambiguity, (Gomez & Meynhardt, 2012).

From 1984 onwards Tetlock and his team collected more than a million predictions from 25,000 forecasters, from which data he developed his categorisations of expert fox/hedgehog forecasting and then his superforecasters (Gardner, 2011; Schoemaker & Tetlock, 2016).

Tetlock found that 'who' the experts were, i.e., professional background, status, and so on, was not an important factor, nor was 'what' the experts thought, i.e., whether they were liberal or conservative, realists or institutionalists, optimists or pessimists. The key factor and finding, was, 'how' experts thought, i.e., their style of cognitive reasoning, and the parallels to Berlin's fox/hedgehog descriptions. Tetlock's findings were unequivocal; foxes were far more proficient predictors than hedgehogs (Gaddis, 2018; Tetlock, 2005).

Hedgehogs shunned self-deprecation and brushed aside criticism, aggressively deploying big explanations, they displayed a brisque impatience with those who 'do

not get it'. When the intellectual holes they dug got too deep, they simply dug deeper. They became 'prisoners of their preconceptions,' trapped in cycles of self-congratulation. These played well as sound bites, but bore little relationship to what subsequently occurred (Gaddis, 2018; Tetlock, 2005).

Foxes were better equipped to survive in rapidly changing environments in which those who abandoned bad ideas quickly held the advantage. Foxes are high in active open-mindedness. By contrast, hedgehogs were better equipped to survive in static environments that rewarded persisting with tried-and-true formulas. Gaddis (2018) suggests organisations need both styles for survival, as hedgehogs have a focus on direction and the 'ends' and foxes focus on the means. Grand strategy is aligning the means with the ends (Gaddis, 2018; Tetlock, 2005).

Tetlock (2005) asserts that hedgehogs irritate only the people who disagree with them, while foxes annoy everyone, by deploying various ideas, they spare no one's sensitivities. The foxes take more factors into account, which often undermines their own recommendations. This tries the patience of their audience, who want certainties and hedgehogs are strong on certainties. Tetlock identified Marx and libertarians (like Ayn Rand) as hedgehogs who stuck/stick to a simple worldview and whose grand predictions never materialize (Tetlock, 2005; Tirole, 2017).

Understanding other interpretations

In a well-known study of factors underpinning success, Collins (2001) found that hedgehogs always win over foxes and that all the good-to-great companies were led by hedgehogs. Collins believed these companies used their hedgehog nature to drive towards what he calls a hedgehog concept for their companies. Those who lead the comparison companies tended to be foxes, never gaining the clarified advantage of a hedgehog concept, being instead scattered, diffused, and inconsistent. Collins and Hansen (2011) define the 'hedgehog concept' as a Venn diagram of three overlapping circles, being; what the company is passionate about; what the company can be the best in the world at; and what drives the company's resource or economic engine. A hedgehog concept is a simple concept that flows

from deep understanding about the intersection of the three hedgehog circles. Once the good-to-great companies of Collin's study were clear on their hedgehog concepts, they built momentum by making a series of decisions relentlessly consistent with that concept. This keeps an organisation focussed in the same direction, which is fine so long as there are no unexpected changes in the environment.

Mauboussin (2009) however questions Collins' methodology, his sample design, data collection and findings. He believes the important question is not, 'were all great companies hedgehogs?' but rather, 'were all hedgehogs great?' He believes the answer is no, so dwelling on the successful and longer lasting companies creates a bias in the analysis, leading to faulty conclusions, i.e., survivorship bias. Mauboussin suggests that a better approach is to consider how many of the companies that deliberately tried that strategy actually succeeded (Mauboussin, 2012).

Collins' fox/hedgehog framework embraces Berlin's framework and that comes before Tetlock's 2005 findings. At face value Collins is saying the exact opposite of Tetlock, but different definitions are used. This study uses Tetlock's 2005 definition of foxes/hedgehogs, which would reclassify Collin's hedgehog as a fox. For example, Collins points out that good-to-great companies need to develop a range of perspectives and a culture where people's view are heard. He states that they form the hedgehog concept through an iterative process. In addition, they need to have honest confrontation of the brutal facts of their current reality; they need mechanisms that turn uncomfortable information into information that cannot be ignored; they need Level 5 leaders who display compelling modesty, are self-effacing and understated. Even then, they take on average four years to develop their hedgehog concept. Building this hedgehog concept is what this study describes as building the organisation's reference narrative. In taking such an approach, which are described as displaying fox-like traits by Collins, would have deeply frustrated any Tetlock hedgehog, as they believe they already know the solution based on their own reference narrative (Collins, 2001).

2.3.1.4 Defining a hedgehog-like cognitive-thinking style

Hedgehog like thinkers may prefer to stick with the known and certain, since they have a strong dislike of uncertainty and ambiguity. This puts them predominantly within the 'known, known' state of knowing. Refer Table 2.3 above. They expect the expected. This cognitive style is especially useful in solving resolvable problems, which gives them great confidence in their decision-making. However, it is likely to be poor in dealing with issues of complexity or uncertainty and it makes them especially prone to surprise events, including black swan events of significance.

Hedgehogs have a very low tolerance for ambiguity, avoid such situations and/or behave in a manner which reinforces their belief that they are operating in a world of resolvable uncertainty (Tetlock, 2005). Hedgehogs equate confidence with competence, since people have a bias that favours those who are more confident. This sense of confident certainty is valuable for experts. Hedgehogs are especially prone to being overconfident, having an aversion to contrary ideas, having hubris and being surprised by black swan events. Hedgehogs tend to be absolutists, who strongly avoid being probabilistic thinkers, so talk of possibilities and probabilities seems like hedging. They give no value to luck, base rates, non-linearity, randomness and regression to the mean. They favour using the least degrees of uncertainty, which could be: certain, impossible and maybe. Hedgehogs end up exposing themselves to risks that they are unaware of, making them inherent, but inadvertent risk takers (Gardner, 2011; Tetlock, 2005; Tetlock & Gardner, 2015).

Hedgehogs believe they are operating in a resolvable and certain world (and inherently hate uncertainty), so they strongly defend their reference narrative from those who think it should be changed. They approach most uncertainties with strong priors, since they believe they have a strong overarching narrative, with strong supporting top-down, deductive arguments, which they are reluctant to move outside the comfort zone of (Tetlock, 2005). They manage the tension for change by strength of personality, position authority and use of controlling management practices such as micromanaging or overriding objections. New knowledge is used to refine their original model, rather than update it. Hedgehogs are exceedingly adept at providing excuses and reasons why their frame, narrative or predictions fail and why they

weren't wrong. They continue with their narrative (Kay & King, 2020; Tetlock, 2005; Tetlock & Gardner, 2015).

Hedgehogs are prone to what Kahneman calls his System 1 thinking and associated cognitive biases. These biases include: the optimism bias, overconfidence, hubris, hindsight bias, inside thinking and the planning fallacy (i.e., overpromise, under deliver), as well as accepting no blame if their views and reference narrative turn out to be wrong (Gardner, 2011; Tetlock, 2005; Tetlock & Gardner, 2015).

Hedgehogs are impatient with speculation. They see the playful exploration of ideas as a sign of immaturity. They want closure. They are concrete thinkers who just want to work with the facts, not with flights of fancy. This concrete reasoning style is a relatively fixed personality trait and it does not leave them very open to new insights (Klein, 2013). Hedgehogs can have 'expert intuition', which is the result of combinations of ideas and elements within the person's memory and experience, which is then applied in familiar situations. These intuitions will support the direction of the reference narrative (Duggan, 2008).

2.3.1.5 Defining a fox-like cognitive thinking style

Foxes are much more aware of uncertainty and complexity and they are comfortable with the ambiguity that entails. This makes them modest in their forecasts. They expect the unexpected. They can use all four states of knowing and this helps them make better decisions under uncertainty. Refer Table 2.4 above.

Foxes have a high tolerance for ambiguity, as they accept that they are operating in a world of radical uncertainty. Foxes are good at integrative complex thinking and they accept that life is messy and data is noisy (Tetlock, 2005). They know more about what they do not know than hedgehogs do. They have an active open-mindedness to understanding new or surprising ideas. Foxes are probabilistic thinkers who understand and are comfortable using a wide range of concepts such as: possibilities/probabilities, black swan events, good/bad luck, base rates, non-linearity, randomness, the 'butterfly flapping its wings' effect, signals versus noise, and regression to the mean. These traits reduce overconfidence, hubris and some of

the surprise of unexpected black swan events (Gardner, 2011; Tetlock, 2005; Tetlock & Gardner, 2015).

Foxes actively seek to extend their reference narrative, since they believe they are operating in radical uncertainty, so they accept there will be limitations of knowledge and understanding. This makes a fox sceptical about the power of any overarching narrative. They challenge their reference narrative by assembling diverse evidence which they are good at aggregating, as increased knowledge and understanding will improve their current narrative to something more robust (Tetlock, 2005). They apply multiple lenses, by using multiple tools, models, heuristics or perspectives. They are active Bayesian belief updaters, as beliefs are hypotheses to be tested. To them more information means more learning, and more learning and understanding of the situation means their views will change in some way to better reflect their new understanding of reality. They ask questions like, 'what is going on here?' and they use bottom-up inductive and abduction reasoning to find the best explanation for one-off events. Any new understanding is used to update the fox's reference narrative and supporting models and beliefs. Foxes are self-critical, having doubts and admitting they can be wrong. They apply this attitude to their management style, which encourages a positive growth and learning environment (Silver, 2012; Tetlock, 2005; Tetlock & Gardner, 2015).

'Insight' is an essential thinking tool for foxes. Klein (2013) defines 'insight' as an unexpected shift to a better frame/story for understanding how things work. Insights shift decision-makers towards a new story, a new set of beliefs that are more accurate, more comprehensive, and more useful. The insight transforms how they understand, act, see, feel, and desire. These shifts are not about making minor adjustments or adding more details (Klein, 2013). Insight provokes a shift in their understanding. Insights are disruptive in that they do not let the decision-maker retain their comfortable beliefs. Instead, they have to modify the core beliefs that anchor their understanding. It means changing the core components, the anchors, used in the story. Some previous anchors are discarded or new ones added (Klein, 2013). An insight is a leap, an unpredictable one, to a related but different story. It catches the person by surprise because it isn't the product of conscious, deliberate, deductive, or statistical inferences. Typically, the people around the insight thinker do

not gain the insights even if they have access to the same information. It is a coherent new story, not a set of possibilities. It shifts from story (1) to the final version, story (n) (Klein, 2013). This has been described as ‘strategic intuition’, which is the result of combinations of ideas and elements from both memory/experience and from outside the person’s memory/experience, and they could come from anywhere. These intuitions are especially useful for unfamiliar situations that require a change in strategic direction (Duggan, 2008).

Figure 2.6 builds on Figure 2.3, but uses the simplified definitions from Table 2.2. The table also includes the different fox/hedgehog uncertainty decision-making ranges based on their preferred state of knowing. Extreme hedgehogs have greater depth of knowledge within the known and certain, whereas extreme foxes have the greater range of operating over the uncertainty spectrum.

Figure 2.6: The fox/hedgehog's tolerance to the uncertainty spectrum

The original source of examples is Berlin (1953), a political philosopher, whose examples come from literature and philosophy. He categorises Tolstoy, Hume,

Turgenev, Shakespeare, Herodotus, Aristotle, Montaigne, Erasmus, Moliere, Goethe, Pushkin, Balzac and Joyce as foxes. By contrast, he categorises Dante, Plato, Lucretius, Pascal, Hegel, Dostoevsky, Nietzsche, Ibsen, Proust and Aquinas as hedgehogs. Berlin (1953) used the definition of ‘*a fox knows many things, but the hedgehog knows one big thing*’. This is so high level that it is open to diverse interpretations. For example, Darwin had one big idea (i.e., evolution) as did Marx (i.e., communism), so Darwin has been described in Table 2.5, as a hedgehog for that reason, and is also described as a fox for his mastery of many things.

Gould (2004) notes this problem with Berlin’s fox/hedgehog metaphor, ‘*Ever since then, scholars have played a common game in designating their favourite (or anathematized) literati either as hedgehogs...or as foxes...The game maintains sharp edges because these attributions have been made both descriptively and proscriptively, and people...argue forever about either and both*’. For example, Gaddis (2018) classifies Lincoln, Machiavelli, the younger Pericles, Octavian Caesar, and Elizabeth 1 as foxes and Xerxes, the older Pericles, Julius Caesar, Augustine, Phillip II, George III, Napoleon, and W. Wilson as hedgehogs. These examples are not further explored in this study.

There are many other sources who give contrary examples of who is a fox/hedgehog and these are listed in Table 2.5 below. Such contrary views can be traced to the definitions (i.e., Berlin or Tetlock), as well as the level of detail provided to the reader to justify the fox/hedgehog classification (i.e., they range from assertions with no supporting description, to very good, detailed descriptions).

Table 2.5: Examples of who is described as a fox/hedgehog

Source	Described as a fox	Described as a hedgehog
Based on Berlin’s description (i.e., hedgehogs are great)		
Collins (2001)	-	Sigmund Freud, Charles Darwin, Karl Marx, Albert Einstein, Adam Smith
Based on Tetlock’s 2005 description (i.e., foxes are great)		
Kay (2011)	John M. Keynes, F.D. Roosevelt, Warren Buffett, George Soros, F. Scott Fitzgerald	Max Planck, Karl Marx, Winston Churchill, George W. Bush and colleagues

Source	Described as a fox	Described as a hedgehog
Gardner (2011)	Martin Gardner, George Soros	Paul Ehrlich, Arnold Toynbee, Bruce Bueno de Mesquita
Tirole (2017)	Today is the world of economic foxes	Most economists 40 years ago
Silver (2012)	Philip Tetlock	Karl Marx, Sigmund Freud, Malcolm Gladwell
Epstein (2019)	Philip Tetlock, Charles Darwin	Paul Ehrlich, Julian Simon, Albert Einstein
Kay and King (2020)	-	Winston Churchill, Steve Jobs

Complementing prior work and literature, this research also emphasizes the decision-makers' attitude to uncertainty which is one of the aspects within the traits described by Tetlock (2005). This change of emphasis/definition/lens may well change the results/outcome, in comparison to others who have sought to categorise decision-makers as foxes/hedgehogs. The study also draws on the 'paradigm' lens of Kuhn (1962). This refers to scientists and other creative thinkers who changed a paradigm/reference narrative. These paradigm changers were clearly people who tackled the deep complexity and uncertainty of their respective subjects and then explained the conflicting evidence, so that it subsequently became part of realm of the known and certain. Over time this became the new reference narrative, as it explained reality better than the previous reference narrative (Klein, 2013). This describes a successful fox.

With this studies interpretation, based on Tetlock, Kuhn and Klein, it is not meaningful to debate whether Plato was a hedgehog and Aristotle was a fox, as both are highly influential and creative foxes, with one being more intuitive and the other seen as more rational. Similarly, it is meaningless to compare Galileo and Marx. Galileo had radical paradigm-changing views on astronomy, that after his death proved more right than wrong, whereas Marx had radical paradigm-changing views on economics that well after his death proved more wrong than right. As an aside, it may make more sense to call most of the people identified in this section suggested as foxes/hedgehog to be foxes. Some of these foxes were far more successful than others in the long term, but some of the foxes that appeared to fail will still be

remembered by history as important thinking leaders who did want to change the narrative. Many of the people (in Table 2.5) described as hedgehogs above may have been blinded at some stage by a single reference narrative and by various inductive cognitive biases that locked them to the known and certain.

Perhaps, hedgehogs represent most of the rest of humanity, especially the practical people of society, such as, plumbers, electricians, accountants, engineers etc., who often have no motivation to move outside the known and certain.

Tetlock moved on from the fox/hedgehog categorisation to then study extreme foxes, whom he called superforecasters, his real interest. (Tetlock & Gardner, 2015). This research focuses on identifying and explaining why hedgehogs fail to foresee black swan events.

The next three sections of this research will discuss three identified and developed common forms of bounded rationality, referred to as 'hedgehog blindnesses'. Induction, inductive biases and the simplification of uncertainty to greater certainty were first identified by the researcher in the text, notes and bibliography of Taleb (2008a). Cognate research, including that of Tetlock (2005) and Kahneman et al. (1982) relating to forms of organisational bounded rationality, had a continuing and evolving impact on this study. The circles of research became ever wider and those two forms of organisational bounded rationality continued to develop throughout the research period. The notion of being blinded by a single top down narrative emerged from the work of Kay and King (2020), supported by other sources such as Schiller (2019), whilst the notion and construct of 'strategic drift' can be attributed to Sammut-Bonnici (2015). These three forms of bounded rationality are then presumed to help 'lock' hedgehog thinkers into this limiting or narrow 'known, known' view of the world. These hedgehog blindnesses are:

- Blinded to a single top-down reference narrative, which they are reluctant to change.
- Blinded by induction and becoming a turkey. This includes being blinded by inductive System 1 cognitive biases.

- Blinded by the illusion of certainty.

These blindnesses will be used later in the case study to explain why the key decision-makers at the Pike River coal mine failed to see the potential for a methane explosion, which was a black swan event for them.

2.3.2 Hedgehog blindness (1): Blinded by a single top-down reference narrative

This section considers the tension of treating the organisation's reference narrative as the sole way forward, since this will often agree with collective thinking and supporting models (i.e., the hedgehog approach), or to treat the organisation's reference narrative like a 'strawman' that is the best that can be done with current knowledge and information (i.e., the fox approach). As the situation changes, then the 'strawman' will need to be updated. Under radical uncertainty, there is a strong need to 'extend' the reference narrative and to move away from any unnecessary defending of the current reference narrative. This involves using the different diversity frames of Boschetti's awareness-perception diagram, refer Figure 2.4.

The following is the first of four sub-sections on the three different and potential blindnesses identified that help lock decision-makers to the hedgehog cognitive-thinking style, with a predominant focus on the 'known, known' state of knowing.

2.3.2.1 Fox/hedgehog decision-makers inherently make different choices

In organisational settings, whether one 'defends' or 'challenges' the reference narrative depends on the decision-makers being foxes or hedgehogs. For example, a hedgehog decision-maker will naturally want to decrease the apparent complexity, as a means of improving the organisation's overall efficiency. This efficiency approach focuses on '*exploit*' options that 'defend' the current reference narrative and avoids '*explore*' options which challenge the reference narrative. This results in a focus on short-term profitability. Historically, this has been the dominant corporate decision-making style (Bar-Yam, 2004; Boisot & McKelvey, 2011b; Snowden, 2005). When operating under complexity, hedgehogs remain unwittingly true to form, they tend to see simple, deterministic rules of cause and effect framed by their area of expertise, like repeating patterns on a chessboard. They view every event through their preferred keyhole and this makes it easy for them to fashion compelling stories about anything that occurs, and to tell the stories with adamant authority (Epstein, 2019).

It is natural for a fox decision-maker, operating under increasing complexity and uncertainty, to want to implement 'extend/challenge' options to the reference narrative through the use of 'explore' options and to avoid purely 'exploit' options (Tetlock, 2005). There are two main ways of 'extending/exploring' in a complex world (Bar-Yam, 2004). First, embrace the widest possible number of affected stakeholders to get the widest possible cognitive diversity (i.e., diverse perspectives/heuristics/models etc). Second, embrace rapid learning at all levels, since the inherent uncertainty has too many conditions and variables. It means to expect the unexpected. Implement small-scale low-risk iterative experimentation that fails fast if it does fail, but embrace what works and scale for exploitation, and allow for redundancy. The organisation needs to avoid anything that limits cognitive diversity and stakeholder involvement, such as in top-down hierarchical structures or optimization, as that locks the organisation into one approach. Excessive focus on a single competence, a single model or investment appraisal process is the way an organisation can destroy requisite complexity of response (Snowden, 2005). The organisation needs to avoid thinking they understand exactly what is happening; that the system is just the sum of the parts; and avoid high risk 'all or nothing' big bets (Bar-Yam, 2004; Boisot & McKelvey, 2011b; Snowden, 2005).

Getting the right leadership style for the situation is essential for organisational survival. Leadership needs both foxes/hedgehogs as they bring different skills. Hedgehogs can have deep subject knowledge. The ideal may be to have hedgehog-dominated narratives during long periods of stability and to have fox-dominated narratives in periods that are dynamic, uncertain and complex. However, the ideal is not easy to achieve. There can be problems if the decision-makers have opposite styles. For example, decision-makers who are fox-like in a period of stability will naturally consider the uncertainties and possibilities. This may negatively affect the efficiency focus and the achievement of immediate objectives. Decision-makers who are hedgehog-like in periods of change/complexity can also cause serious problems because they may not consider all the uncertainties and possibilities. This makes them prone to being blindsided by events and incorrectly relying on the existing reference narrative to explain a changed environment (Epstein, 2019).

Foxes see situational complexity in what hedgehogs' mistake for simple cause and effect. They understand that most cause-and-effect relationships are probabilistic, not deterministic. There are unknowns, and luck and history may appear to repeat, but never exactly. Foxes like to aggregate perspectives, not stick to just one. As Tetlock (2005) says, it is not what they think, but how foxes think that is important. Foxes are high in active open-mindedness. They are extremely curious, and they do not merely consider contrary ideas, they proactively cross disciplines looking for them (Epstein, 2019).

2.3.2.2 Organisational attitudes and mechanisms that RESIST new insights (shifts to new frames/stories)

There is a natural tension between wanting a group/organisation to all align and wanting to retain diversity of thinking. The desire to align, when pushed too hard, impacts negatively on the diversity of thinking within a group. This is reflected in peer pressure, groupthink, homophily, conformity, herd behaviour and jumping on the bandwagon. Without cognitive diversity, groups/organisations can falter (Page, 2007).

Organisations have a structure of established power relationships through lines of authority and responsibility for assigned duties. Inherent in running an organisation that depends on managing people and projects, is a quest for perfection and a quest for predictability (Klein, 2013). In well-ordered situations, with clear goals and standards, stable conditions, and optimisation, the pursuit of perfection makes sense. This suits hedgehogs who only want to work with the known and certain. Decision-makers may believe that they want insights and innovations but they are most receptive to new ideas that fit within their reference narrative, existing practices and maintain stability and predictability. In these circumstances organisations therefore treat disruptive insights and innovations with suspicion, since they are inherently 'dis-organising'. The hierarchical structure of organisations filters insights out of sight of the higher hierarchy. Every single level has to sign on if an insight is to make it through to the top decision-makers. The filtering pervades all levels (Klein, 2013).

In organisational settings, it is hard to stray beyond the 'established thinking' and leave the security of the dominant mode of thought and behaviour (van Asselt et al., 2010). Often in such situations there is a strong confirmation bias, that means the focus is on corroborative facts that appear to confirm the existing reference narrative, which means decision-makers see only white swans, not black swans (Taleb, 2008a). Challenging a dominant mindset is deeply uncomfortable and outside most people's comfort zone. Dissonant views are rarely welcomed, being either ignored or receiving some form of punishment, so self-interest favours being part of the herd. It takes courage to be any type of internal/external whistle-blower (Kahneman, 2011; van Asselt et al., 2010; van't Klooster & van Asselt, 2011).

Heffernan (2011) states that many people who have dissenting views, but are outside the formal leadership structure, effectively go with the flow to avoid conflict, by passive conformity (i.e., adopting the habits, routines and language of their peers) or passive obedience (i.e., complying with the orders of a formal authority). Conformity is compelling because much of our sense of life's meaning depends on other people. Few people wish to be typecast as a troublemaker or a complainer, so in many cases they chose 'employee silence' (Milgram, 1970, 1974; Milliken & Morrison, 2003).

Groupthink is where individuals, for various reasons, suppress raising valid objections to the dominant view. They may withhold information or not voice their true beliefs or opinion in order to facilitate group harmony, and to avoid contradicting or clashing with a strong boss or manager (Heffernan, 2011). The pressure to maintain a consensus results in less thinking. Members do not look for information to confirm or disconfirm. This is a serious problem in the corporate setting as the more amiability and esprit de corps among the decision-making in-group, the greater the danger that independent critical thinking will be replaced by groupthink. This is likely to result in irrational and dehumanising actions directed against out-groups. Groupthink makes groups think they are invulnerable and this results in less vigilance and more vulnerability to bad and dangerous decisions. Dissent is discouraged and in most organisations a good team player is implicitly defined as the person who goes along, not the one who asks hard questions (Heffernan, 2011; Janis, 1972). Accountability also binds people to collectivities by specifying who must answer to

whom, for what, and under what ground rules. This restricts dissent (Tetlock, 1985, 1992).

What is disagreeable or intolerable to an organization is called 'uncomfortable knowledge'. There are four strategies of increasing order of sophistication for how organizations typically deal with uncomfortable knowledge: denial, dismissal, diversion and displacement. When organizations and institutions have become deaf or blind to uncomfortable knowledge, there is an urgent need to increase the level of diversity in decision-making processes (Rayner, 2012). Unless decision-makers add back uncomfortable knowledge into decision-making and the associated strategic conversations, there is effectively no chance of achieving a solution to any 'wicked problem' (Flyvbjerg, 2013).

An example of uncomfortable knowledge is the former US Secretary of Defence Donald Rumsfeld's search for weapons of mass destruction in Iraq; he steadfastly believed they existed and he disregarded any evidence or opinions to the contrary. Ex-post, these weapons were never found because they never existed, which is what Iraq and other sources said all along. Finding no weapons was a black swan event for Rumsfeld, since ex-ante he refused to even consider the possibility that no weapons of mass destruction existed (uncomfortable knowledge), because he seemed to want to go to war, perhaps as unfinished military business from the first Iraq war (Rayner, 2012; Zizek, 2014).

Uncomfortable knowledge (Rayner, 2012) invokes the problem of obtaining an audience that is willing to listen to information that is not palatable. Those who attempt to raise uncomfortable knowledge can be considered as unwelcome whistle-blowers. They can be punished even more severely if they are eventually proved correct, as they can be seen to effectively discredit and thereby de-legitimise the official reference narrative. This type of denial was present in both the 2007-2008 Global Financial Crisis and the 2010 BP Deepwater Horizon pollution catastrophe. Whistle-blowers of all sorts were ignored, derided, or punished (Ramírez & Ravetz, 2011).

2.3.2.3 Organisational attitudes and mechanisms that SUPPORT new insights (shifts to new frames/stories)

An important characteristic of the complexity worldview is that it helps the individual/organisation maintain an open stance towards episodes of learning and experiencing. That is, rather than seeing knowledge as closed, the individual/organisation comes to expect variability, novelty, and interdependence in knowledge and its uses (Feltovich, Hoffman, Woods, & Roesler, 2004).

When decision-makers move into complex settings and work with wicked problems that do not have right answers, they may have to discover the goals as they pursue them. The notion of optimisation, perfection and certainty does not work in these settings because they do not want to stick with their original plan. They want insights about a better vision than the one they started with. They do not want to be trapped by perfection. Insights are disruptive, which undermines predictability. They come without warning, take forms that are unexpected, and open up unimagined opportunities. Insight gets in the way of performance reviews because they reshape tasks and even revise goals (Klein, 2013).

The value of insight in business has a parallel in science. Kuhn (1962) noted that most scientists spend their careers doing 'normal science', basically puzzle-solving within the popular research paradigm of the day. Normal science suppresses fundamental novelties and contradictions because they are inherently subversive of that reference narrative. Over time these discrepancies grow into crises until someone comes along to propose a paradigm shift. Paradigm shifts count as insights because the result is a shift from what may be recognised as an incomplete frame to one that provides a better understanding of the same phenomenon (Klein, 2013).

To deal with complexity needs requisite diversity. To capture all these different aspects of dealing with complexity, Boisot and McKelvey (2011b) developed Ashby's Law of Requisite Complexity, being a variation of the earlier Ashby's Law of Requisite Variety. Ashby's Law of Requisite Complexity states that to be effective, the internal complexity needs to match the complexity of the external environment.

Part of this is cognitive diversity (Page, 2007), which Page defines as the mix of four cognitive tools that make up a person's cognitive toolbox, as the acceptance of:

- diverse perspectives: which are the ways of representing situations and problems;
- diverse interpretations: which are the ways of creating categories;
- diverse heuristics: which are the ways of generating solutions to problems; and
- diverse predictive models: which are the ways of inferring cause and effect.

Requisite variety evolves/emerges from the collective diversity within a group/organisation of the different perspectives, interpretations, heuristics and models. Page (2007) suggests that it is not just the diversity of the decision-makers that matters, but the number and diversity of models available. The greatest benefit from having diverse models is not necessarily the models themselves, but the average of them (itself a model). This logic implies that rather than having a single perspective, interpretive, heuristic, or predictive model, we should have many. This requires accepting some dissonance (Page, 2007). To acquire cognitive diversity, organisation's often use outside consultants, as they have the critical advantage of having different thinking, which challenges the status quo (Page, 2007).

In complex problem-solving situations, organisations need everyone to play a valued part in the overall picture, as it is not known in advance who's holding an important piece of the puzzle (RCPRCMT, 2011-2012 - Dr Callaghan). Normally multiple people may hold different pieces of the puzzle that need to be put together. What is needed is an open and honest environment so that teams/people can come forward with issues/solutions and they are dealt with constructively. It is therefore essential to avoid punishing people inappropriately using derogatory language, blaming people, or failing to look at the reasons why behaviour is being undertaken, as that is the antithesis of good decision-making under uncertainty (RCPRCMT, 2011-2012 - Dr Callaghan).

2.3.2.4 The uncertainty spectrum – summary of section

Figure 2.7 provides a high-level summary of this section, using the uncertainty spectrum diagram and highlights in red, the cognitive blindness that can potentially blind hedgehog decision-makers.


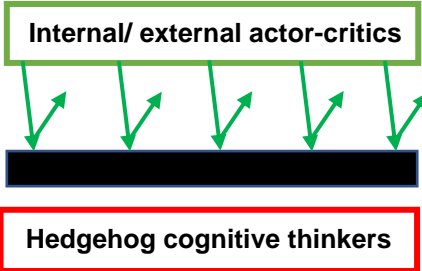

Level of uncertainty	Simplified Cynefin domains	Simplified states of knowing	When operating in a complex and uncertain environment, there is a problem with being blinded by a single top-down reference narrative which rejects disconfirming viewpoints	Potential consequence
<div style="text-align: center;"> High  Low </div>	<div style="text-align: center;"> <i>Unordered domains</i> <i>Ordered domains</i> </div>	<div style="text-align: center;"> Unknowable Unknowns Knowable Knowns </div>	<div style="text-align: center;">  </div>	<div style="text-align: center;">  GAP (Strategic drift) </div>

Figure 2.7: Staying with the ‘known and certain’ – Blinded by a single top-down reference narrative

2.3.3 Hedgehog blindness (2a): Blinded by induction and becoming a turkey

This is the second of three different potential hedgehog blindnesses that have been identified that help lock decision-makers to the hedgehog cognitive thinking style, with a predominant focus on the 'known, known' state of knowing.

As outlined in section 2.2.2.5 and in Figure 2.3, inductive reasoning is essential when using Bayesian (mostly subjective) probability approaches, which is the approach that covers the greatest spectrum of uncertainty outside the small area applicable to objective probability. The subjective approaches are mostly very effective, but, not always, giving rise to dramatic negative (or positive) consequences of a black swan event. This section looks at the problem of decision-makers who put complete reliance on inductive reasoning (usually a good thing when high certainty), when the environment has radical uncertainty. It is difficult, but essential under radical uncertainty, for decision-makers to challenge the inductive thinking of their reference narrative.

2.3.3.1 Induction: All swans in Europe are white, so are all swans white?

Throughout history, in Europe and the surrounding areas, all swans are white, and whiteness became part of the definition of a swan. Over time, the phrase 'black swan' was used as something that was impossible, as black swans were presumed not to exist. Real black swans remained unknown to most of the world until 1697 when Dutch sailors were exploring what is now Western Australia, when they saw black swans for the first time in their native habitat, which included a river they named 'Black Swan River'. This is now the Swan River, running through the city of Perth (Hammond, 2015). This was a surprise discovery for the Europeans, but not for the locals.

The term subsequently changed to mean an idea that is perceived as impossible that might later be disproven. In the 19th century, John Stuart Mill, paraphrasing David Hume, wrote: *"No amount of observations of white swans can allow the inference that all swans are white, but the observation of a single black swan is sufficient to*

refute that conclusion". (Taleb, 2004). The importance of the metaphor lies in its analogy to the fragility of any system of thought, that is potentially undone once any of its fundamental postulates is disproved, with the observation of a single black swan. In philosophy, the existence of black swans has become a classical example of the limits to inferential reasoning (Hammond, 2015).

2.3.3.2 The ‘problem of induction’ is the surprise

The ‘problem of induction’, is also known as "Hume's problem", after David Hume (1748), who wrote about the process of justifying knowledge and claimed, that we cannot rationally justify inductive inference. His concern centres around how we justify what we know is valid (Bendassolli, 2013). Inductive thinking is problematic because we can never be certain that a recurring (known) event will continue to occur. The past may not be the best guide for forming current knowledge, otherwise, how can we not explain unpredictable events? Hume opposed the subsequent Bayesian methods first published in 1763, as they are clearly based on induction. Ever since Hume raised the problem of induction, it has become one of the most serious issues in the philosophy of science. Many philosophers have tried to address this problem. In contrast, natural science has made “remarkable successes” by way of inductive inference. Thus, as C. D. Broad (1952) aptly put it, induction is “the glory of science and the scandal of philosophy” (Lee, 2011). Most of the time, induction is one of the most valuable tools of science and management, therefore we rightfully come to rely on it. However, for a very small amount of time in the scheme of things, especially when we are dealing with high complexity and uncertainty, it does not work, and it does not work in a dramatic way (Bendassolli, 2013; Cargile, 1998; Lee, 2011; Weisberg, 2014; White, 2015).

Blinded by induction and becoming a ‘Turkey’

Taleb (2012) uses a ‘turkey metaphor’ to describe the philosophical problem of induction. In Taleb’s example, the turkey is fed and protected by the farmer for a thousand days, and every day the turkey thinks with increased confidence that the farmer will never hurt it, until Thanksgiving, which results in an unexpected surprise

for the turkey. Thanksgiving was an unknown event for the turkey and nothing in the past had prepared the turkey for it.

Taleb asserts that people should have a mission 'not to be a turkey'. Rare events often do not show up in models of past results, so decision-makers get a rosier picture than is reality. What they do not see can be both significant and also hidden from the past. Taleb (2008a, 2015) uses examples from finance, such as the 1982 banking crisis, where large American banks lost close to all their accumulated profits; how in one single episode, asbestos liabilities bankrupted families of Lloyd underwriters, losing income made over generations; the crash in 1998 of Long-Term Capital management (LTCM), that nearly took down the entire US finance sector; and the 2007-9 subprime crisis. Figure 2.8 graphically illustrates an example used by Taleb, that shows the black swan/turkey effect diagrammatically (profit/loss over time), where for Indy Mac, their hidden subprime risks were increasing, while they were making increasing profits, until the financial blow-up in 2007, and when that unexpectedly occurred, it effectively swiped out all their historical profits.

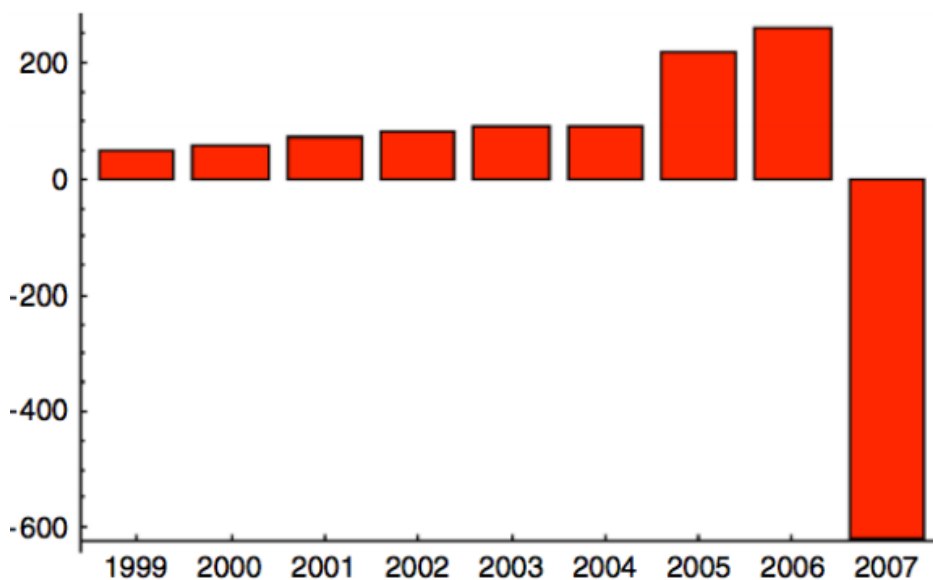


Figure 2.8: The turkey problem, for Indy Mac during the subprime crisis, where nothing in the past indicated a significant financial loss

Source: (Taleb, 2015, p. 293)

2.3.3.3 The ‘problem of induction’ is the technical name for the ‘black swan’ concept

Taleb (2008a) takes the historical black swan problem of philosophy (i.e., the problem of induction) and gives black swan events three attributes: *‘rarity, extreme impact and retrospective predictability. Rarity is defined as an outlier. It lies outside the realm of regular expectations, because nothing in the past can convincingly point to its possibility’*. These rare, unexpected black swan events have a disproportionate role in historical affairs, science, finance, politics, business, and technology. Taleb’s examples of black swan events include, World War I, the dissolution of the Soviet Union, and the September 2001 attacks in New York (Aven, 2015; Taleb, 2008a).

Black swans can be positive or negative events. Most people when using the term black swan, focus on negative black swans, such as various physical or financial disasters. Positive black swans involve little investment but have massive upside from a rare event manifesting, for example, non-linear effects from the complexity domain. Taleb puts most scientific discoveries and venture capital investments in this positive black swan category (Makridakis, Hogarth, & Gaba, 2010).

Black swans are defined by Taleb and others in two different ways

There are two interpretations of Taleb’s definition of black swan events.

Interpretation 1 – Black swans are ‘unknown unknowns’ for each person, the organisation and everyone else

The terms ‘unknown unknowns’ and black swans, are often used more or less interchangeably. Taleb defines a black swan, as an event which lies outside the realm of regular expectations, because nothing in the past can convincingly point to its possibility. A reasonable interpretation of this statement is that he means an ‘unknown unknown’ and these types of event are extremely rare (Aven, 2013). Examples include the 2010 volcanic eruption in Iceland, which because of ash in the atmosphere, closed Heathrow and other northern European airports. The 1908

‘Tunguska fireball event’ in Siberia which flattened 2,000 square kilometres was also a black swan (Schwartz, 2012). Since these types of black swans are beyond the scope of imagination or possibility, they are not so much a low-probability event, but an unimaginable event (Kay & King, 2020).

Interpretation 2 – Observer dependent, i.e., not being the ‘turkey’

A second interpretation of a black swan event is that it is observer dependent, since the decision-maker always needs to ask, ‘for whom?’ The black swan for the turkey is not one for the farmer, hence this example is not inherently an ‘unknown unknown’. This interpretation is a more inclusive definition and it includes high impact events of potentially any level of probability since it is observer dependent rather than just low probability (Taleb, 2008a, 2015). Under this approach, a black swan can be defined as ‘*a surprising extreme event relative to one’s knowledge/beliefs*’, Aven (2015). Therefore, one event, can have many interpretations, with some people being surprised (i.e., the ‘turkey’) and others not surprised (i.e., farmer). The ‘turkey’ had not understood the farmer’s reference narrative. This type of black swan event can potentially apply to anyone at any scale, whether as individuals, groups or organisations. For this research, the Aven (2015) definition has been used as a key construct.

2.3.3.4 The difficulty of challenging induction and belief perseverance/confirmation bias

There is a conscious/unconscious bias towards historic determinism (i.e., induction). This is because this approach is easy to defend (i.e., based on historic knowledge), is realistic, more plausible and is not too different from the present. This approach has an inherent ‘business-as-usual’ assumption, that current conditions with incremental changes will continue to exist into the future. Consistency, stability, and plausibility are the key words in this analytic approach. Ideas about possible futures that violated historic trends are easy to dismiss, as are deviations from extrapolations based on past-based computer models (van Asselt et al., 2010; van’t Klooster & van Asselt, 2011).

While it could be argued that historic determinism is the preferred stance in forecasting, foresight should lean towards futuristic difference. Foresight is frequently presented as the art of understanding uncertainty and discontinuity and is associated with the development of scenarios. However, van Asselt et al. (2010) found that most actual real-world scenarios they studied, fitted either explicitly or implicitly into the historical determinism category. They therefore questioned this forecasting/foresight distinction, as well as wondering why this was occurring, since that approach, while very comfortable to client's expectations, completely avoids preparing clients to the real threats of black swan discontinuities. For this reason, they believe the futuristic difference approach was correct and they did not believe that scenario analysis should be treated as a forecasting method. They suggest that what is needed, is creative thinking that is informed by scientific knowledge, rather than extrapolation of trends (van Asselt et al., 2010; van't Klooster & van Asselt, 2011).

The development of scenarios is suggested as a way of considering future discontinuity. The basic idea of scenarios is that they present different futures that break away from the past and the present. Discontinuity is therefore assumed in the idea of scenarios. They help to prepare for 'surprising' change and recognise the problem of uncertainty, avoid illusions about a knowable future and help understand 'emerging situations while they are still in flux'. Scenarios are not predictions of the future. They show how different interpretations of the driving forces of change can lead to different possible futures. Dealing with discontinuity is difficult, because uncertainty, radical change and potential disruption is hard to deal with. Managers like having a single vision of the future, not multiple options (van Asselt et al., 2010; van't Klooster & van Asselt, 2011). Future scenarios of black swan change can be very controversial as they outline frightening stories that many people do not want to believe (Dator & Yeoman, 2015).

Dealing with prospective or radical uncertainty is a tough challenge. Just being aware of radical uncertainty is not enough. Analysis of the practices employed in scenario development tend to contribute to a pattern that is called certainification – namely, a pattern in which initial uncertainty awareness is compromised by increasing uncertainty intolerance and all kinds of solidifying efforts which, in the end, leads to

outlooks presented as definite and solid accounts about an uncertain future. This leads to a preference for the historic determinism. Personal ambitions, group dynamics and institutional, or even cultural, incentives all reinforce this retreat to historic determinism (van Asselt et al., 2010; van't Klooster & van Asselt, 2011).

Klein (2009) comments on Taleb who '*believes he is a pessimist because his description of black swan events shows the limitations of analytical risk-management methods. I think Taleb is too optimistic. He is just arguing, that we can't predict black swans. I am suggesting that even when they appear in front of us, we may refuse to believe in them. By definition, these kinds of events are hard to comprehend and so we explain them away.*'

2.3.3.5 The uncertainty spectrum – summary of section

Figure 2.9 provides a high-level summary of this section, using the uncertainty spectrum diagram, and highlights in red, the cognitive blindness that can potentially blind hedgehog decision-makers.

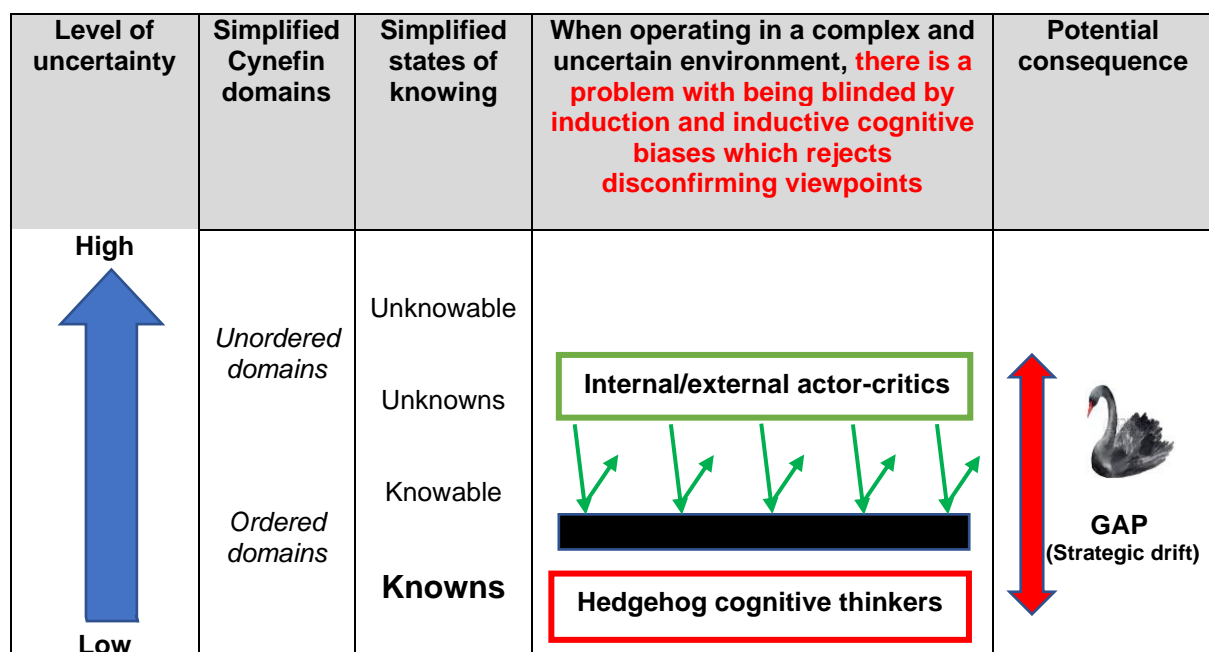


Figure 2.9: Staying with the 'known and certain' – Blinded by induction and inductive cognitive biases

2.3.4 Hedgehog blindness (2b): Blinded by inductive System 1 cognitive biases

This section is complementary to the previous section, being the second of three different potential hedgehog blindnesses that have been identified that help lock decision-makers to the hedgehog cognitive-thinking style, with a predominant focus on the 'known, known' state of knowing.

While this blindness is one of the main ways decision-makers are blinded by induction, it is treated separately because it has been addressed within a different literature, that of behavioural economics, to the previous section which has its origins in philosophy.

2.3.4.1 Cognitive biases cause blindness to potential black swan events

People are blinded, both individually and collectively, by various cognitive biases, such as the confirmation bias, hindsight bias, and survivorship bias. Each bias in its own way blinds decision-makers to potential black swan events because they all focus on what is known, or what the decision-maker thinks they know, rather than on what they do not know (Taleb, 2008a).

When using past data, there is a tendency for individuals to confound 'no evidence of black swans' with 'evidence of no black swans'. People's default cognitive thinking (called System 1 by Kahneman) gives rise to various black swan misunderstandings, such as the love of stories and narratives, the sensational and the emotional which impose on them a wrong map of the likelihood of events (Darlow & Sloman, 2010; Kahneman, 2011; Sloman, 1996; Stanovich & West, 2000; Taleb, 2008a).

Kahneman (2011) uses the term '**WYSIATI**', being, 'What you see is all there is', as a typical System 1 type thinking which is radically insensitive to both the quality and quantity of information that gives rise to impressions and intuitions. WYSIATI causes many biases of judgement and choice. Most of the time the coherent story put together by decision-makers is close enough to reality to support reasonable action.

These stories build on the available information and tend to overlook our ignorance. Compelling stories are simple and concrete rather than abstract; they assign a larger role to talent, stupidity, and intentions than to luck; and focus on a few striking events that happen rather than on non-events that failed to happen. Taleb describes this story telling as the '**narrative fallacy**', where the more detail to the story, the more persuasive, but the less true. (Kahneman, 2011; Taleb, 2008a).

While there are numerous cognitive biases covering a wide range of psychological aspects, listed below are some of the inductive cognitive biases and heuristics used when decision-making under uncertainty.

The **confirmation bias** is the tendency to search for, interpret, focus on and remember information in a way that confirms one's preconceptions, while giving disproportionately less consideration to alternative probabilities. This is an error of inductive reasoning. The effect is stronger for emotionally charged issues and for deeply entrenched beliefs (Pohl, 2004).

The **optimism bias** is the tendency to be over-optimistic, overestimating the likelihood and level/size of favourable and pleasing outcomes. Optimism is useful in obtaining resources and encourages persistence. Optimism is caused by the inductive WYSIATI. Decision-makers focus on what they know and neglect what they do not know, which makes them overly confident in their beliefs. They focus on skill and the presumed effect of skill and neglect luck (Kahneman, 2011; Kahneman et al., 1982).

The **overconfidence effect** is the subjective confidence in a judgement that is not a reasoned evaluation of the probability that this judgement is correct. Confidence is a feeling which reflects the coherence of the information, being the quality of the story people tell about what they see, even if they see very little, and the cognitive ease of processing it. People disregard or are unaware of their ignorance of what they do not know and the fact that critical information may be missing. They are happy to suppress any doubts and ambiguity. The result is they overestimate how much they understand about the world and underestimate the role of chance in events.

Kahneman (2011) quotes the following example, for certain types of questions, that

people answer with "99% certainty" turn out to be wrong 40% of the time.

Overconfidence is often fed by the illusory certainty of hindsight. While an unbiased appreciation of uncertainty is a cornerstone of rationality, it is not always what people and organisations seem to want. Confidence is valued over uncertainty (Adams & Adams, 1960; Kahneman, 2011).

2.3.4.2 The planning fallacy, inside/outside thinking and base rate neglect

These are three interrelated terms. The 'base rate fallacy/neglect' is the tendency to focus on a specific case and its uniqueness or vividness in storytelling and to ignore base rate information which is generic and general, has parallels with 'What we see is all there is' and does not allow for unknowns. The 'planning fallacy' is the tendency to underestimate task-completion times and costs, while overestimating benefits. It is not possible in advance to predict the succession of events that cause a project to drag out. When evidence is weak, decision-makers should stick to using the base rate. Decision-makers exaggerate their ability to forecast the future which fosters optimistic overconfidence. It is a case of both optimism bias (effectively being the best-case scenario) and base rate neglect. Within any type of complex project, anything unexpected, any shock, any volatility, is more likely to extend the total project time. The solution is using the base rate (also known as reference class forecasting) for that type of project, since it allows for difficulties (including the unknowns) that have not been anticipated. When decision-makers suffer from the planning fallacy, this is called the 'inside view' and contrasts with what is called the 'outside view', which uses the baseline prediction as the anchor for further adjustments. The outside view takes into account that there will be unlikely events and unpredictable problems and difficulties. Decision-makers inherently favour the inside view. Personal impressions count (e.g., every case is unique) and the inside view wins in the competition with the outside view. It is important to overcome this natural tendency to treat problems in isolation (Kahneman, 2011; Kahneman & Lovallo, 1993; Kahneman et al., 1982; Taleb, 2012).

2.3.4.3 The sunk cost fallacy and prospect theory

Loss aversion is built into the automatic evaluation of System 1. Loss aversion is a powerful conservative force that favours minimal changes from the status quo in the lives of both institutions and individuals. This can lead to the sunk-cost fallacy which is when people invest additional resources in a losing account/business, when better investments are available. This throwing good money after bad may be a bad investment, but the person who owns it wants to retain their reputation, perhaps to delay the day of reckoning and the humiliation of closing the account as a costly failure. Kahneman (2011) believes that the sunk-cost fallacy keeps people for too long in poor jobs, unhappy marriages and unpromising research projects. The outside view is a useful antidote for the sunk-cost fallacy but is easy to ignore and does not come naturally.

Prospect theory (Kahneman & Tversky, 1979) suggests people care more about losses than about same-sized gains. Usually, the loss aversion ratio is in the range of 1.5 to 2.5 and it varies between people (Kahneman, 2011). Loss aversion is a powerful conservative force that favours minimal changes from the status quo in the lives of both institutions and individuals. Loss aversion protects us from the extremes of overconfident optimism, just as exaggerated optimism protects individuals and organisations from the paralyzing effects of loss aversion. Prospect theory states that people seek to avoid risk and like the certainty of a 'sure thing'. As a result, people prefer a sure gain to a gamble with the same expected value, while rejecting a sure loss in favour of a gamble whose gain has the same positive expected value. Prospect theory also highlights that people place extra value on certain outcomes, so that going from 90% to 100% certainty means much more than going from 40% to 50% certainty (Fischhoff & Kadvany, 2011; Kahneman, 2011; Kahneman et al., 1982).

Of interest to this study, is the desperate choices made in the top-right quadrant of Table 2.6, where the choice is between a sure loss and an unfavourable gamble, which is often unwisely preferred. Decision-makers are said to be risk averse if the sure thing is preferred or risk seeking if the gamble is preferred. The top right quadrant (highlighted in red) is where all options are bad, so this bad option leads to

risk seeking due to diminishing sensitivity. The sure loss is very aversive because the reaction to a loss of \$9,500 is more than 95% as intense as the reaction to a loss of \$10,000 (Kahneman, 2011). There is overweighting of low probabilities that favours the gamble. Decision-makers who take this desperate gamble are accepting the high probability of making things worse in exchange for a small hope of avoiding a large loss. Risk taking of this kind often turns manageable failures into disasters. The thought of accepting the large sure loss is too painful, and the hope of complete relief too enticing, to make the sensible decision that it is time to cut one's losses. An example of this is where businesses that are losing ground to a superior technology waste their remaining assets in futile attempts to catch up. Because defeat is so difficult to accept, the losing side in wars often fights long past the point at which the victory of the other side is certain, and only a matter of time (Kahneman, 2011).

Table 2.6: Prospect theory's fourfold pattern

	Gains	Losses
High probability (Certainty effect)	95% chance to win \$10,000 Fear of disappointment Accept unfavourable settlement <i>RISK AVERSE</i> (Lock in sure gain, rather than the gamble of the expected value.)	95% chance to lose \$10,000 Hope to avoid loss Reject favourable settlement <i>RISK SEEKING</i> (Take the unfavourable gamble over a sure loss, in the hope (small) that it saves them from complete humiliation.)
Low probability (Possibility effect)	5% chance to win \$10,000 Hope of large gain Reject favourable settlement <i>RISK SEEKING</i> (Take the gamble of a dream win with the possibility effect, for example lottery tickets.)	5% chance to lose \$10,000 Fear of large loss Accept unfavourable settlement <i>RISK AVERSE</i> (Lock in certainty to protect from an unlikely event, even if the insurance costs more than expected.)

Source: This table is slightly modified from Kahneman (2011, p. 317)

2.3.4.4 The hindsight and outcome bias

The hindsight bias is the tendency to see past events as being more predictable than they actually were. When an unpredicted event occurs, decision-makers immediately adjust their view of the world to accommodate the surprise. This makes it hard to reconstruct past states of knowledge, or beliefs that have changed. Instead of reconstructing their former beliefs, they bring up their current ones. This causes them to underestimate the extent to which they were surprised by past events. Fischhoff and Beyth (1975) call hindsight, 'I-knew-it-all-along'. People appear to exaggerate the probability that they had assigned to it earlier. This tendency to revise the history of one's beliefs in light of what actually happened produces a robust cognitive illusion. The worse the consequence, the greater the hindsight bias. For example, in the case of a catastrophe, such as 9/11, people are especially ready to believe that the officials who failed to anticipate it were deliberately negligent or blind. The idea that the future is unpredictable is undermined every day by the ease with which the past is explained. The illusion that people understand the past fosters overconfidence in our ability to predict the future (Fischhoff & Beyth, 1975; Kahneman, 2011).

Time matters when considering decision-making. For example, looking back ex-post is not the same as looking forward ex-ante. Figure 2.10 below highlights the two ways to look at a black swan event. When looking backwards once a crash has occurred, the non-crashes have disappeared from reality, because decision-makers are no longer trying to explain them. Their interest is in purely what happened, and that gives them a clear but misleading narrative. The hindsight bias means predicting the future (including crashes) is very poor (Dawes, 1999; Watts, 2012).

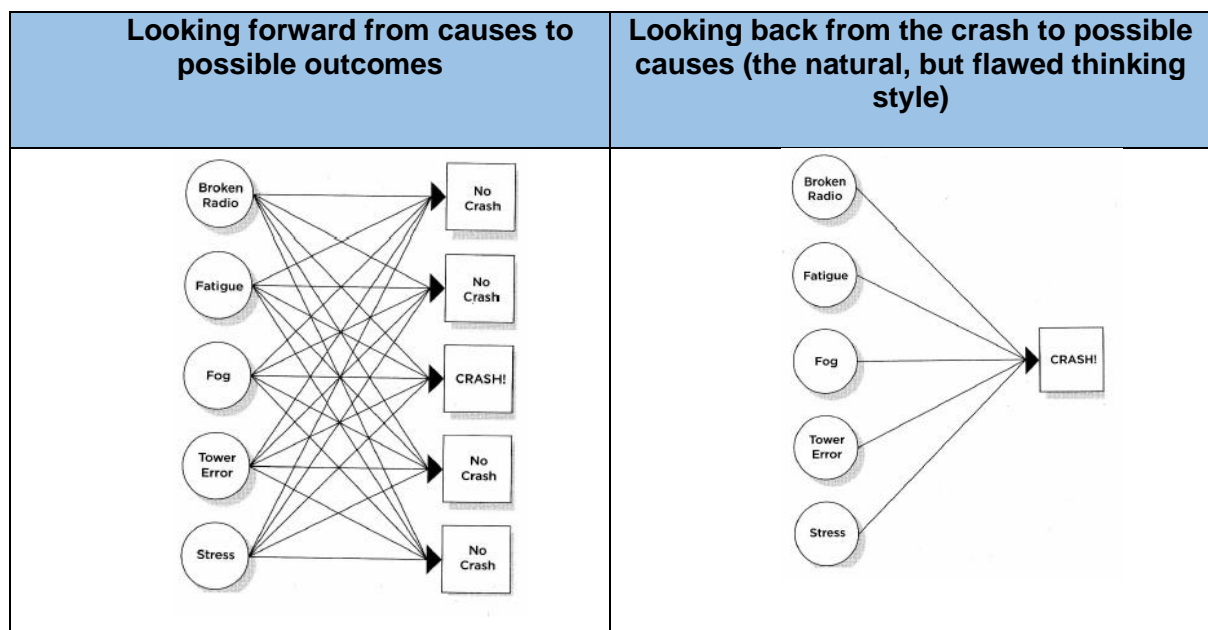


Figure 2.10: Two ways to look at a surprise black swan event (airplane crash)

Source: Dawes (Watts, 2012)

Another way of thinking about hindsight is through the use of the four states of knowing. While most of the inductive cognitive biases, such as optimism and confirmation, lock a decision-maker into the 'known, known' state before an event, with the surprise event being outside that state, hindsight is different because it is looking backwards, rather than forwards. Before the surprise event, the potential future event is outside of the 'known, known' state, being mostly in the 'unaware' states of knowing, so the hedgehog decision-maker places no value on it, just like the other inductive cognitive biases. The potential surprise event is represented in Table 2.7 with a green star. However, once the event has occurred, it has become known and certain, which fits into the 'known, known' state. The hedgehog decision-maker acknowledges it as a fact and the event is incorporated into their thinking, and their mind effectively deletes their previous position (See Table 2.8), as in this case, the mind works on the information it has, i.e., induction.

Table 2.7: A hedgehog-like cognitive thinker dealing with a potential surprise event

	Certain	Uncertain
Unaware	Unknown, knowns	Unknown, unknowns
Aware	Known, knowns	Known, unknowns





Table 2.8: A hedgehog-like cognitive thinker dealing with an actual surprise event

	Certain	Uncertain
Unaware	Unknown, knowns	Unknown, unknowns
Aware	Known, knowns	Known, unknowns



The outcome bias is the tendency to judge a decision by its actual outcome instead of based on the quality of the decision at the time it was made. For example, an outcome bias is where decision-makers think a share portfolio (or sports team) is badly managed, based solely on the share price falling (or the team losing) and no other evidence (Baron & Hershey, 1988; Kahneman, 2011).

2.3.5 Hedgehog blindness (3): Blinded by the illusion of certainty

This is the third of the three different potential hedgehog blindnesses that have been identified that help lock decision-makers to the hedgehog cognitive thinking style, with a predominant focus on the 'known, known' state of knowing.

2.3.5.1 The illusion of certainty

The conscious/unconscious default from radical uncertainty to resolvable uncertainty is highlighted in the emergence of the 'illusion of certainty'. People tend to hate high uncertainty (Stacey, 1996). Uncertainty is psychologically disturbing, as it leads to anxiety and stress. People counter this with the illusion of certainty, because it makes them feel more in control of their lives as it assumes events are predictable. It ignores uncertainty and minimises the role of luck. The term illusion of certainty refers to an emotional need for certainty when none exists. An illusion of certainty is a major emotional obstacle toward learning to live with uncertainty, especially as practically everything has a fundamental element of uncertainty and there is no zero-risk, but only risks that are more or less acceptable (Gigerenzer, 2014; Gigerenzer, Gaissmaier, Kurz-Milcke, Schwartz, & Woloshin, 2007; Makridakis, Hogarth, & Gaba, 2009a).

There are two types of illusion of certainty, being the zero-risk illusion and the turkey illusion. The 'zero-risk illusion' occurs whenever known risks are mistaken for absolute certainty. In areas of uncertainty, people often seek advice from 'experts' (e.g., health, investments or business decisions), with the aim of reducing their risk of uncertainty. There is often an illusion of certainty in the feeling that is attached to medical test results that are taken to be absolutely certain (without understanding false-positives and false-negatives for mammograms, HIV tests etc) and to treatments that appear to guarantee a cure. The 'turkey illusion' is based on Taleb's example of the Thanksgiving turkey, refer 2.3.3.2. The turkey illusion mistakes uncertainty for known or calculable risks. The result is an illusion of certainty (see Figure 2.11 below). In each case, the illusion corresponds to an arrow moving from the right side to the left. In both cases, there is a clash between the real world and

the perceived one. Of particular interest to this study is the 'Turkey' illusion (Gigerenzer, 2014).

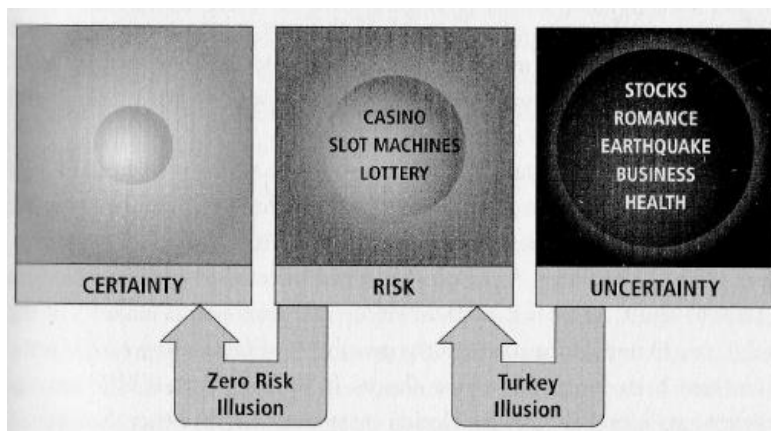


Figure 2.11: The two kinds of illusions of certainty

Source: (Gigerenzer, 2014, p. 33 Figure 2.4)

Treating systems as ordered when they are, in fact, complex/non-ordered is the likely default option in strategy. The orthodox default requires evidence and assumes recipes (Snowden, 2005). For example, statistics may be developed to deal with known risks, but finance operates mostly in an uncertain world of unknown risks, such as the 2008 Global Financial Crisis and associated credit crunch or the 2000 dot-com crisis. Banks and finance companies suffered from the turkey illusion and lost billions of dollars, since these events were not signposted or should not have happened according to their models (Gigerenzer, 2014).

Stacey (2007) proposed that understanding high uncertainty/complexity is important to reduce the anxiety of not knowing. When working in a situation of not knowing, often a new and creative kind of emergent meaning arises. In a highly uncertain world, a quality action is one that keeps options open for as long as possible. It is also important to learn fast from errors. Stacey (2007) believes that the decision-maker can still act, based on their limited knowledge, as they will never be in a position to understand the 'whole', as suggested by systems theory. No one is in control in a complex environment, since that environment produces an emergent rather than designed outcomes, due to the self-organisation from the numerous interactions of all the parties/agents. Patterns over time amplify small differences into

novel patterns. This is in marked contrast to the rational-linear approaches of intentional strategic choice which work well in certain short-term environments (Stacey, 2007).

Stacey (2007) believed that there is a poor understanding of complexity, since most theories of the organisation ignore or downplay radical uncertainty. The problem with the default to resolvable uncertainty is that people will tend to believe that long-term predictability is possible if one is well informed and competent enough or when there is a principal/agent relationship and these aspects of being informed and competent are assumed by the principal of the agent. When the inevitable black swan surprise event happens, this view leads to a search for whom to blame. The perspective that predictability is possible leads to the view that the surprise must be due to ignorance, incompetence or some form of bad behaviour whereby people did not do what they were supposed to do. However, the managers/agents were simply surprised, like everyone else, since surprise is a natural companion to radical uncertainty, no matter how well informed, competent and well-behaved everyone is. This surprise is inseparable from creativity.

2.3.5.2 The conscious/unconscious default to known (especially linear) distribution systems

Oversimplification of complexity can occur if there is an incorrect conscious/unconscious default from unknown probability distribution systems to known (especially linear) probability distribution systems. This creates the potential for surprise black swan events that tend to be outliers in what are defined ex-post as non-linear systems, especially those in Cynefin's unordered domains. These unordered domains primarily have non-linear distributions that are based on systems such as Paretian, Power-law or long tails. These distribution systems have extreme events/outcomes (i.e., black swan events) due to the inherent characteristics of non-linear emergent scalability that often involves networked systems that have feedback loops. These distributions are inherently not predictable and uncertainty reigns (Boisot & McKelvey, 2011a).

Historically, this default to a known distribution has meant that variables are assumed to be normally distributed and independent from each other, despite the fact that for most business situations and socio-economic variables data is non-linear/non-parametric or interdependent. Statistical distributions should only be used when there is evidence that it is the right distribution system for the situation (Blyth, 2009; Makridakis, Hogarth, & Gaba, 2009b; Taleb, 2008a).

There is asymmetry involved in the nature of validation of propositions. For example, to reject a linear system, only one single outlier observation is needed, but numerous observations will not fully confirm the validity of a non-linear distribution system. A linear normal distribution curve disallows large deviations, but the non-linear long tail does not disallow long quiet stretches. Just because the data shows a long period of no outliers, it is not proof that the system is linear, it may just mean the outliers are yet to arrive. One extreme black swan event can be greater than all previous events. This can be applied to wealth, health or happiness (Taleb, 2008a).

Since the 2008 global financial crisis, the terms “black swans” and “fat tails” have become a familiar part of the risk conversation. Yet standard risk management tools (such as Value-at-risk) still assume that system risks follow a normal parametric distribution, because this provides easy-to-understand narratives and is easy to model mathematically (i.e., what you have is all that is used). But non-linear non-parametric fat tail risks are not normal parametric distributions. The consequences of using the wrong statistical distribution system can impact an enterprise, perhaps catastrophically, as it did in the 2008 financial crisis (Kupers, 2014; WEF, 2018). The 2008 financial crisis was mostly caused by the oversimplification of complexity within the model used for decision-making around financial derivatives. The linear parametric Gaussian copula model was widely used to collapse the complexity of a risky situation into a single elegant number. The result was subsequently used for decision-making and blinded decision-makers to the consequences of complexity in the environment in which they were operating. Only ex-post did the flaw of this oversimplification become obvious (Dekker, 2011).

Organisations have a natural bias towards ‘parametric’ thinking and the world of stable and finite objects that it generates. Organisations are therefore keen to

consciously/unconsciously default to the ordered domains in order to economise on the resources needed to respond, which requires exploit rather than explore approaches. This is a problem in a dynamic complex world which requires a fast pace of innovation and change (Boisot & McKelvey, 2011b; Child & Ihrig, 2013).

2.3.5.3 The few large non-linear outliers (i.e., black swans) have a big effect

Non-linearity is a difficult concept to understand because it is not inherently intuitive to most people, as to how small incremental changes can lead to large outcomes. This is not easily visualised. The result is not what they expect, as the marginal changes are not constant (Mauboussin, 2009, 2012).

Taleb (2008b) believes most business situations and socio-economic variables (e.g., commodity prices, share markets, currencies, inflation numbers, interest rates, GDP, company performance, etc.) exhibit long tail (i.e., they exceed ± 4 standard deviations) distribution system characteristics (i.e., non-linear), consistent with complexity. Because of these few extreme outliers, complex systems are called 'wild', but ironically for a system called 'wild', most of the time movements can be mild, and only infrequently they become wild (Taleb, 2008b, 2009). There are huge numbers of ordinary events compared to the few extreme events. In the financial markets, there are at least 10,000 times more events of 0.1 percent magnitude than events of 10 percent magnitude. There are about three million microearthquakes, being below 2 on the Richter scale, a year. They are harmless. However, shocks of intensity 6 and higher on the Richter scale make the newspaper. These highly unpredictable non-linear events play a disproportionate role (Taleb, 2012).

This feature of having mild fluctuations most of the time, then very occasionally extreme fluctuations, results ex-post in a punctuated equilibrium effect. Beinhocker (2006) notes that the equilibrium nature of change in complex adaptive systems can have perverse and pernicious effects. It lulls people's pattern-recognition, rule-building minds into thinking that a long period of mild events fit into a stable pattern and then a sudden punctuation occurs, being a surprise extreme event. Very

occasionally, emergent economic data such as business cycles, growth and inflation, which is mostly linear, will be hit with a surprise punctuation and this creates wild turbulence. Since these extreme events occur only rarely, then ex-ante, people mentally default to thinking there is no probability of the event occurring.

2.3.5.4 The uncertainty spectrum – summary of section

Figure 2.12 provides a high-level summary of this section using the uncertainty spectrum diagram and highlights in red the hedgehog blindness that can potentially blind decision-makers.

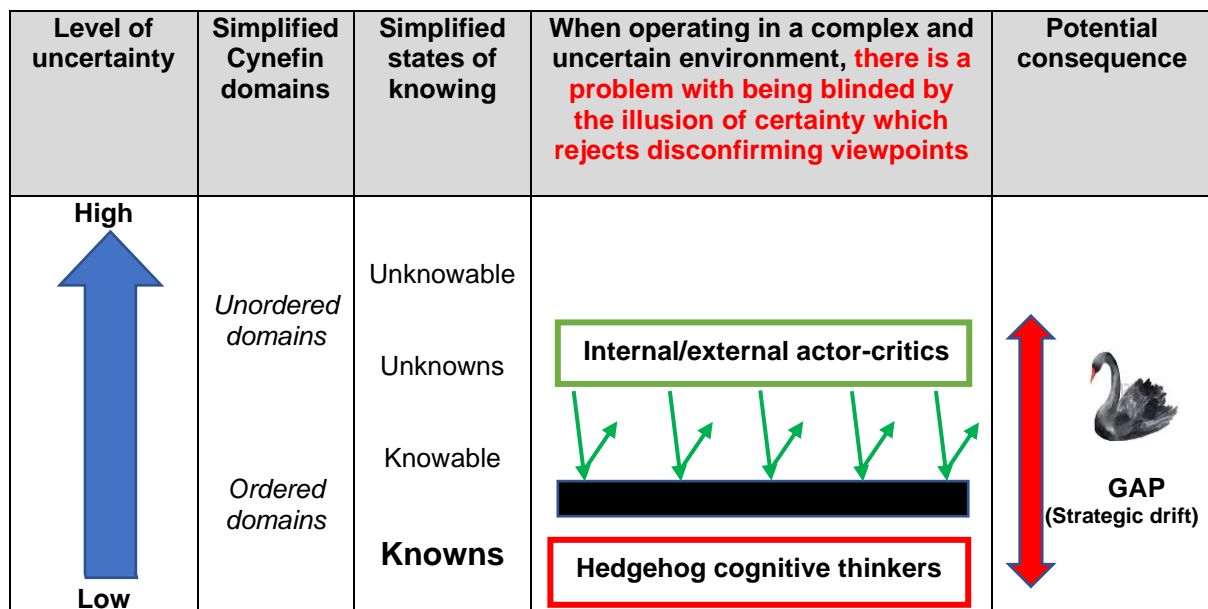


Figure 2.12: Staying with the ‘known and certain’ – Blinded by the illusion of certainty

2.4 Summary – Literature review and conceptual framework construction

This section provides a high-level summary of Chapter 2: Literature review and conceptual framework construction, based on the four foundation constructs as per Section 1.1.4 – Base theory, constructs and the research gap, being radical uncertainty, strategic drift and the reference narrative, black swan events and the three common forms of organisational bounded rationality.

2.4.1 Radical uncertainty

2.4.1.1 Describing the uncertainty spectrum

There are many different ways of describing the uncertainty spectrum. For example, Knightian risk/uncertainty (Knight, 1921); objective/subjective (Friedman, 2007; Savage, 1954); Cynefin domains (Kurtz & Snowden, 2003); state of knowing (Boschetti, 2011; McLeod & Childs, 2013; Snowden & Boone, 2007), or thinking styles, i.e., deductive, inductive, and abductive. Each approach is valuable as each approach uses a slightly different interpretative lens which highlights important differences. Refer Section 2.2.2.5.

For this research, uncertainty is defined as resolvable/radical as described by Kay and King (2020). Resolvable uncertainty is uncertainty which can be resolved by looking something up or which can be represented by a known stationary probability distribution of outcomes. Probability has a clear and objective meaning. Objective or subjective probability approaches are valuable. Radical uncertainty cannot be described in the probabilistic terms applicable to a game of chance. In situations manifesting uncertainty, there would be no stable structure of the world about which decision-makers could learn from past experience and extrapolate future behaviour. This is a world of uncertain futures and unpredictable consequences. Under radical uncertainty most decision-makers satisfice or cope rather than optimise. The focus of this thesis is on radical uncertainty. Refer Section 2.2.1.5.

This definition of radical uncertainty is overlaid with the Cynefin framework of Kurtz and Snowden (2003), extending the definitional construct to add their complex and chaotic dimensions with their distinct and sometimes overlooked characteristics. The Cynefin framework can be simplified from four domains to just two, being the ordered and the unordered domains and this is useful to overlay on the resolvable/radical categorisation, being ordered/resolvable and unordered/radical. Also used in defining resolvable/radical uncertainty was the simplified state of knowing. For example, resolvable being the knowns and knowables, and radical uncertainty being the unknowns and unknowables. Refer Section 2.2.2.

2.4.1.2 Describing the two high-level management approaches to uncertainty

At a high-level, the level of uncertainty (i.e., low and high) creates a duality of approaches across different management decision-making processes. For example: **in strategy**, e.g., Mintzberg (1994)'s deliberative versus vs emergent, top down vs bottom up, Liedtka (1998)'s strategic planning vs strategic thinking, Martin (2009)'s exploit vs explore; **in risk analysis**, e.g., Kupers (2014)'s conventional vs systemic risk, Ramírez and Ravetz (2011)'s tame vs wild/feral, Lempert (2002)'s probabilities vs deep uncertainty; **in futures**, e.g., van Asselt et al. (2010)'s historical determinism vs future difference, forecasting vs foresight, extrapolation vs new patterns; **in systems thinking**, e.g., Senge (2006)'s detailed complexity vs deep complexity; **in policy**, e.g., Rittel and Webber (1973)'s tame vs wicked problems; **and in other**, e.g., Kuhn (1962)'s normal incremental science vs transformational paradigm shifts. This is shown diagrammatically in Figure 2.13.

The key to managing uncertainty is to know whether you are dealing with the known and expected or the unknown and unexpected. Decision-makers then need to apply the appropriate toolkit for that level of uncertainty. Historically, the default business-as-usual approach is to assume the situation was known and expected, where there are well developed analytical toolkits. The toolkit for dealing with the unknown and unexpected requires a completely different mindset and toolkit. Making this mindset change can be a challenge as assumptions of certainty have to be abandoned.

and decline in performance (Sammut-Bonnici, 2015). In this research, the collective management/board mindset is called the 'reference narrative'. The reference narrative is not constructed in isolation, but may be discussed with family, friends, and be subject to professional advice and the collective intelligence accumulated and available in the various communities in which the decision-makers live (Kay & King, 2020). Implicit within any collective mindset, is the inherent reality that some visionary participants will always be ahead of the agreed position and are keen for the reference narrative to be updated. These visionary participants may or may not be within the group of key decision-makers that construct, approve and implement the reference narrative.

2.4.2.1 The 'reference narrative' is how decision-makers understand what is going on under radical uncertainty

Decision-makers cope with radical uncertainty by drawing on the reference narrative(s), that is, by referencing the dominant narrative. A central element of this ability is people's capacity for, and pleasure in storytelling (Kahneman, 2011). Under radical uncertainty the reference narrative needs to change and evolve over time to better explain what is actually happening. People change their reference narrative in response to disconfirming events, but infrequently and discontinuously (Kay & King, 2020).

2.4.2.2 Management approaches that influence the reference narrative

Under high uncertainty, decision-makers need to ensure that the dominant collective reference narrative is robustly challenged and options explored to ensure no strategic drift has occurred. Relevant management techniques include: 'explore, experiment and learn'; pro-actively managing luck and valuing and seeking out new insights. 'Explore, experiment and learn' is achieved by low-cost, low-risk and low-distraction tests or experiments to find what works. Because of the unknowns, success and failure can only be understood after the tests or experiments, and what is learnt may be something unexpected. If something works, then scale up (Collins & Hansen, 2011). Pro-actively managing luck is the ability to recognise luck when it happens; the wisdom to see when, and when not, to let luck disrupt the reference

narrative; being prepared to endure bad luck; and creating a positive return on good/bad luck when it happens (Collins & Hansen, 2011). Under high uncertainty insight is important. Klein (2013) defines an insight as an unexpected shift to a better frame or story (i.e., reference narrative) for understanding how things work. Insights are disruptive as they challenge the dominant reference narrative. In science a successful insight causes a paradigm shift (Kuhn, 1962).

2.4.3 Black swan events

When there is strategic drift and the organisational reference narrative becomes increasing distant from the reality, then if a black swan event occurs, this may lead to a 'reality check'. Black swan events are defined for this research as, '*surprising extreme events relative to one's knowledge/beliefs*' (Aven, 2015). This fits with Taleb (2008a)'s 'observer dependent' or turkey black swan interpretation. Implicit within this definition is the assumption that someone, somewhere has more knowledge or a different belief, that was not surprised by the unexpected event. That person or persons will often be outside the group of key decision-makers who construct, approve and implement the organisational reference narrative. Refer Section 3.3.1.

2.4.4 Bounded rationality and the two very different decision-making attitudes to uncertainty

The gap in the research is not just about what happens when strategic drift connects with a black swan event but why do otherwise good boards and management teams get into this 'cognitive sloth' of strategic drift. (Sammut-Bonnici, 2015). The research question asks why key decision-makers failed to foresee, listen to or act upon a black swan event? The answer lies in the three types of organisational bounded rationality which this research explores. All three forms of organisational bounded rationality actively work to make a fixed and time bound organisational reference narrative, which causes strategic drift and therefore the potential for a black swan event.

2.4.4.1 Fox/hedgehog cognitive thinking styles

Tetlock (2005) suggests that in dealing with uncertainty there are two clear cognitive thinking styles based on the decision-makers preferred states of knowing. These are called fox/hedgehog cognitive thinking styles. The fox/hedgehog categorisation is based on a fragment of a Greek poem by Archilochus (c660 BC) – ‘*The fox knows many little things, but the hedgehog knows one big thing*’. This research puts emphasis on the fox/hedgehog attitude to uncertainty. Hedgehogs like the known and certain and they avoid uncertainty. They reduce all challenges and dilemmas to simple top-down deductive narratives which they effectively defend. For a hedgehog, anything that does not somehow relate to their organising idea is discarded. Foxes deal with complexity by drawing from an eclectic array of traditions and approaches, which means they are better equipped to survive in rapidly changing environments as they can quickly abandoned bad or flawed ideas. The fox/hedgehog relationship to uncertainty is shown diagrammatically in Figure 2.6.

2.4.4.2 Three common forms of organisational bounded rationality

A review of complexity and decision-making literature (starting with Taleb (2008a) and going out ever wider) identified three interdependent factors that cause hedgehog cognitive thinkers to be blind to black swan events. These factors are: the illusion of certainty, a top-down reference narrative and reliance on induction. Each of these factors is ideally suited to a known and certain environment, where hedgehog cognitive thinkers excel but become problematic as uncertainty increases. The following paragraphs describe the three hedgehog blindnesses in greater detail. Refer Section 2.3.1.6.

Individually each simplification may not be a problem, for example, it is common for CEO's to be extremely confident with a clear narrative (Moxey, 2019). The three forms of bounded rationality are interdependent, so collectively form a cocktail of simplifications that can cause decision-makers to fail to see potential black-swan events.

2.4.4.3 The ‘illusion of certainty’ is a problem under radical uncertainty

There is a universal human emotional need for certainty, which can mean there is a conscious or unconscious reduction in the level of uncertainty acknowledged. This creates an illusion that there is greater certainty than there really is. The focus is on what is known and certain. What is unknown or uncertain is minimised (Gigerenzer, 2014). Common simplifications include: default to the known and expected (resolvable uncertainty); default to the normal distribution when power law or other non-linear distributions apply; or assuming high levels of control over events and downplaying the role of luck, chance or random events that are features of complex or chaotic systems. Sometimes it is unclear what level of uncertainty actually exists, since the decision-makers don't know what they don't know and there is a conscious default to the known and certain. The ‘illusion of certainty’ (Gigerenzer, 2014) is an important factor in why hedgehog decision-makers can be surprised by the unexpected.

2.4.4.4 A top-down reference narrative is a problem under radical uncertainty

A top-down deductive reference narrative works well in situations that are known and certain, especially those that focus on ‘exploit’ or optimisation approaches (Kay & King, 2020). There is little need to continually revise underlying assumptions. Top-down approaches require hierarchical obedience and conformity. Dissent or diversity of views is not appreciated. When decision-making under uncertainty, a top-down reference narrative is not appropriate, as it may not recognise, accommodate or encourage the need to change as new information or events occur since the new insights may originate anywhere in the organisation, rather than just at the top. This will cause different actors to question the reference narrative, but groupthink and the confirmation bias can keep the ingroup together, so the reference narrative may provide a perspective that is more positive or less negative than is warranted. Having a single top-down reference narrative is an important factor in why hedgehog decision-makers can be surprised by the unexpected.

2.4.4.5 Induction is a problem under radical uncertainty

Induction can be a necessary and valuable thinking style for decision-makers, especially when there is incomplete information, and the underlying pattern can be determined. This approach uses the information available or as Kahneman (2011) describes it, 'What you see is all there is'. The 'problem with induction' was identified by the philosopher Hume (1741), is that it only considers in-sample data and is prone to the surprise of out-of-sample information/events, i.e., black swan events (Taleb, 2008a). The 'problem of induction' is a feature of the various inductive cognitive biases, such as optimism bias, confirmation bias, sunk cost fallacy, and the planning fallacy (Kahneman, 2011). Being blinded by induction and inductive cognitive biases is an important factor in why hedgehog decision-makers can be surprised by the unexpected. Many successful business leaders have overconfidence or the optimism bias. This becomes a problem when the organisations they lead unexpectedly falter, e.g., the 2018 British Carillion pic collapse (Moxey, 2019) or Elizabeth Holmes of Theranos.

Figure 2.14 is a diagrammatic presentation of these three potential hedgehog blindnesses.

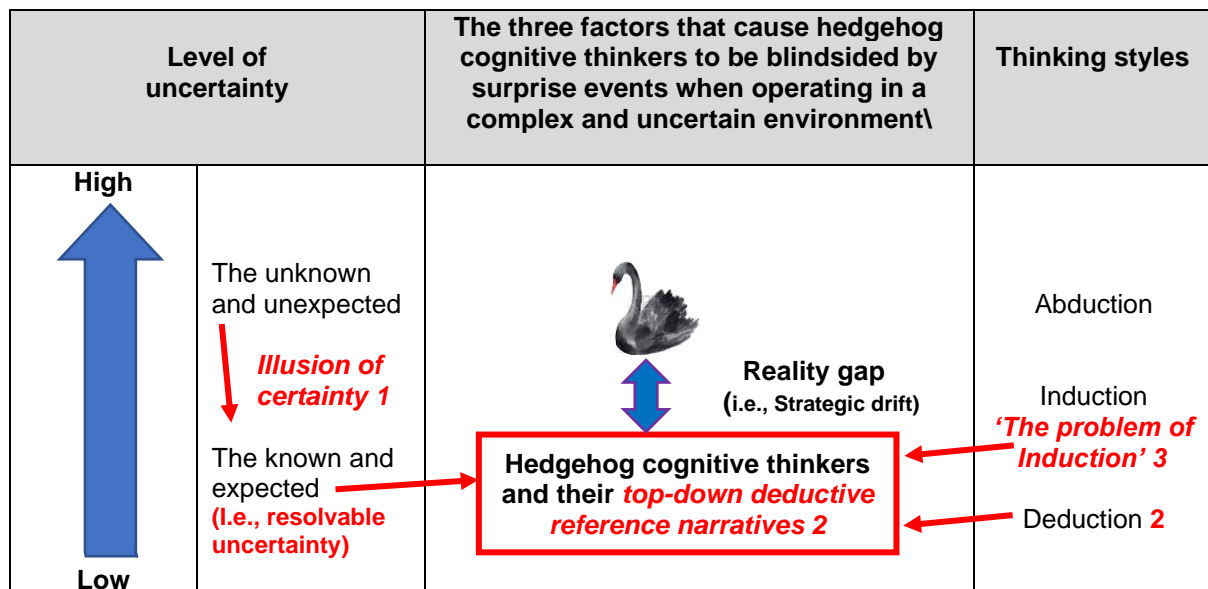


Figure 2.14: The three factors that cause hedgehog cognitive thinkers to be blind to black swan events

The ideal is to avoid simplifications of uncertainty, ensure there is challenge to the reference narrative and to expect surprises.

3. Research methodology

This chapter deals with the research design appropriate to the needs of the study of a surprise black swan event that is outside of the official reference narrative of organisational decision-makers and the implicit decision making models they may have used. The chapter sets out the ontological and epistemological approach (in this case, the constructivist interpretation paradigm) and provides the rationale for its use. This leads on to deciding the appropriate research methods and design, unit of analysis, population/selecting a case study, and data collection and data analysis approaches. This chapter also details the different methodological steps involved in the analysis and how the various themes were extracted from the source information via these steps.

3.1 The ontological and epistemological assumptions

The main characteristic of the study context – the mining operations, its broader legal, technical, ecological and social environment, and the diversity of stakeholders, is complexity. The Chapter 2 discusses the complexity around decision-making under uncertainty and the variety of disciplines, behavioural economics, psychology, statistics, philosophy, and risk management, which results in an array of potential perspectives. There is also complexity in the case study as there are multiple business and operational uncertainties in play, which are dynamic in nature. This study seeks to generate a conceptual framework through qualitative exploration and understanding of the multiple subjective perceptions within the decision-making process of a large complex organisation. The organisation selected was one that experienced a significant and unexpected, that is, ‘black swan event’ that led to a Royal Commission of Inquiry. Having a public commission of inquiry enabled the researcher to ex-post apply documentation analysis to the commission hearings to understand the different perspectives.

This research has used a constructivist approach. This is in contrast to positivist/post positivist research that has the aim of theory verification, quantitative data and a single answer. Constructivism adopts a relativist ontology, a subjectivist transactional

epistemology and a hermeneutic dialectical methodology. Users of this paradigm are oriented to the production of reconstructed and co-constructed understandings of the realities experienced. It uses an interpretive case study narrative. The inquiry aim of a constructivist approach is understanding and 'reconstruction'. Constructivists value transactional knowledge. Constructivism connects action to praxis and builds on antifoundational arguments while encouraging experiment and multi-voiced texts (Guba & Lincoln, 2008).

Constructivism deals with the subjectivity of different actor perceptions

The aim of constructivism is to understand a complex situation and to inform improved practice, insight and learning. This approach believes that the world is constructed by human beings as they interact and engage in interpretation and that you gain understanding by interpreting subject perceptions, in this case subjective perceptions around organisational uncertainty and complexity. Researchers using this approach try to be 'true' to this complexity, by ensuring that the knowledge produced is reflective of the multiple realities held by the key actors being studied. Constructivist researchers tend to focus on meaning in context. They aim to understand the context of a phenomenon, since the context is what defines the situation and makes it what it is. They assume that meanings are emergent and depend on the context and it is these emergent meanings that they seek to elucidate (Denzin & Lincoln, 2011; Myers, 2009; O'Leary, 2014).

The constructivist approach is appropriate for this study because different actors have different subjective views of reality, as well as potentially having different views at different times, e.g., before, during, and after the black swan event, due to more information becoming available over time. As described later in section 3.3.2 Unit of analysis, this difference is simplified into two positions in this research: the company's official reference narrative as represented by the public statements and opinions of the key decision-makers (ex-ante and ex-post) and the various actor critics of this reference narrative, who may or may not agree with each other.

Constructivism deals with complexity by applying the non-linear bricolage and quilt-making approach

Research is sometimes portrayed as a set of procedures with formalized steps, or as a set of logical and sequential skills, all decided upon in advance, often in what seems a linear sequence. In reality, the qualitative constructivist research process is almost the exact opposite, needing to be, dynamic, complex, recursive, continuous and non-linear. This type of research approach is difficult to describe in advance (or even ex-post) because of uncertainties about methods needed and results that will emerge. Non-linear and non-sequenced research will be messy, especially in comparison to linear and sequenced research, but the researcher needs to accept and be comfortable with that reality. Aligning with these views, the approach taken throughout this research process when dealing with the complexity of the case study is to apply a bricolage approach (Lambotte & Meunier, 2013).

The many methodological practices of qualitative research used in complex qualitative case studies may be viewed as bricolage or quilt making. The qualitative researcher, in turn may be seen as a bricoleur or the maker of quilts (Levi-Strauss, 1966). The quilter stitches, edits and puts slices of reality together. A bricoleur makes do with what they have, using whatever strategies, methods, empirical materials or recombined parts that are to hand. Many different things are in play at the same time – different voices, different perspectives, different points of view, and different angles of vision. The product of the interpretive bricoleur's creative labour and synthesizing is a complex quiltlike bricolage, a sequence of representations connecting the parts to the whole in order to create the unity of a pattern (Denzin & Lincoln, 2008).

There are many aspects of bricolage and the activities of bricoleurs, e.g., being interpretive, creating narrative, being critical, being theoretical, and being methodological. The *interpretive* bricoleur adds different tools, methods and techniques of representation and interpretation to the puzzle, resulting in a bricolage, being an emergent pattern that is constructed from different pieces of the complex situation. The *interpretive* bricoleur understands that research is an interactive process shaped by their own personal history and by those of the people in the setting. The *narrative* bricoleur knows that researchers all tell stories about the world

they have studied, framed within their specific storytelling traditions, often defined by relevant paradigms. The *critical* bricoleur stresses the dialectical and hermeneutic nature of interdisciplinary inquiry. The *theoretical* bricoleur reads widely and is knowledgeable about the many interpretive, competing and overlapping paradigms and perspectives that can be brought to any particular problem. The *methodological* bricoleur is adept at performing a large number of diverse tasks, including intensive self-reflection and introspection (Denzin & Lincoln, 2008).

Sensitive to complexity, bricoleurs use multiple methods to uncover new insights, expand and modify old principles, and re-examine accepted interpretations in unanticipated contexts (Kincheloe, 2001). Bricolage selects and uses methodological strategies as they are needed in the unfolding context of the research situation. The bricoleur constructs a far more active role for humans both in shaping reality and in creating the research processes and narratives that represent it (Kincheloe & McLaren, 2008).

These bricoleur and bricolage concepts are developed and applied in section 3.4 (There, 12 different steps or individual quilt squares are bricolaged from the different methods and approaches used in the bricoleur's research journey). Section 3.5 (Analysis of the bricoleur's research journey) outlines how emergent themes were extracted from each of these 12 steps to build an overall pattern or quilt and this section describes how the different aspects of a bricoleur, such as interpretative, narrative, critical, theoretical and methodological were applied at different stages within the 12 steps. Section 3.6 provides a conclusion on the bricoleur journey.

3.2 Research design

A qualitative research approach used

The constructivist approach relies heavily on naturalistic methods, such as interviews and analysis of existing texts because these approaches are effective in building on understanding the different perceptions of different actors involved. Typically, qualitative methods are used. Qualitative methods differ from quantitative methods in

a number of significant ways. These include having a different philosophical approach, focus, data collection techniques and final outcomes/products. Qualitative methods have the following attributes. They are mainly inductive, have a focus on meaning in context, and they use purposively sampling that relates to the research question (Cavana, Delahaye, & Sekaran, 2001; Denzin & Lincoln, 2011; Myers, 1997; Zhang & Wildemuth, 2005).

Compared to quantitative approaches, qualitative approaches use thematic analysis and a closer, more entwined relationship between entering and coding data, data analysis and interpretation. It is an organic process that sees all three steps (coding data, data analysis and interpretation) influencing each other and working in overlapping cycles. Qualitative research argues the value of depth over quantity and works at delving into social complexities in order to truly explore and understand the interactions, processes, lived experiences, and belief systems that are part of individuals and institutions (Cavana et al., 2001; Denzin & Lincoln, 2011; Orlikowski & Baroudi, 1991).

Using a qualitative interpretative case study

The study focuses on the Pike River Coal Ltd (Pike) and the related black swan event. A single qualitative case study approach is proposed. A case study is appropriate where, as in this research, there is a focus on 'why' questions because they deal with links over time rather than with frequency or incidence; where there is complexity; the situation is unusually revelatory; where it is unclear at the start as to what the critical variables or themes are; where there is the need for exploration and the need for developmental knowledge building; where there is an opportunity to explore a significant phenomenon under rare or extreme circumstances; and where the results derived depend heavily on the integrative powers of the investigator (Benbasat, Goldstein, & Mead, 1987; Yin, 1994, 2009, 2011).

This research seeks to understand Pike's reference narrative as represented by the statements and decisions of its three key decision-makers and how/who/what/when this narrative made them seemingly blind to the black swan event. The critical part in

this process is to understand the many actor critics who questioned different aspects of Pike's reference narrative and the attitudes of the three key decision-makers ex-ante. Usually the views of actor-critics were sufficient to change the official narrative or management's attitudes.

3.3 Research methods

The 'methods' used are the actual techniques used to collect and analyse the data. Since this study is in the qualitative tradition, the methods used include an in-depth case study using thematic analysis of documents. Thematic analysis involves searching through primary and secondary data to inductively identify interconnections and patterns. Patterns are then analysed and explored as potential themes that characterise context behaviour, beliefs etc. As themes solidify, the next level of abstraction leads to theory building (O'Leary, 2014; Onwuegbuzie & Leech, 2007).

3.3.1 Determining the data - population, sample frame and sample

The criteria for sample selection was based on finding examples of what Taleb (2008a) described as being black swan events, being events that are rare/outliers, with extreme impact and with retrospective (though not prospective) predictability. This was the theoretical construct at the start of this research. As the research progressed and the two interpretations by Taleb of this definition were identified (refer Section 2.3.3.3) it was implicitly assumed that the research was following Taleb's observer dependent interpretation. Following feedback, to make this choice explicit, the foundation construct definition of a black swan event was clarified in line with the definition of Aven (2015), being '*a surprising extreme event relative to one's knowledge/beliefs*'. This change in definition did not require any retrospective changes to the initial sample selection process. With any change of definition at the end of the process, if that definition had been applied initially, then the initial analysis would have been slightly different, but in this case the answer should be the same.

The important initial step in the research process was the selection of an organisation that was ‘blindsided’ by a black swan event. To do this, Royal Commissions of Inquiry (for events of public significance/importance) were used as the sample frame of ‘surprise’ events of consequence for an organisation. Of course, not all public inquiries relate to significant surprises. Public inquiries can cover a range of subjects, including genetic modification, Police conduct or Commission on Auckland governance. The key source of information on inquiries comes from The Department of Internal Affairs (D.I.A., 2017) and Te-ARA - The Encyclopedia of New Zealand (Heritage., 2017).

Area of study/sampling frame: Table 3.1 sets out all Government-initiated public inquiries from 1980 to 2016. Using this as the sample frame, all inquiries that focus on a ‘surprise’ related to safety and loss of life have been identified (shaded in grey).

Table 3.1: Government initiated public inquiries from 1980 to 2016

Surprise event	Organisation involved	Type of inquiry RC = Royal Commission CI = Commission of Inquiry GI = Government Inquiry	Date	Safety/ loss of life?
Air NZ Flight 901 (Mount Erebus) disaster	Air NZ Ltd	RC	1980-81	√
Impropriety - Marginal Lands Board	Marginal Lands Board	CI	1980-81	x
Conviction - Arthur A. Thomas	Police	RC	1980	x
Administration - District Court at Wellington	District Court	CI	1982-83	x
Air traffic control services	Air traffic control	CI	1982	x
Drug trafficking	Police	RC	1982-83	x
Release of a psychiatric patient	Health	CI	1983	x
Contracts of Broadcasting Corp. NZ	BCNZ	CI	1983	x
Industrial relations - Whangarei refinery	Industrial	CI	1984	x
Broadcasting	Policy	RC	1985-86	x
Electoral system	Policy	RC	1985-86	x
Mikhail Lermontov ship wreck	Picton Harbourmaster	NZ/Russian Inquiry	1986	√
Social policy	Social Policy	RC	1986-88	x
Auckland power-supply failure	Mercury Energy	CI	1998	x

Surprise event	Organisation involved	Type of inquiry RC = Royal Commission CI = Commission of Inquiry GI = Government Inquiry	Date	Safety/ loss of life?
Taxation (Winebox)	IRD	CI	1994-97	x
Collapse of a viewing platform at Cave Creek	DOC	CI	1995	√
Computer system (INCIS)	Police/IBM	CI	1999	x
Genetic modification	MfE	RC	2000-02	x
Police conduct	Police	CI	2004-07	x
Auckland governance	Local Govt.	RC	2007-09	x
Pike River coal mine tragedy	Pike River Coal Ltd	RC	2010	√
Building failure caused by the Canterbury earthquakes	CTV and PGC buildings	RC	2011	√
Rena container ship wreck on the Astrolabe Reef	Mediterranean Shipping Company	Transport Accident Investigation Commission	2011	x (No loss of life)
Whey Protein Contamination	Fonterra	GI	2014	x (health)
Allegations regarding Hon. Judith Collins	S.F.O.	GI	2014	x
Havelock North Water Contamination	Local Govt.	GI	2016	x (health)

Source: Derived from Government records (D.I.A., 2017; Heritage., 2017)

As described in Table 3. 1, there are three types of public inquiries. There are Royal Commissions (RC) and Commissions of Inquiry (CI) which are virtually the same thing and there are no differences in their purpose, functions, procedures and effects. Royal Commissions are commonly seen as having greater prestige and standing than CIs. From 2013 there are government Inquiries (GI), which are appointed by and report to a Minister and the intention is that these are simpler and quicker to establish (D.I.A., 2017).

Sample selection

A first cut sample was selected using the criteria of recency (for availability of records), significance of the consequence (i.e., loss of life/long-term effect) and complexity of the situation (i.e., multiple stakeholders/layers). Of the five possible

safety/loss of life samples, three were initially selected, being those with significant loss of life and being relatively recent, covering the years 1995 to 2011. They all relate to human activity in the natural environment, where there was a surprise event of consequence, refer Table 3.2.

Table 3.2: The sample of three surprise events of consequence (to the organisation and NZ)

The sample – 3 surprise events	Organisation	Type of inquiry	No of Commissioners	Date	The consequence
Collapse of a viewing platform at Cave Creek	Department of Conservation (Government department)	Commission	1	1995	Killed 14. Consequential changes to funding and management of the conservation estate, including the need to comply with building standards.
Pike River Coal mine disaster	Pike River Coal Company (Public company)	Royal Commission	3	2010	Killed 29. NZ's worst mining disaster since 1914 (i.e., Huntly, with 43 killed). This crushed the hopes of safe eco-friendly mining in the West coast, an area of declining GDP/population. There were consequential changes to Health and Safety laws and mining regulations.
Building failure caused by the Canterbury earthquakes	CCTV and PGC buildings	Royal Commission (The focus was on engineering aspects)	3	2011	Killed 185 – mostly in three buildings. Many were foreign students. NZ's fifth deadliest natural disaster. Worst disaster since 1979 (Erebus crash).

					Consequential economic impact, liquefaction, and initial population reduction.
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Source: Compiled from Government records (D.I.A., 2017; Heritage., 2017)

Initially all three surprise events were deemed suitable as case studies, but after some investigation, Cave Creek was eliminated because it was in several respects, comparatively lacking in complexity. That is, it essentially involved only one organisation (which in itself was large and complicated) and the technical issues leading up to the collapse were relatively straightforward, rather than complex. The review of the Canterbury Earthquakes was also eliminated as it either revolved around the public policy surprises over liquefaction by the Councils or around one unsupervised person designing the CCTV building. The review of the Pike River coal mine disaster was considered complex enough for a single case study as it involved numerous actors with different perspectives, a good source of documentation from the Royal Commission and would be ideally suited to a bricolage constructivist qualitative approach.

3.3.2 The unit of analysis

The unit of analysis is operationally defined as the reference narrative of the 'key decision-makers', i.e., the company's official viewpoint and the actor critics of this narrative. It is the key decision-makers who determine the company's official positions, attitudes and policies. There are two criteria for selecting who were the key decision-makers. First, these need to be the senior managers who made the key decisions and secondly, there is a need to know from Pike's company reporting to shareholders (ex-ante) and the Royal Commission transcripts (ex-post) what they thought and said throughout the process.

In the three years leading up to the explosion, it is clear from Pike's public reporting to shareholders that there were only three 'key' decision-makers. They represent the company's official reference narrative, as they physically fronted all public meetings and were the only signatures within the company's public reporting. These were:

- John Dow – Chair of Pike’s Board, 2007 – 2010;
- Gordon Ward – CEO, 2007 – Sept. 2010, when the board replaced him; and
- Peter Whittall – General-Manager (GM) Mines, 2005 – 2010, then CEO October 2010.

These three key decision-makers represented the Chair of the Board, the CEO (a former accountant) who was the ‘boss’ of the company and the other (being a mining engineer) was the ‘boss’ of the Pike mine. All three featured strongly in company reporting, with the Chair/CEO signing off all documents. The three had worked together for at least the three years leading up to the explosion, and from the outside it is unclear who was the dominant person. For example, the chair’s report could be written by the chair or a first draft could be written by the CEO.

There is no record of what Gordon Ward (CEO) thought about the explosion, as his employment was terminated six weeks before the explosion, so he had already left New Zealand when it occurred and did not participate in the Royal Commission process, even though he was asked. Dow and Whittall’s views are known ex-post, as they were cross-examined by the Royal Commission. Because these three people seemed to work well together (i.e., Dow offered praise of the calibre of senior management at the hearings) and they had a consistent narrative which is represented by their public statements (ex-ante and ex-post), it is reasonable to treat them as a unit of analysis, which is effectively impossible to split further. Throughout the period from 2007 there was a consistent reference narrative from this senior management team. From the transcripts it is clear that they made the key decisions and their opinions were the company’s official view and there is an audit trail of their views through the public documents ex-ante and ex-post the explosion. (Refer sections 4.2 and 4.3).

There are two sets of two people who are excluded, who do not quite meet both selection criteria. One set is the NZ Oil and Gas Ltd’s (the company that set up Pike) board chair and deputy chair, who also became the original board chair and deputy chair of Pike before it went public. These directors (Tony Radford and Dr Ray Meyer)

stayed on the Pike board when it became public. They would fit the first criteria of being key decision-makers over a very long period of time, but their individual thoughts are not known as they let the Pike chair speak for the whole board during the cross-examinations of the Royal Commission hearings. From what is said in the Royal Commission transcripts, it seems the board was relatively passive with little dissent and all that can be assumed is they were willing participants to all key decisions. At no time leading up to the explosion did any board member challenge their collective reference narrative.

There is a second group of two that was initially considered for possible inclusions. These were Doug White (Operations Manager, 2010, successor to Whittall as mine boss) and Steve Ellis (Coal Manager, October 2010). These two senior managers were late appointees, being only employed in 2010. Both were strong supporters of Pike's actions at the Royal Commission hearings and therefore took some of the blame off Dow, Ward and Whittall. As senior mine management, White and Ellis were making important decisions. But the key decisions, such as determining the mine design and the board/company operating procedures had all been determined by the three key decision-makers in the years leading up to the explosion. White and Ellis fail the first criteria of being key decision-makers in a holistic sense for what happened, since they arrived too late to effectively be able to change anything. They mostly supported the collective reference narrative, but not completely as detailed in 4.2.6.1.

3.3.3 Document analysis

For this study, the prime data collection and analysis method is document analysis.

Document analysis includes the collection, review, interrogation and analysis of various forms of written text as a primary source of research data. In this case, it starts with secondary data, being the official inquiry reports and the detailed transcripts of the cross-examination of key witnesses by multiple parties which effectively is a source of primary data and Pike's official annual and quarterly public reports. This was very rich data. This became primary data once thematic analysis had been undertaken (O'Leary, 2014).

The three main sources of public documentation to analyse

- **The Royal Commission** (on its own website, supported by the Department of Internal Affairs)
 - The Royal Commission final report. This is useful for a considered overview of events.
 - The transcripts of the Royal commission's hearings and cross-examinations of witnesses (over 6,000 pages). This is useful for getting the comments of the key decision-makers on their reference narrative and their critics views.
 - There is a third level of valuable information that Commissions of Inquiry collect, being submissions from the various stakeholders. These are normally publicly available on the Commission's website. For the Pike inquiry, the Department of Internal Affairs Te Tari Taiwhenua, has made a decision to embargo this information for 100 years '*to protect personal privacy as well as to maintain implied and existing undertakings in relation to confidentiality*'. (Lamm, 2017) This source of evidence is therefore not available, but if actor-critics wrote submissions reflecting what they said to the Inquiry, then this lack of information should not affect the research analysis.
 - Other documentation, which are not the final reports or transcripts mentioned above, on the Royal Commission website, such as miscellaneous reports. These were of minor use.
- **Pike's public reports**

Pike's own public announcements via its quarterly, half-yearly and annual reports. This is useful for understanding and building Pike's official reference narrative.
- **Other**

For example, books and articles. There are numerous articles that discuss the Pike River coal mine explosion. Most come from the NZ Journal of Employment Relations or the Journal of Industrial Relations and they have a strong focus on health and safety aspects or legislation, which is not the focus of this research. There are few sources that have gone beyond the Royal Commission transcripts

and ask what the key decision-makers and their reporting managers were thinking. One secondary source that has, was the journalist Rebecca Macfie's award-winning book *Tragedy at Pike River Coal Mine – How and why 29 men died*, where she interviewed over 100 people. This source was useful since she interviewed a number of the actor critics of Pike's reference narrative, such as senior managers and consultants, and this provided additional information to that provided in the Royal Commission process, especially about motivations and details of their issues with the key decision-makers, which is the focus of this research. These personal narratives are consistent with what was said at the Royal Commission hearing, which Macfie herself listened to and which she has built on. Her narratives helped flesh out some of the 'quilt' squares or Steps described in Section 3.4.

In many case studies it is very important to interview key actors, as that provides direct source material. In this case study, due to the circumstances of the situation, documentation analysis was considered appropriate, if not better, than ex-post interviews. This is because it is now 10 years since the explosions and there are practical problems locating the key players, since at least two of the three key decision-makers are now living in Australia. More importantly, that two of the key decision-makers were extensively cross-examined during the Royal Commission so their views are public record. Underlying all this, is the fact that all parties, including the key decision-makers would have developed clear narratives to explain their actions and motives that any subsequent questioning, would mean those questioned would bring up their already developed narrative. Since there was no hint of any ex-post doubts in their thinking (in fact the reverse) when they were cross-examined a year or so after the first explosion, it is likely that they will be of that same opinion even more years later. The hearing transcripts provide very detailed verbatim questions and answers that occurred over many weeks. Relying on these transcripts mitigates the risk of ex-post justification or endeavours to alter personal narratives in light of subsequent events.

3.3.4 To understand complexity, a multimethod, multi-lens perspective used

When studying complexity or using a qualitative research paradigm it is important to use a diversity of approaches. The qualitative research paradigm is described by O'Leary (2014) as an approach to understanding and studying the world that rejects positivist rules and works at interpreting the world through multiple lenses and perspectives. To understand complexity, multiple lenses and perspectives are needed to review the requisite diversity (Colander & Kupers, 2014; Page, 2007). This research follows that approach.

3.4 The bricoleur's research journey

3.4.1 The bricoleur's research journey

The following steps provide a simplified summary of the researcher's non-linear bricoleur journey of bricolage (use of multiple methods that are available and are appropriate) as outlined in Section 3.1 (Ontological and epistemological assumptions). The following steps deal with a case study that is complex and complicated, which started with only broad objectives and no favoured tool kit.

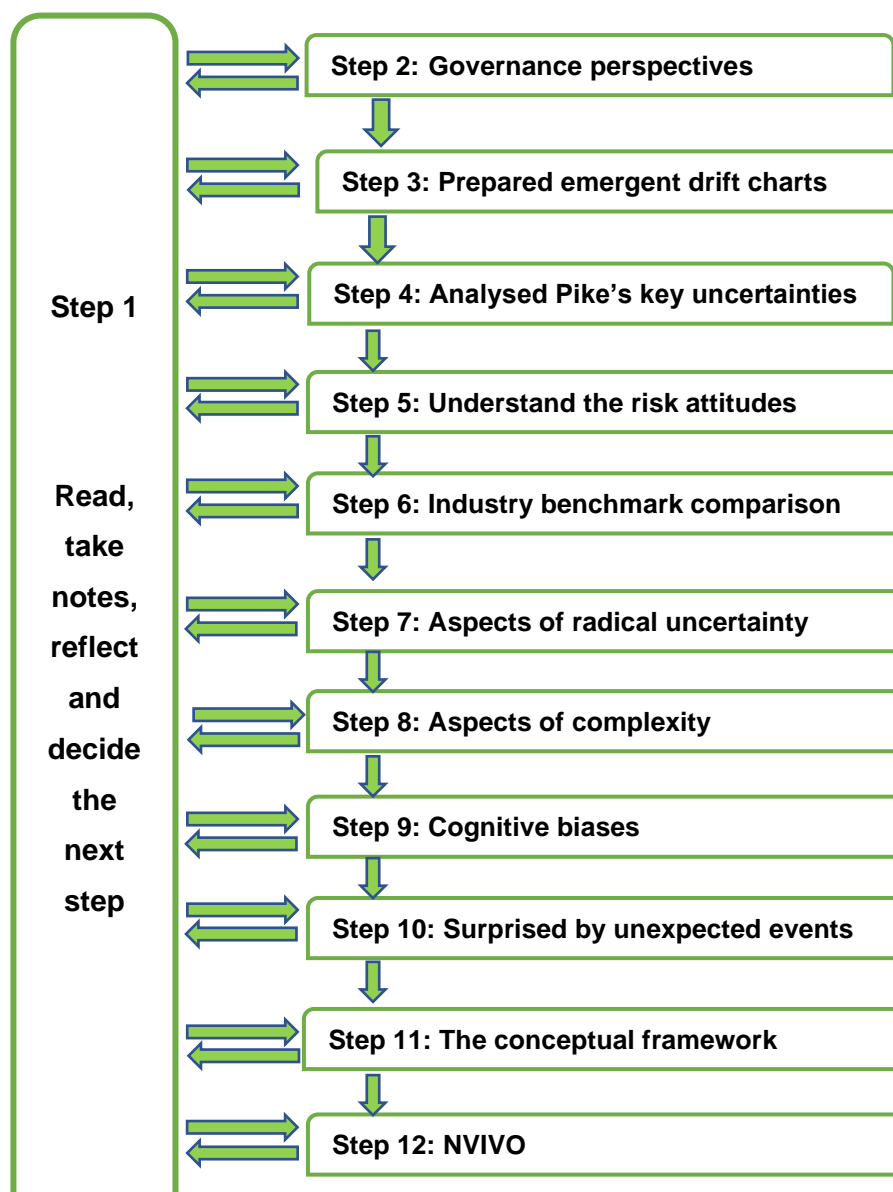


Figure 3.1: Summary of the bricoleur process

Step 1: Read, take notes, reflect and decide the next step

Asked the question: What is going on here? (Kay & King, 2020) This meant reading widely, taking notes, reflecting on the vast amount of detail in so many variables of interest and then determining the next step.

Step 2: Understand Pike from a governance perspective (Refer 4.2.2)

From all sources, understand the background to the Pike River coal mine, including:

- Who set up Pike River Coal Ltd?
- Who were the key shareholders?
- Who were the board members and what was their previous experience?

The emergent theme: While Pike was a publicly listed company, its board was in fact controlled by its founding shareholder (NZ Oil and Gas Ltd) supported by two passive Indian shareholders who were also Pike's coal customers. Most on the board and the CEO had many years of working together. This resulted in the three key decision-makers having a tight control of the board and Pike's reference narrative.

Repeat Step 1: Read, take notes, update, reflect and decide the next step

Repeat Step 1. This meant reading widely, taking notes, updating as required anything in the previous steps, reflecting and then determining the next step.

Step 3: Prepared emergent drift charts (Refer sections 4.2.1 to 4.2.6)

From reading accident investigation literature (Dekker, 2002, 2011; Mandis, 2013; Snook, 2002; Vaughan, 1996) it was observed that these sources all reconstructed the episodes leading up to the particular failure using a simple drift or episode sequence approach. This approach is described in Dekker (2002) and was used as a starting point in this research to summarise large amounts of data and to highlight the relevant trends. It helped build the context in the case study especially around

understanding the key uncertainties. Using Pike's publicly available company reports (quarterly and annual), emergent drift charts were prepared (Refer Tables 4.4 to 4.9) covering the period from 1 July 2007 (date of public listing) to 19 November 2010 (date of first methane explosion), for:

- ***Pike's estimated coal reserves and coal production levels*** (Refer Table 4.5), e.g.,
 - estimated coal reserves;
 - coal price (spot);
 - quality of saleable coal;
 - estimated date of 'first coal';
 - estimated date of 'saleable coal';
 - estimated date of export sales; and
 - estimated date of regular production of 1 million tonnes.
- ***Pike's methane risk levels*** (Refer Table 4.7), e.g.,
 - in seam drilling;
 - hydro-mining; and
 - ignitions, outbursts, cave-ins.
- ***Pike's turnover of senior human resources*** (Refer Tables 4.4 and 4.9), e.g.,
 - the Board; and
 - senior managers reporting to the General Manager – Mines.
- ***Pike's financial position*** (Refer Table 4.8), e.g.,
 - cost of mine development;
 - funds raised from shareholders;
 - funds raised from borrowings; and
 - reasons given for the time delays.

The emergent theme: For the three years that Pike was publicly listed, Pike's three-key decision-makers consistently overpromised and underdelivered in all areas,

which had serious financial consequences. There was a serious reality gap between actual results and those promised. There was no revision of the vision/targets of Pike's reference narrative, except that it was taking years longer to get there and was costing a lot more.

Repeat Step 1: Read, take notes, update, reflect and decide the next step

Step 4: Analysed Pike's key uncertainties using the forced scenario process lens (Refer section 4.3.1)

When explaining the findings from Step 3 with the Thesis supervisors, there was discussion about risk seeking versus risk aversion. The suggestion was made that this aspect could be developed by the use of a forced scenario process, as outlined in Maani and Cavana (2000) using a framework from Schoemaker (1993). Using information from all sources including from Step 3, the researcher compiled a number of tables (refer Tables 4.11 to 4.14) in a modified forced scenario process. Normally this process is used to get a quantitative answer (i.e., the difference between a pessimist and optimist financial scenario), but here it was modified to get a qualitative answer (i.e., to determine the different risk profiles of the actor-critics and those that supported Pike's reference narrative. This defined who were pessimists and who were optimists and optimistic about Pike achieving its objectives).

Step 4a: Defined the key uncertainties at the time of the explosion into five categories – market factors, operational factors, human relations factors, finance factors and combined factors. This generated 26 sub categories/codes. (Refer Table 4.11).

Step 4b: Building on Step 4a, for each of the 26 key uncertainties, defined the most pessimistic and most optimistic potential outcomes. (Refer Table 4.12).

Step 4c: Building on Step 4b, for each of the 26 key uncertainties, inserted a summary of the supporting data for both the pessimistic and optimistic scenarios into the table. It was apparent straight away from preparing Table 4.13 that the

official reference narrative of Pike's key decision-makers was always the most optimistic outcome. Meanwhile, all the ex-ante and ex-post actor critics suggested pessimistic outcomes, which resulted in the unusual situation that the status quo forecasts were also the most optimistic. Pike had no potential upside beneficial risk on any of its uncertainties, only considerable downside negative risk. Pike's reference narrative was ambitious in all aspects. There was a 'red flag', indicating high levels of uncertainty for each of the five factor areas, being: market, operational, human resource, finance and combined.

Step 4d: Building on Step 4c, for each of the key uncertainties, inserted names of the people who held the different viewpoints. This further highlighted that Pike's three key decision-makers were always the only people in the optimistic scenario and all others were in the pessimistic scenario. Refer Table 4.14.

The emergent theme: At the time of the explosion, there was high uncertainty that Pike would be able to achieve its objectives in any of the five category factors listed in Step 4a. The reference narrative of the three key decision-makers was so optimistic, compared to Pike's actor-critics, that there was no potential upside, only considerable negative downside. The three key decision-makers were in fact strong 'risk seekers', as opposed to what they said, which was that they were prudent as to the risks.

Repeat Step 1: Read, take notes, update, reflect and decide the next step

Step 5: Understand the risk attitudes of the risk seekers and the risk averse (Throughout sections 4.2.3 to 4.2.6).

From all sources, profiles of the risk appetites of the three key decision-makers were made and for anyone else who described interacting and disagreeing with them. These actor-critics also included geological and other consultants. The aim of doing this was to understand the issue in dispute and the reasoning behind each of the views taken. The focus was always on the decisions of the three key decision-makers (the official reference narrative) and those that were actively challenging it,

and the reasoning behind the official reference narrative remaining unchanged. This included comments from:

- **Senior Pike managers who reported to the General Manager - Mines, whose views became public ex-post:** I.e., Renk, Louw, Slonker, White, Rockhouse, and van Rooyen.
- **Consultants, whose views became public ex-post:** Bell, Cave, Nishioka, Newman, McNee, and Rawiri.
- **Key feedback reports:** the Stewart Report 2010, and the Behre Dolbear report 2010.

The emergent theme: The three key decision-makers were very confident in their decision-making and their over-optimistic reference narrative. As a consequence of this strong 'inside' thinking and the organisational power of the three key decision-makers, many actor critics (i.e., senior managers/consultants) found their suggestions rejected or discounted. This resulted in a high turnover of senior managers, which was incorrectly put down to turnover due to the mining boom occurring at the time.

Repeat Step 1: Read, take notes, update, reflect and decide the next step

Step 6: Analysed the industry benchmark comparison, i.e., Spring Creek mine (Throughout sections 4.2.3 to 4.2.6).

The largest coal mining company in New Zealand, at that time, was the State-owned Solid Energy Company. It owned a number of mines geographically close to the Pike mine on the West Coast, including the troubled Spring Creek mine. The CEO of Solid Energy, Dr Elder, gave extensive evidence to the Royal Commission giving his industry bench mark comparison of the Pike River mine to the Spring Creek mine. The troubles at both mines were similar – production and methane problems leading to financial and safety issues. This is an ex-post comparison by Dr Elder, since Pike for various reasons (e.g., private v public, non-unionised v unionised etc) thought themselves superior to Solid Energy and therefore never thought this comparison

was valid ex-ante. Pike did not value 'outside' thinking at any stage. Key themes that were summarised from the Solid Energy evidence and cross-examination included, Solid Energy's views on:

- organisational maturity and risk management;
- that their own troubled Spring Creek mine was persistently compromised by insufficient geological knowledge;
- that Pike lacked basic geological information;
- that Pike did not understand hydro-mining and its risks;
- that Pike overestimated the quality of its coal;
- that Pike overestimated the quantity of its saleable coal reserves and the potential production levels;
- that coal mining operates under radical uncertainty and that you should always expect the unexpected, including expecting the possibility of a methane explosion;
- that they assessed Pike as having high commercial risk, right from the time it was proposed; and
- that in hindsight Solid Energy (i.e., themselves) had suffered from the sunk cost fallacy in not closing problem mines earlier.

The emergent theme: Pikes over-optimistic reference narrative was protected by its strong 'inside' thinking and this included the three key decision-makers being very clear, throughout the entire period, that Pike could not learn anything from New Zealand's largest coal producer, Solid Energy.

Repeat Step 1: Read, take notes, update, reflect and decide the next step

Step 7: Understand if aspects of radical uncertainty were contributing factors
(Refer sections 4.4.1 and 5.1)

Compiled and read the literature on different aspects of radical uncertainty. These included:

- the simplified Cynefin sensemaking framework;

- Ashby's Law of Requisite Complexity for organisations (Initially thought relevant, then later considered as unnecessary); and
- Black swan events
 - Those who were completely surprised;
 - Those who were surprised, but ex-ante had concerns about something;
 - Those who were NOT completely surprised.

The emergent theme: Pike's three key decision-makers used a cognitively flawed reference narrative that had oversimplified the inherent complexity, but since they confidently defended their view, this had the effect of driving out dissenting views and created a serious problem of not having enough requisite variety of thinking.

Repeat Step 1: Read, take notes, update, reflect and decide the next step

Step 8: Understand if aspects of complexity were contributing factors

(Refer 4.1.1)

Influenced by concepts from Dekker (2011), the researcher compiled from all sources profiles of different aspects of complexity. These included:

- ***System drift/failure due to cross-systems interactions and unruly technology:***
 - Pike had an unconventional mine design and fan placement;
 - Pike had a poor system of gas monitoring;
 - Pike's methane drainage was at full capacity and required free venting;
 - Pike's ventilation system was inadequate;
 - Pike had an unconventional underground electrical system; and
 - Pike had inherent troubles with hydro-mining.
- ***System drift/failure due to failure of protective systems:***
 - the failure of protective structures, such as the Department of Labour's mine inspectorate;

- the lack of the requisite variety/diversity of views in decision-making, due to the management churn;
- ex-ante, Pike's local rationality failed to see the potential black swan event; and
- ex-post, the public enquiry greatly increased the collective knowledge.

The emergent theme: Pike's three key decision-makers seemed to have a confident but over-simplified view of the mining operations, its problems and the value of the information they were getting. Ex-post, serious flaws were identified in all critical mining systems and Pike's management information system was not always collecting or reporting critical information.

Repeat Step 1: Read, take notes, update, reflect and decide the next step

Step 9: Understand if cognitive biases made the decision-makers risk seekers

(Refer section 5.2)

From all sources, profiles of the different cognitive biases that were evident in the actions and decisions of the three key decision-makers were compiled. These all related to bounded and inductive rationality involving inductive type biases, i.e., where there is a 'what you see, is all there is' approach applied, which neglects what they did not see (Kahneman, 2011). This list started small, but kept growing to include the following:

- optimism bias, overconfidence;
- planning fallacy;
- inside/outside thinking;
- sunk cost fallacy;
- prospect theory;
- confirmation bias;
- hindsight and outcome biases;
- groupthink; and
- fox/hedgehog cognitive thinking styles.

The emergent theme: Pike's three key decision-makers used a cognitively flawed thinking style that used a number of cognitive biases to over-simplify the inherent complexity, which as a consequence meant that the risks had also been over-simplified and understated.

Repeat Step 1: Read, take notes, update, reflect and decide the next step

Step 10: Understand why Pike's three key decision-makers kept being surprised by unexpected events (Refer section 4.4.1)

From all sources, collected and analysed examples, over the three years Pike was operating, Pike's three key decision-makers expressed surprise at some 'unexpected' event of significance. This list started with just the final unexpected methane explosions, but kept growing to include the following:

- the 'unexpected' poor-quality rock in building the 2.3 km entrance tunnel (September 2006 to October 2008);
- the 'unexpected' shaft collapse when building the 111-metre ventilation shaft (mid 2008 to June 2009);
- the 'unexpected' graben/rock fall, where there was meant to be coal (June 2009);
- the 'unexpected' hardness of the coal (2010); and
- the 'unexpected' methane explosions (19 November 2010).

The emergent theme: Pike's three key decision-makers used a cognitively flawed reference narrative that had oversimplified both the inherent complexity and uncertainty of the situation, which understated the significant risks. This made them especially prone to unexpected surprise events (including negative black swan events) that kept occurring. The three key decision-makers did not appear to learn from these events or update their reference narrative.

Repeat Step 1: Read, take notes, update, reflect and decide the next step

Step 11: Understand how to structure the synthesis sections, i.e., determining what conceptual framework to use

Initially it was unclear how the different sections should be structured, since the conceptual framework kept being developed based on the new ideas emerging from each new step taken. Over time, the following broad steps were taken:

- The sections were clustered around the various approaches as detailed above in the different steps. For example, all the cognitive biases were in one section and all Step 8 complexity issues were in their own cluster of sections.
- As the overarching theme of ‘the danger of oversimplifying complexity’ emerged, there was considerable re-sorting of sections around aspects of that.
- One of the last cognitive biases to be considered was the fox/hedgehog cognitive thinking styles (Tetlock, 2005). Initially the focus was on comparing the cognitive thinking style of Pike’s three decision-makers to superforecasters (i.e., foxes), but this proved unsatisfactory, so the focus shifted to the more fruitful comparison of comparing the key decision-makers to the hedgehog cognitive thinking style.
- Once the link to hedgehog cognitive thinking became apparent, this led to the review of a fox/hedgehog comparison chart developed by Silver (2012). These definitions were developed (and later removed) with an explicit focus on each of the six attributes being defined in terms of the oversimplification of complexity. Once this was done, all the case study sections were re-sorted to fit this new framework. The six Silver based attitudes are, the attitude to:
 - evidence/knowledge;
 - changing circumstances or to new information;
 - diversity of thinking and approaches;

- acknowledging mistakes/blame;
 - uncertainty and complexity; and
 - risk and probability.
- Further reading on radical uncertainty (Kay & King, 2020) led to a revision of the six fox/hedgehog attributes to three overarching hedgehog blindnesses. This higher-level conceptual framework incorporates the six Silver/Tetlock attitudes. With this new approach, all the case study sections were again resorted to fit under this new structure. The three-overarching hedgehog blindnesses are blinded by:
 - the illusion of certainty;
 - induction and inductive cognitive biases; and
 - a single top-down reference narrative.

This included preparing the uncertainty spectrum charts which incorporated the key points from all these learnings.

- At the examination phase, the four foundation constructs were defined as per Section 1.1.4, as the Aven (2015) black swan definition; the Kay and King (2020) radical/resolvable definitions of uncertainty, overlaid with the simplified Cynefin framework; the three common forms of organisational bounded rationality, described above as hedgehog cognitive blindnesses; and the concept of strategic drift (Sammut-Bonnici, 2015) and related to that, collective reference narratives (Kay & King, 2020).

Repeat Step 1: Read, take notes, update, reflect and decide the next step

Step 12: Applied and then abandoned using NVIVO

The research process was not quite as linear as suggested with the sequential steps above, as more than one step may be happening at any time. Mid-way through this process NVIVO was used when reading through the 6,000 pages of transcripts of the

Royal Commission hearings. However, after a break, it was abandoned because the text extraction levels were 30% of the original text, due to the desire to keep the context around the sentence or fact of interest. This process started with the hearing text and then the NVIVO coding application was applied for variables of interest. This approach meant that the same variable of interest may be repeated in different cross examinations by different lawyers with the same person or raised in the cross examination of others.

On reflection, to avoid massive duplication of data, it was decided to first summarise all key areas of interest and then reread the entire 6,000 pages again with the intent of searching for the much smaller numbers of items of interest that modified whatever had already been written. Variables of interest could relate to any of the steps above and now had the lens of the three overarching hedgehog blindnesses. The alternative was to carry out a massive amount of text extraction, then embark on a massive summarisation process. Step 1 above, would need to be repeated because doing the summarisation process of each area of interest clarified the focus and thinking, and this would result in rereading the original source material in light of the new understanding. Even so, the various texts were reread a number of times as the bricoleur's focus was clarified and thinking further developed. This involved an informal NVIVO process of numerous data extraction files, with the consequential summarised files.

This process was used on all the major sources of information, being the report of the Royal Commission (i.e., what the Commissioner's thought happened), Pike's annual and quarterly reports (i.e., what Pike believed), the transcripts of the hearings (i.e., what individual actor-critics thought happened) and the book by Macfie (i.e., her interpretation of the hearings). The process was extremely iterative and to effectively manage the process, only one set of variables was considered at a time. Large sections of the transcripts were only marginally related to the research, e.g., the post-explosion review of rescue agencies or the sections on engineering details involving critical mining systems, which needed to be read and understood but were found to be either too detailed and/or not relevant.

In some research applications, using a process like NVIVO ensures that there is no unconscious bias to overlook data that does not suit for some reason. As described in section 3.5.4, there was no inherent motivation in overlooking a critical part of Pike's official position/reference narrative or what the actor-critics thought was wrong with it. It was the exact opposite, as it is the gap between Pike and its actor-critics that provides the greatest potential insights, and this was recognised accordingly when doing the research. It is not the numerous things that the different parties agreed on, but the different actor-critic interpretations from management that are the source for further reflection and investigation, and this helped build the final conceptual framework.

Not completing a comprehensive NVIVO analysis did not undermine addressing the research question, as the NVIVO part of the process was only important in developing the context of the case study, i.e., the different quilt squares. It was never intended to be a necessary prerequisite for effectively addressing the research question, as that involved interpreting and theorising of all the quilt squares supported by aspects of the different quilt squares. The risk of unconscious bias being introduced by abandoning a comprehensive NVIVO analysis is therefore assessed as low.

Repeat Step 1: Read, take notes, update, reflect and decide the next step

Repeat Step 1 and reflect on all the above steps.

3.5 Analysis of the bricoleur's research journey

3.5.1 Developing a coding scheme - 'directed' qualitative content analysis

There are many possible methods that analyse subjective qualitative data. These include ethnography, grounded theory, phenomenology, and historical research. This research used qualitative content analysis because it was the best fit with a constructivist approach, to the interpretation of the data available, the tools available and the research question. This approach has a focus on organisational behaviours and stakeholder perceptions. Hsieh and Shannon (2005) believe there are three distinct approaches for qualitative content analysis based on the degree of involvement of inductive reasoning. These are conventional (i.e., open coding, direct from data), directed and summative (i.e., word counts and then latent meanings). All three approaches are used to interpret meaning from the content of text data and adhere to the naturalistic paradigm.

For this research, 'directed' qualitative content analysis was used, as that approach is useful when an area of research would benefit from further description. This results in confirming or extending the preliminary conceptual framework. This conceptual framework provides variables of interest which helps to determine the initial coding scheme. Then with increased immersion in the data, new themes can emerge from the data. These new themes refine, extend, and enrich the theory. The main strength of directed content analysis is that it makes it explicit that the study is building on existing knowledge. This can lead to the confirmation bias if the focus is purely to support the initial framework, rather than seeking alternative explanations. How this research avoided this bias is described below, as is the process of the emerging coding structure (Bazeley, 2009; Hsieh & Shannon, 2005; Zhang & Wildemuth, 2005).

Applying the coding system to the data to get summaries of the variables of interest

As described in the 12 steps outlined above, the coding framework of the 'directed' qualitative content analysis approach was an emergent result of inductive research

after reading widely. Each Step was a module of work that had different variables of interest that were being investigated. Because all the steps involved complexity, the coding expanded from simple beginnings, to better represent the true complexity as the research progressed. For example, in Step 9 the research started with one or two biases becoming evident from doing the initial emergent drift charts on coal production, e.g., the optimism bias and the planning fallacy bias and this kept rising as more were mentioned in the documentation or were observed. There are now at least 11 cognitive biases identified with the Pike case. This increasing complexity is common in many of the other steps, such as Steps 3, 6, 8, and 10.

While the bricoleur was careful to record all cases of each variable of interest under investigation, based on the evidence available, the process and environment is complex. It is not possible to say that each module is absolutely complete in any sense. It does not pretend to be exhaustive but it should be an accurate representation of the available facts from public records. There is always the potential that further categories or sub-categories of the variables of interest will potentially be identified, perhaps with new information. This limit of knowledge/understanding is a reality, not a problem. It means that each module of work is like a quilt square, that always has the potential that with new input (via resources/knowledge/effort) it could be slightly expanded. It is not the individual parts in isolation that make a quilt, but the numerous squares showing different trends that put together creatively make an emergent pattern. Each Step considers a different aspect of the case study and in themselves, none of them fully answer the research question. They are all building blocks to understand the context, so that when there are multiple quilt squares, these can be moved around, with new heuristics, such as putting 'like-with-like', and this higher-level framework starts to build the picture that answers the research question.

3.5.2 Extracting the themes

The bricolage process had a broad pattern. The first Steps were to understand the context, then to understand who were the key actors and decision-makers and then to understand the areas where there were differences in mindsets between the key

decision-makers and the actor-critics. Table 3.3 is a high-level summary of the key methods/tools applied, matched against the three sub research questions;

- **What** did they fail to foresee, listen or act upon? (I.e., context)
- **Who** failed to foresee the black swan event?
- **Why** did they fail to foresee, listen or act upon the black swan event?

While the research question is the ‘**why**’ question, the answers to the ‘what’ and ‘who’ question are needed first. The different Steps used different methods/tools applied to different variables of interest and answered different sub-research questions. All parts of the final quilt are important in answering and understanding the various aspects of the research question.

Table 3.3: Matching the methods/tools applied to the sub-research questions

Methods/tools applied	Steps	What	Who	Why
Determine key uncertainties , e.g., drift time charts	3	Mostly		
Determine risk attitudes , e.g., modified forced scenario	4, 5	Partly	Mostly	
Benchmark comparisons , e.g., Solid Energy	6	Mostly		
Inductive cognitive biases	9			Mostly
Models of uncertainty and complexity	7, 8, 10			Mostly
Metaphors , e.g., black swans, fox/hedgehog	11			Mostly

Figure 3.2 below summarises the emergent themes from the 12 steps described in Section 3.4 (The bricoleur’s research journey), as they relate to Pike’s three key decision-makers. These themes are further developed in Chapter 5: Synthesis.

Emergent themes as to the actions of the three key decision-makers



Figure 3.2: Quilt chart of the emergent themes arising from the Steps outlined in section 3.4: The bricoleur's research journey

Colour code:
Green – Oversimplifying uncertainty.
Red – Defending rather than extending their reference narrative.
Blue – Oversimplifying complexity.

3.5.3 Trustworthiness or quality criteria of qualitative research

In positivist research specific notions of validity, reliability and objectivity are key criteria used to evaluate the quality of the research. In constructivist research, qualitative content analysis differs from the positivist tradition in its fundamental ontological and epistemological assumptions, research purposes, and inference processes, thus making the conventional criteria unsuitable for attesting research and its findings. While qualitative research is inherently multimethod in focus, the use of multiple methods, or even triangulation, reflects an attempt to secure an in-depth understanding of the phenomenon in question. It is assumed that objective reality can never be captured; that we know a thing only through its representations; and that triangulation is not a tool or a strategy of validation, but an alternative form of validation. The combination of multiple methodological practices, empirical materials, perspectives and observations in a single study is a useful strategy to add rigor, breadth, complexity, richness, and depth to any research involving qualitative research (Flick, 2002).

Denzin and Lincoln (2011) proposed four criteria for evaluating interpretive research work: credibility, transferability, dependability and confirmability. Credibility refers to the adequate representation of the constructions of the social world under study. Techniques like triangulation and peer review can increase credibility. Transferability refers to the extent to which the researcher's working hypothesis can be applied to another context, i.e., could another researcher read the research report and have a good idea how to apply it to another context. Dependability refers to the coherence of the internal process and the way the researcher accounts for changing the conditions in the phenomena. Confirmability refers to the extent to which the characteristics of the data, as posited by the researcher, can be confirmed by others who read or review the research results (Zhang & Wildemuth, 2005).

This research has been mindful of these four criteria. This research has used triangulation of different sources and approaches to analyse and verify the data to strengthen the credibility, coherence and dependability of the research. The research has an inherent focus on an event that blindsided the decision-makers' collective

reference narrative and the models that supported that view, which is a relatively common occurrence and therefore has wide applicability (transferability criteria).

A qualitative case study relies on 'triangulation' of multiple sources of evidence and data collection to enhance the credibility of the study. The main sources and approaches to determine Pike's official reference narrative were from Pike's ex-ante public records using the drift time charts (Dekker, 2002), the modified forced scenario process (Schoemaker, 1993), and the ex-post transcripts of the Royal Commission hearings, supported by the other documentation sources.

There is also an element of triangulation within the hearings of the Royal Commission. This is because there is a natural adversarial situation between stakeholders and their different legal counsel. Both counsel for the Commission and the counsel for each of the relevant stakeholders can examine the same set of data with diametrically opposing perspectives, constantly challenging each other's sources, interpretations, and arguments. Each stakeholder has an explicit perspective for presenting the data in a particular light. Understanding these different motivations is critical to understanding the background of the black swan event (Snook, 2002). All counsels have a right to question any witness, and most did. The adversarial approach adopted makes the questions/answers in the transcripts a lot more contested than the Royal Commission's final report. Most of the stakeholders cross-examined clearly fit into either defending or challenging Pike's official reference narrative, or who were just defending their own reference narrative, e.g., government agencies.

3.5.4 Assessing the credibility, transferability, dependability and confirmability of the research process and results

To be able to assess this, the research process of answering 'what is going on here?' needs to be broken down into its major components. At a high level, there are two parts to answering the research question. That is:

- **First part** - Pike's reference narrative was defined and understood and then secondly, the thinking of Pike's actor-critics needed to be defined and understood.
- **Second part** - The interpretation of what the differences were and what they meant. This led to answering the research question: 'Why did the key decision-makers in a large complex organisation fail to foresee, listen to or act upon a black swan event?'

The first part of this process is to determine Pike's official reference narrative and context. This was obtained from Pike's own official publications to shareholders, such as annual reports. This information was summarised, as in Step 3: Emergent drift charts. This was a 'factual' phase as the answer is just restating known facts and patterns that are not contentious to either Pike's key decision-makers or to Pike's shareholders. A different type of example of summarising Pike's position is the first part of Step 8: which defined Pike's lack of a systems and cross-systems overview. (See section 4.1.1.). This section is primarily a summation of the information contained in the final report of the Royal Commission with a discussion and interpretation of what it meant for this research. In its final report, the Royal Commission had set out detailed descriptions of Pike's critical mining systems, including all the flaws and weaknesses raised by any party throughout their deliberations. Most of Steps 2, 3, 4, 8, 9, and 10 contribute to building Pike's reference narrative or actual situation. Since these steps are a summarisation of public data, there is minimal interpretation necessary in these steps. Credibility, transferability, dependability and confirmability for this aspect is therefore assessed as high.

The second aspect of the first part is defining and understanding the ex-post comments of actor-critics of ex-ante interactions with the key decision-makers. Most of these comments come from the ex-post hearing transcripts of the Royal Commission. An example of this is Step 6: the submission from Dr Elder of Solid Energy. This is referred to in various sections of this study with extensive verbatim extracts of what was actually said. While the data is coded and summarised, the

content is inherently consistent within itself (i.e., Dr Elder was critical of Pike on most things). There has been minimal necessary interpretation of the information by the researcher in this phase. The aim of Step 6 is to accurately present the views of one actor-critic.

Describing the actor-critics comments about what was wrong with Pike's reference narrative was of critical importance for this research as those comments provided the key insights about why Pike's key decision-makers failed to foresee the black swan event. These insights were not likely to come from Pike's key decision-makers admissions or from their public statements, because they were blind (or even wilfully blind). It is therefore very important to consider carefully what the actor-critics were saying, why they were saying that and what it meant for this research. This aspect of the analysis needed special attention and whatever time was needed. Credibility, transferability, dependability and confirmability for this aspect of the research is also assessed as high, as the researcher's interpretations remain faithful to what the relevant actor-critics were quoted at length as saying.

The second part of the process was more interpretative. It involved building on other steps and putting individual quilt squares into a greater conceptual pattern. While this second part is critical to answering the research question, most of the research effort is spent in the first part, constructing the individual quilt squares. While developing the conceptual framework for this research was an evolving process, going through different but similar concepts, including using the Tetlock (2005) forecasting classification of better (i.e., fox) and worse (i.e., hedgehog) cognitive thinking styles, the final answer came down to just three hedgehog blindnesses to uncertainty, complexity and the reference narrative. The level of credibility, transferability, dependability and confirmability for this aspect is considered to be good, based on the good-quality information from the publicly available information and the inherent importance of the three-hedgehog blindnesses.

3.5.5 The research required all the aspects of a bricoleur to be used

As described in section 3.1, there are many aspects of being a bricoleur, such as interpretive, narrative, critical, theoretical, and methodological. Table 3.4 is a high-level analysis of the 12 steps outlined above, matched against the different aspects of a bricoleur. All the different aspects of a bricoleur were applied during this research.

Table 3.4: Aspects of a bricoleur applied in this research

Aspects of a bricoleur	Steps
Interpretive , e.g., putting all the different parts together	Mostly 11
Narrative , e.g., creating and telling a coherent overarching story	Mostly 11
Critical , e.g., interpreting diverse texts and opposing viewpoints	Various – 5, 6, 8, 10
Theoretical , e.g., developing an overarching conceptual framework	Mostly 11, plus 7, 9
Methodological , e.g., applying diverse tasks and tools	Most steps

3.6 Applying emergent drift charts to accident investigations

This is one of the micro methods used to summarise Pike's key data across a range of subject areas, so that it becomes clear as to what Pike's reference narrative is for that area/item compared to what actor-critics thought it should be.

The 'drift into failure' lens

What appears wrong in hindsight, appeared normal, or at least reasonable, at the time, and that abnormal data was rationalized away by participants. The drift is only seen in hindsight. Detecting organisational drift requires a sensitivity to the passage of time, as single snapshots won't do. Drift is a dynamic process; it cuts across time just as it does levels of analysis. To notice drift requires system movement and movement requires the passage of time. Conventional explanations for accidents – design, equipment, procedures, operators, materials or environment, explicitly excludes the passage of time as a central element. Drift does. Changes on a drift chart relate to each other, impact each other, compound each other and have varying degrees of importance and significance (Dekker, 2011; Snook, 2002).

In her classic investigation of the decision-making that led to the launch of the space shuttle *Challenger* in 1986, Diane Vaughan used a drift framework that was grounded in her observation that organizational deviation is systematically produced by the impact of the elements of environment and organisation. This came down to categories in her framework of regulatory (Government), organisational (internal) and competitive pressures (market). What is important is the combination of the three theoretical building blocks and their interlinkage and combined effect. Vaughan used the three building blocks and their sub concepts to organise the data and conceptualize. Organisational cultural patterns are then observed as an emergent effect from presenting a chronological account of the history of decision-making and examining the connection between the environment, organisation and individual choice. This helps in understanding what they were thinking at the time. This contrasts with the normal retrospective outsider interpretations (Mandis, 2013; Vaughan, 1996).

For his study of Goldman Sachs, Mandis added a fourth category of 'technology', which Vaughan had included within her organisational category. The approach is inherently focused on analysing organisational failure in retrospect from a specific event. Mandis used the drift framework to analyse Goldman Sachs over three decades through evaluating organisational elements, regulatory, technological, and competitive factors dynamically over time, and to appreciate how change happens at different paces and with different emphases. Mandis's analysis illustrates that the process of change is not as simple as identifying an independent variable that affects a dependent variable in a direct chain of events. Examining the change over time helps to illuminate how many factors interact in producing the change. Mandis used 'five' dates in his framework, representing the starting point, end point and dates of key events (Mandis, 2013; Vaughan, 1996).

From these descriptions, this study will use the basic concept of different categories over time and apply the periods as per Dekker's methodology outlined below.

Dekker's approach to reconstruct emergent drift charts

Dekker (2011) believes that the direction of the 'drift' is very difficult to recognise as drift per se without a bad outcome eventuating. The technique relies on the benefit of hindsight and the particular direction becomes visible only from the position of the retrospective outsider looking back on what has happened. From the inside, drift can be 'invisible'. Knowledge of initial conditions is not enough because the system can develop all kinds of unforeseeable ways from then on, and a description of system complexity may be unattainable.

Dekker (2002) provides a five-step process for understanding the mindsets of key decision-makers before failure, and for closing the 'gap' between data and interpretation. In doing so, the process provides an audit trail for others to follow.

- **Step 1. Describe the sequence of events and activities**, based on the context-specific data available. Structure the events and use time as an organising principle.
- **Step 2. Divide the sequence of events into episodes**, based on the context-specific data available. Each of these episodes may later fit different psychological phenomena.
- **Step 3. Find what the world looked like during each episode**. Reconstruct critical features of the situation around each of these events, using data that was available in that period.
- **Step 4. Identify knowledge, focus of attention and goals for each episode**. Reconstruct people's unfolding mindset by reconstructing what goals people were pursuing, what knowledge they used, and where, as a consequence, their attention was focused. Understand any goal conflicts and any trade-offs made.
- **Step 5. Develop a conceptual description**. Link the details of the sequence of events to human factor concepts. This will help synthesize the broader patterns of failure. It is important not to let the data/concepts be blinded by hindsight/outcome bias.

This approach is used in Section 4.2 - Analysis of Pike's ex-ante information using the 'Drift into failure' lens.

3.7 Summary - research methodology

The purpose of this chapter is to describe and explain the research methodology based on the four foundation constructs as per Section 1.1.4 – Base theory, constructs and the research gap where possible, being, black swan events; strategic drift and the reference narrative; radical uncertainty; and the three common forms of organisational bounded rationality.

Black swan events

The methodology described in this chapter will be used in the case study on the Pike River coal mine disaster to answer the research question as to why the key decision-makers of a complex organisation failed to foresee, listen to or act upon a black swan event. The case study was selected as it fitted both the Taleb (2008a) and the Aven (2015) definitions of what is a black swan event.

Strategic drift and the reference narrative

To understand how the organisation's reference narrative drifted away from reality, it is essential to define what was Pike's reference narrative and what were alternative views ex-ante. This meant that it was important to define the unit of analysis correctly so that the research focus was always on clearly defined defenders versus challengers of Pike's reference narrative.

The unit of analysis applied was the three key decision-makers (Board Chair, CEO and General Manager (Mines)), supported by the board and some senior managers. The views of the three key decision-makers represented the reference narrative of Pike, as the three key decision-makers signed off all public disclosures ex-ante. The Royal Commission of Inquiry sought to light ex-ante information not previously publicly available about the thinking of the three key decision-makers and a number of internal/external actor-critics. For all issues, the views on any issue will be split between the three key decision-makers who were active supporters of Pike's reference narrative versus the actor-critics who challenged all or part of that narrative. The focus was exclusively on the reaction of the three key decision-makers to the ex-ante and ex-post criticism. This split in views between defenders versus challengers of Pike's reference narrative will be highlighted by all the analysis techniques used during the research. This included the drift over time charts (Dekker, 2011), forced scenario process (Maani & Cavana, 2000; Schoemaker, 1993, 1995), and in reading the transcripts of the Royal Commission hearings and the Royal Commission's final report (RCPRCMT, 2011-2012, 2012).

Synthesis - Making a pattern of all the findings

This part of the methodology considered the results of the defenders versus challengers of Pike's reference narrative and what implications that had on concepts such as radical uncertainty and the various forms of bounded rationality.

The research dealt with the inherent complexity, by asking the question 'what is going on here?' (Kay & King, 2020; Rumelt, 2011), and repeating that question after each module of work. The research used the approaches suggested within the research for situations of high uncertainty and complexity. For example:

- **Foxes** have an open mind, use an eclectic array of traditions, including multiple lenses, tools, models, heuristics and perspectives (Tetlock, 2005).
- **Abductive reasoning** seeks to filter disparate evidence to provide the best explanation or narrative account of a unique event (Kay & King, 2020; Sober, 2013)
- **The bricoleur** makes do with the methods, data, and perspectives that are at hand and they synthesize all the individual parts into a complex quiltlike pattern (Denzin & Lincoln, 2008; Levi-Strauss, 1966).

The result was the development of a simple conceptual framework based on the uncertainty spectrum; the preferred states of knowing of fox/hedgehog cognitive thinkers, and the importance of the three-hedgehog cognitive blindnesses.

The research methodology reflects a constructivist interpretation paradigm. Within this paradigm, responsibility for the credibility of the research lies with the researcher, as traditional positivist notions of validity and reliability are never captured fully. Rather, it is the researcher as a bricoleur that makes a series of interpretations based on a number of different models and approaches in order to construct an emergent conceptual pattern with new insights. It is inherently a messy non-linear process or journey. The process depends upon capturing a wide variety of knowledge, then interpreting this in a meaningful way, which can be explained and

justified using notions of credibility, transferability, dependability and confirmability. This is a process that is more of an 'art' than a 'science' and this is the 'art' or skill of the bricoleur or quilt maker.

4. Findings and analysis: Case study – Pike River Coal Limited (Pike) mine explosion

Chapter 4 is divided into four subsections. Section 4.1 is an analysis of a number of key uncertainties raised by the Royal Commission of Inquiry. Section 4.2 applies what Dekker (2002) calls the 'drift into failure' approach for the key functional areas of coal reserves/production, methane levels, financial position and human resources. Section 4.3 uses the 'forced scenario' method on the same data. For both section 4.2 and 4.3, Pike's ex-ante reference narrative is compared to ex-post actor critic comments. Section 4.4 describes the series of unexpected surprises that Pike experienced from the day Pike started digging the entrance tunnel in 2007 to the final black swan event of a methane mine explosion in November 2010.

4.1 Analysis of Pike's key uncertainties as reported by the Royal Commission of Inquiry

Background to Pike

Pike was set up by New Zealand Oil and Gas Ltd (NZO&G), who had no prior experience in underground coal mining. The mine is located in a very difficult operating environment and some parts of the operation could only be accessed by helicopter. Refer Figure 4.1 below.



Figure 4.1: The sheer west-facing escarpment at the edge of the Pike coalfield marks the boundary of Paparoa National Park

Source: Pike (2010b)

Pike was publicly listed in 2007, with the aim of developing a single coal mine at Pike River, near Greymouth. Pike set very ambitious targets and considered itself a 'showpiece' for modern coal mining (Macfie, 2013). Pike experienced unexpected difficulties, causing massive cost/time overruns. Minimal coal (i.e., 42k tonnes in three years) was produced. In November 2010, a methane explosion occurred, killing 29 men. A Royal Commission of Inquiry was established, with a report released in 2012. The explosion ended all mining at the site. Figures 4.2 to 4.4, highlight at a high level the extreme difficulties Pike encountered with the geography and geology of the Pike mine.

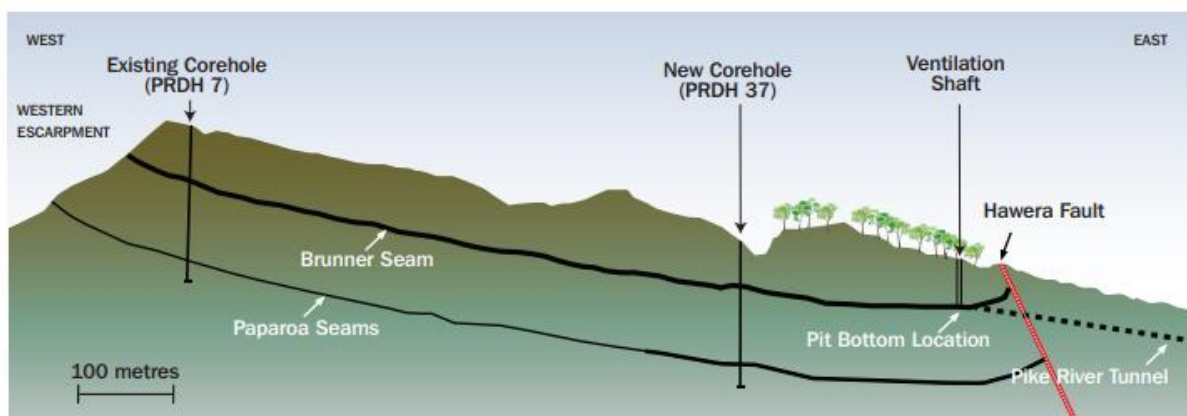


Figure 4.2: Pike River mine cross section showing the two seams of interest

Source: Pike (2009a, p. 5)

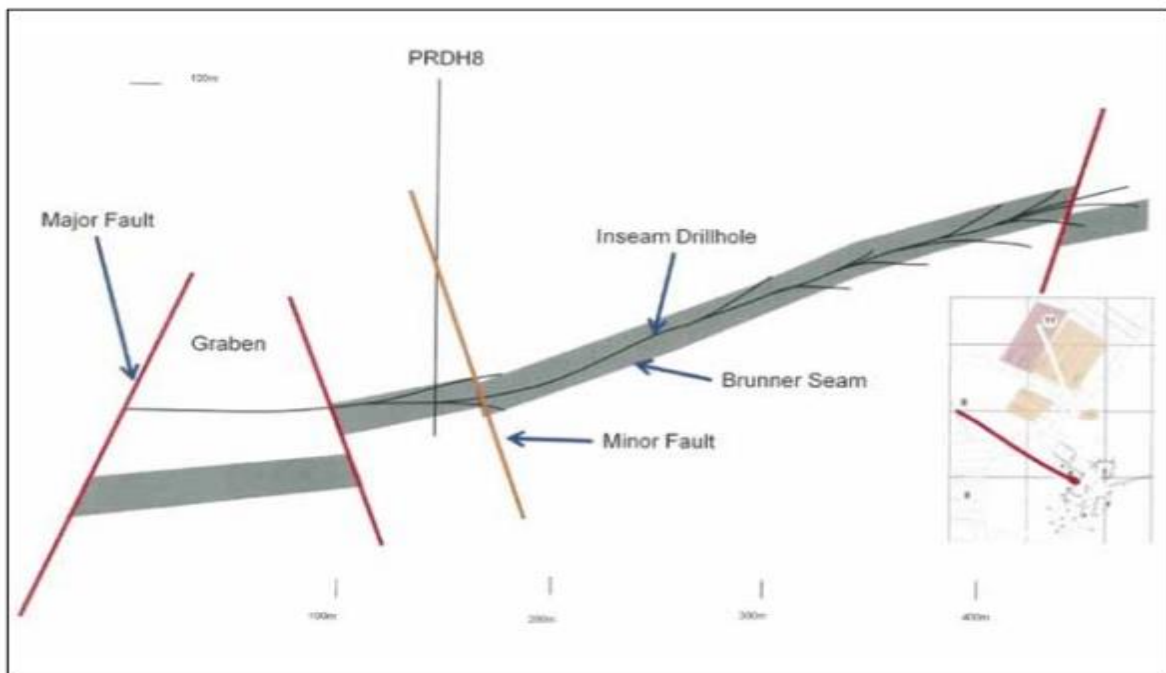


Figure 4.3: The effect of earthquake faulting on Pike River's Brunner seam

Source: RCPRCMT (2012, p. 156 Volume 2, Figure 12.1)

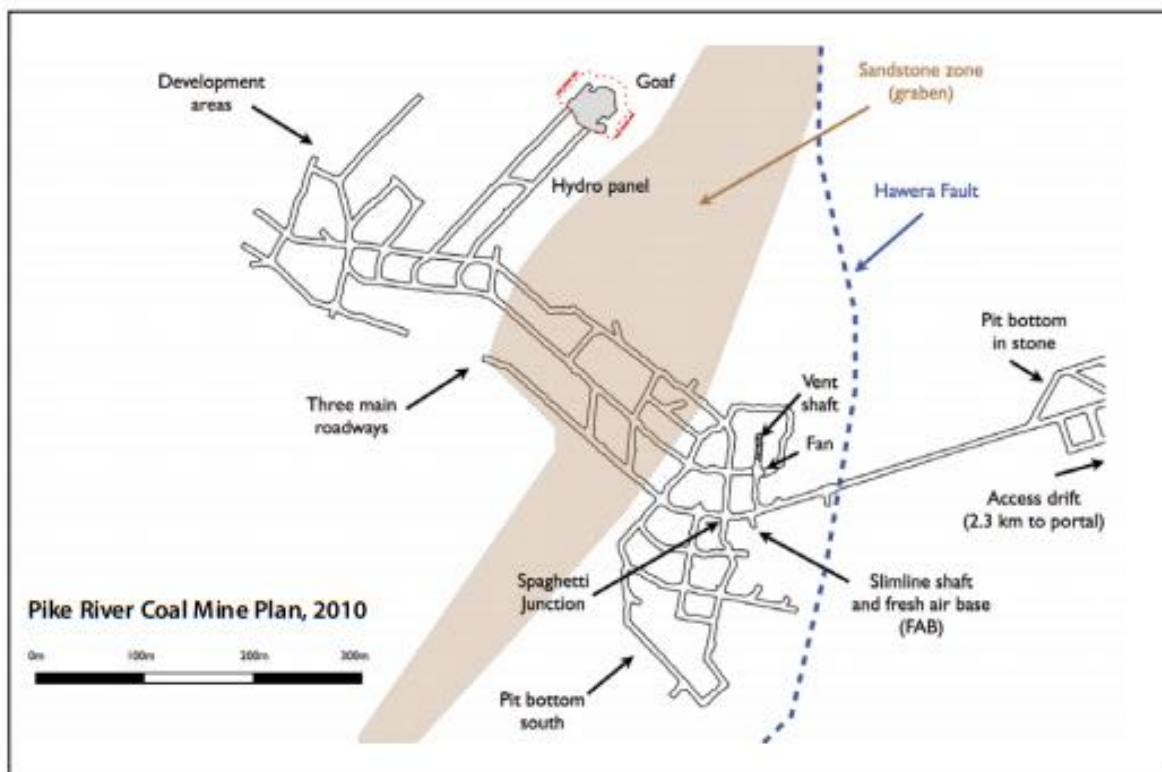


Figure 4.4: Pike's mine plan as at November 2010, showing the extent of the faulted rock graben/rockfall, which contained no coal

Source: RCPRCMT (2012, p. 16, Volume 1, Figure 1)

4.1.1 Pike had complex, rather than complicated mining systems and interconnections

This section considers a number of Pike's critical management systems and their overlapping relationships with each other. They were all still under development at the time of the explosion. The analysis comes from the findings of the Royal Commission and therefore, inherently show good collective knowledge from wide information-gathering ex-post. The overall picture is complex, and is very messy, with essentially all systems performing poorly. While this ex-post reference narrative is quite precise and certain (i.e., now a 'known known'), no key decision-maker would have had this ex-ante narrative. The ex-ante reference narrative was that all systems were being managed under dynamic conditions, often with active upgrades being planned or implemented as required.

The key infrastructure systems considered are:

- the system of gas monitoring
- the methane drainage system
- the ventilation system
- the underground electrical system
- the hydro-mining system

4.1.1.1 Pike had a poor system of gas monitoring

Pike had a poor standard of gas monitoring at the mine throughout the period leading up to the explosion. There were numerous issues with the monitoring equipment they had. Key information was not summarised and reported upwards. There was no online real-time monitoring, such as a 'tube bundle system' (which is standard in Australian mines), going to the control room, and they were short of hand-held gas monitors (RCPRCMT, 2012).

4.1.1.2 Pike's methane drainage was at full capacity and required free venting

Pike's gas drainage system was designed with insufficient information on gas flows or the mine's future drainage requirements. Pike started with no significant pre-drainage of the methane before mining had commenced and once mining started, drainage was adversely affected by bore-holes from in-seam drilling and later by hydro-mining, which added to the methane already in the mine. Managing the methane drainage throughout 2010 was a serious problem for Pike, even after the main fan improved the ventilation capacity, because the drainage system was constrained and operating at full capacity, it could not cope with the volume of gas needing to be removed (RCPRCMT, 2012).

To reduce the high-risk hazard of over-pressurised drainage pipes, Pike relieved the pressure in the drainage system by free-venting the methane into the mine. This technique is not deemed good practice, but may be needed as a temporary stop gap measure. This began in July 2010. This process releases large quantities of methane into the mine, extending the duration and location of potentially explosive mixtures underground. Upgrades of the drainage system were being planned, but not for some time. For operations staff, it was tricky managing the levels of methane released, due to Pike having such a poor gas monitoring system. In August 2010 both Hawcroft Consulting International and Zurich Financial Services Australia Ltd, Pike's insurance consultants, advised Pike in their annual insurance assessments that Pike needed to conduct a risk assessment of the methane hazard in the mine to ensure the methane levels remain at risk-free levels. This was not done (RCPRCMT, 2012).

4.1.1.3 Pike's ventilation system was inadequate

The ventilation management plan was incomplete, largely ignored in practice and needed to be resourced effectively. It required the appointment of a ventilation engineer to be responsible for the ventilation system. No one was appointed to the role and the mine manager became the de facto ventilation engineer, without the

time or resources to carry out the role adequately. Consultants were used for specific tasks, but not for overall co-ordination of the ventilation system (RCPRCMT, 2012).

Pike chose to develop hydro-mining (i.e., coal production, which is a method known to produce large quantities of methane) over developing a second intake/entrance that was long-planned and was needed to increase free air flow. It is considered unusual to have a single intake and return system for a mine with four or five working areas extending from it. While a single intake might be adequate as a stop-gap measure, it is not considered good practice or even legal in other countries because, from a ventilation perspective, it left no room for error. Any compromise to the main return system could have become very serious adverse events. Since Pike had a ventilation shortfall, they should not have been working so many places in the mine (RCPRCMT, 2012).

When the main fan was installed in October 2010, there were problems immediately in getting it to operate correctly and it needed the help of the manufacturers to solve these. Pike chose to place the main fan underground, which was highly unusual and would be illegal in most of the world. This decision/action was then aggravated by the failure to adequately protect the fan motor against methane ingress. Most mine ventilation 'stoppings' were of variable quality and were not built to any rated standard, since New Zealand does not have any. This further compromised the effectiveness of the ventilation system and created a safety hazard. Pike continued to increase the number of mining areas, despite already having a ventilation shortfall, with no margin of safety to meet foreseeable hazards. The 19 November 2010 explosion damaged both the main and back-up fans, and the ventilation system failed. The mine was now unventilated (RCPRCMT, 2012).

4.1.1.4 Pike had an unconventional underground electrical system

Pike lacked a sufficiently experienced senior electrical engineer with responsibility for the whole electrical system, so Pike's external/internal electrical experts were not adequately supervised to ensure the individual parts they worked on reduced the inherent problems rather than added to them (RCPRCMT, 2012).

Pike's underground electrical system developed in a piecemeal fashion, that was unconventional in a number of ways. This included having the main fan underground; having the non-restricted zone extend to the coal seam; the significant use of variable speed drives (VSDs) underground to drive key infrastructure and a range of problems were associated with their use; and high-voltage cables and utility services that were intermeshed at Spaghetti Junction (refer Figure 4.4). Individually, and in combination, these unconventional arrangements introduced significant risks to the underground environment, because they were largely untested and unusual. NZ regulations require a gassy mine to have a restricted zone where all electrical equipment must be incapable of sparking an explosion, but Pike's non-restricted zone, which contained some non-flameproof and non-intrinsically safe electrical equipment, extended to the coal seam. A risk assessment conducted before creating the non-restricted zone at pit bottom south would likely have led to the view that it ought not to be located in, or near, the coal seam in this gassy mine. If risk assessments had been done, it may have led to a halting or restriction of hydro-mining operations while these electrical problems were being corrected (RCPRCMT, 2012).

4.1.1.5 Pike had inherent troubles with hydro-mining

Delays in starting production and achieving coal production targets resulted in a change of location for the hydro-mining. This change was hurried and poorly managed. There was poor productivity due to poor geotechnical knowledge, poor planning, poor equipment, crew inexperience, ventilation and methane problems. A major collapse of the roof of the hydro panel on 30 October expelled a large volume of methane into the mine. Overall, the specialist system was not well engineered and not fit for a hydro-mining operation. Methane readings were always high. The hazards of hydro-mining were not sufficiently understood (RCPRCMT, 2012).

4.1.1.6 Management response - Pike was facing shareholder credibility problems

By mid-2010, the board acknowledged internally it was facing credibility problems because of overpromising and underdelivering. Pike was burning through the cash and had extremely poor production. In an email to directors on 5 July 2010, Dow (board chair) said it was *'worth paying [the hydro bonus] to retain short-term market credibility'*. The board initiated a \$2.3 million staff bonus scheme based on reaching a coal production target promptly, with the bonus then reducing from week to week. Dow believed the targets were 'modest enough and readily achievable' (RCPRCMT, 2012).

At the commission's hearings, Dow suggested the bonus was a response to poor work practices and, in particular, a lack of productivity and efficiency by workers. He said workers were not showing up for shifts, not looking after equipment and forgetting to fuel vehicles, and the bonus was *'about making sure people were thoughtful before they came to work'* (RCPRCMT, 2012, p. 162, Volume 2). This narrative deliberately omitted inconvenient or disconfirming facts, which is the way in which complexity is reduced to a more tractable set of decisions/actions (Kahneman, 2011).

The bonus did achieve modest productivity, though at the cost of workers and management focussing exclusively on production at all costs and overriding normal safety concerns. It was not a modest effort that they had to achieve and it was not readily achievable. Workers worked very long hours with poorly performing equipment and with individual and machine methane meters continually 'tripping' once the methane reached the meter's pre-set limit. Their reality differed considerably from what the chair and board were thinking was happening. The more plausible narrative was that the high absenteeism was caused by the poor productivity, which was caused by the poorly performing equipment, which management unfairly blamed on the workers (i.e., poor attitudes etc) and the real worry that gas monitors were being tripped every day - a real safety concern for workers. For the mine workers Pike was a very unhappy environment (RCPRCMT, 2012).

A disconnect between the reality and the public image was always present. For example, on 15 November 2010 Whittall (Pike's CEO) told Pike's annual general meeting: *'I am very pleased with the way the process has gone. There have been no significant issues and the hydro system cuts and flows through the Coal Preparation Plant as it is supposed to'* (RCPRCMT, 2012, p. 169, Volume 2).

4.1.1.7 Discussion on the attributes of complex systems failure

From the Royal Commission's findings, it is clear that within the various operational systems/sub-systems, Pike lacked subject matter experts with organisational seniority, whose job it was to reduce, amongst other things, any unnecessary complexity of the system configurations. This included the mines electrical system, mine design and the reduction of non-standard or unique/prototype parts, such as the hydro-mining equipment or ventilation system. Because of this, all these systems/sub-systems had increased uncertainty/risk than they needed to.

However, this analysis, as presented makes the problems and solutions look too tidy, too definite, and it overlooks the messier and unsettling complexity perspective which is embedded within the whole Pike context. This perspective includes the poorly understood non-linearity (small things can cause big problems, which is not intuitive), the inherent unknowability of many important things (since you may be relying on computer simulations and indirect measurements, as well as no one can understand the whole system as there are too many parts), and how a system's failure is a failure driven by the connections between different parts, rather than the parts themselves (Dekker, 2011).

All the systems/sub-systems described above were inherently tightly coupled. This coupling was increased with very tight timetables and no margin for error. Problems happen when you have a complex system that is tightly coupled. Different parts of a system unexpectedly interacted with one another, small failures combined in unanticipated ways, and people didn't understand what is happening. Clearfield and

Tilcsik (2018) suggest, they simply cannot understand enough about complex systems to predict all the possible consequences of even a small failure.

Dekker (2011) believes that complex systems that drift into failure are often characterized by the uncertainty of 'unruly technology'. Unruly technology introduces and sustains uncertainties about how and when events may develop and fail. Even though parts or sub-systems can be modelled exhaustively in isolation, their operation with each other in a dynamic environment generates the unforeseeabilities and uncertainties of complexity. Dekker (2002) says, local sense-making applies and every change in thinking is only an increment away from the previously established norm. But small changes in a system can have big consequences.

4.1.1.8 Ex-post public inquiries greatly increase collective knowledge

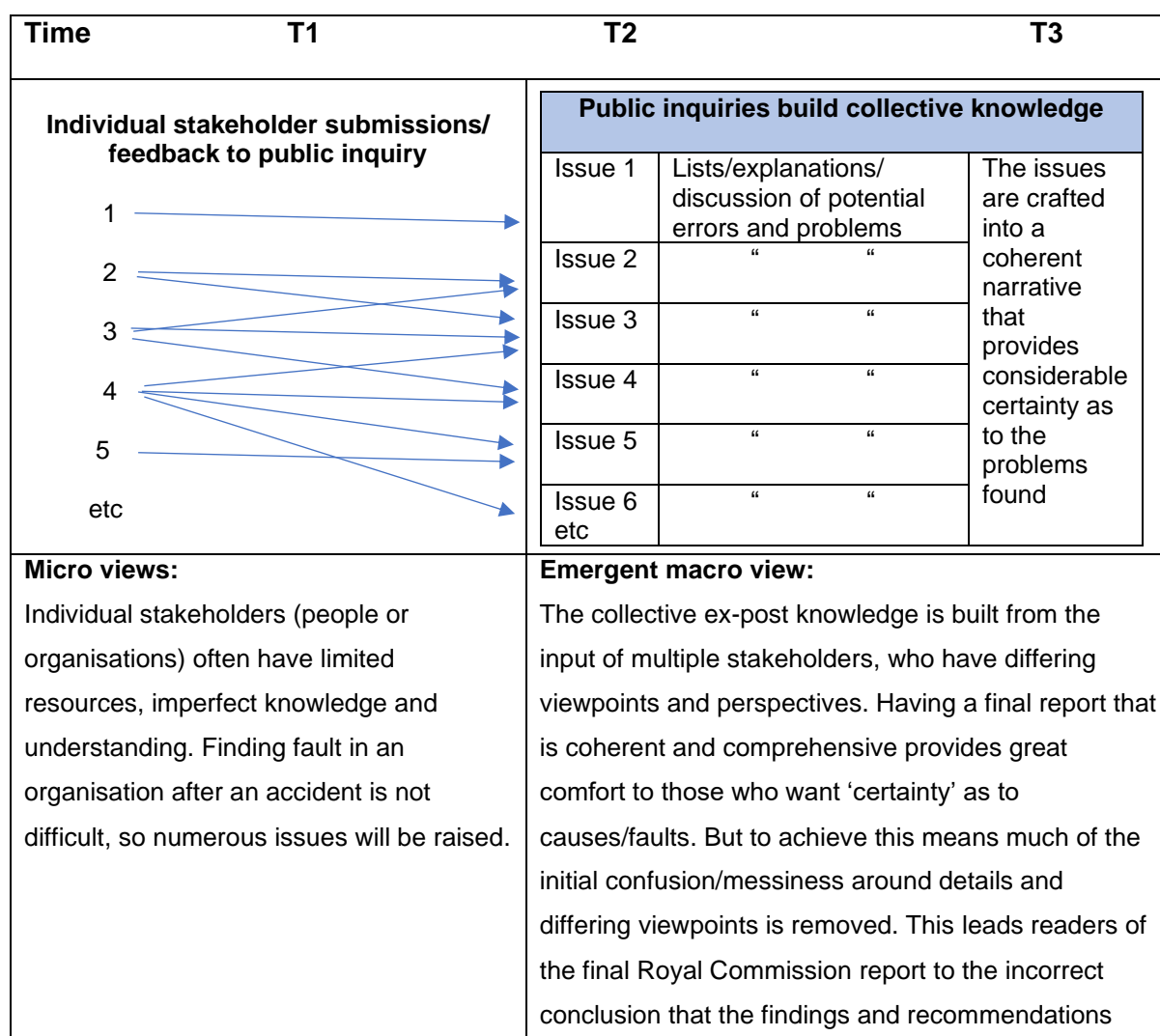
In complex systems, decision-makers are locally, that is boundedly rational rather than globally rational. This means that decision-making involves making judgements under uncertainty, ambiguity and time pressure. Reasoning is governed by people's local understanding, by their focus of attention, goals, operational pressures, time constraints and knowledge, rather than some (fundamentally unknowable) global ideal. What matters is whether the decision (mostly) works in their situation. However, the problem with this is that what works well locally can make things fail globally (Dekker, 2011). This local rationality is evident in stakeholder reflections at Pike.

Royal Commissions of Inquiry by contrast, are required to extend beyond local rationality. They endeavour to build collective knowledge from all the divergent and messy local rationality that the various stakeholders have. The final report of the Royal Commission of Inquiry builds this collective knowledge from the data collected, which is then coded, aggregated and cleaned. The final result is a coherent (i.e., internally consistent) narrative from the information that is known and agreed. It provides a good 20:20 hindsight vision. In one sense this is valid as it provides a more comprehensive picture of events, based on all available evidence.

Nevertheless, from a complexity viewpoint, this is more problematic as the Royal

Commission's ex-post findings can be viewed as equivalent to perfect global rationality, which would be a near impossibility ex-ante because of the limitations in cognitive resources and time for all stakeholders. The Royal Commission process assumes that the world is completely describable, however complexity denies this possibility. While a collective consensus ex-post narrative can be produced, it may still be unable to capture the dynamic elements of moving and interacting systems and relationships. Important aspects like emergence and non-linearity are lost in the detail (Dekker, 2011).

Figure 4.5 gives a diagrammatic representation of the process used by the Royal Commission, i.e., they received submissions, cross-examined witnesses, analysed the data into relevant issues, constructed a narrative, came to conclusions and recommendations, considered any trade-offs/ambiguity and then crafted the report.



	<p>which are then clearly stated, were also obvious before the disaster to the various stakeholders.</p> <p><i>Collective knowledge = data collected, coded, aggregated and cleaned</i></p>
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Figure 4.5: Diagrammatic representation of how public inquiries build collective knowledge from multiple sources

4.1.1.9 Protective structures will periodically fail in the complex world of radical uncertainty

Throughout the Royal Commission hearings, there was considerable criticism of the Department of Labour (DOL) mine inspectorship/inspectors and how they were ineffectual regulators of Pike and other mining organisations, since they only carried out compliance inspections, rather than full mine audits; and since DOL lacked resources, training, leadership, and legislative authority (Ewen, 2014; RCPRCMT, 2011-2012). Inherent, in these valid criticisms is the assumption that if the regulator had been strong, then the Pike explosions would/may not have occurred.

That view is probably too optimistic, as looking through a ‘complexity lens’ sees the Pike River disaster as one of numerous international examples of complex disasters, in a New Zealand setting. One of the critical features of all of these examples is the serious problem of the failure of protective governance and regulatory structures in complex situations. Examples include the credit rating agencies for the finance industry pre-2007 global derivative crash; the external auditors and the internal risk management department of Enron; the US government environmental regulator for BP Deepwater Horizon, or the Columbia Space Shuttle. The failures cover financial, environmental and safety protective structures. Dekker (2011) believes that with each failure, there is surprise that the protective structures failed. This surprise reflects our confidence that these protective structures should always work, but these surprises should also remind us that we need to understand how complexity actually works.

The protective structure is set up and maintained to ensure safety. It can include parts of the organisation (e.g., health and safety programmes), or it can be external (e.g., the regulator, or legislation). Protective structures are exposed to an environment that influences them with societal expectations, resource constraints, imperfect knowledge, limited access to information and goal interactions. The meaning of different issues gets constructed, negotiated, and transacted through the web of relationships that is strung through the structure. This affects how it condones, regulates and helps rationalize or even legalizes definitions of 'acceptable' system performance. Viewpoints between the operator and the regulator about what is risky and what is acceptable start to overlap, even while promoting an image of control and diversity. These agreements are then taken as the basis for confidence that risk is under control, and the organisation has struck a good balance between safety and production (Dekker, 2011).

Since the protective structures (internal/external) are subject to the same interactions and independencies with the operations that it is supposed to control and protect, it means that there is often something inescapably paradoxical and corruptible about the role of a protective structure (Dekker, 2011).

For example, Pike's regulator, the DOL mine inspectorate said ex-post, *'Much of the information before the Commission regarding deficiencies or hazardous events at Pike was not notified by Pike River Coal to the Department of Labour or was not in the normal course of an inspection available to be seen by the inspectors. Some of this information was not even known by the mine manager... such as Pike River Coal's methane readings and calibration records.'* (RCPRCMT, 2011-2012, p. 5375 - DOL, April 2012).

4.2 Comparing Pike's ex-ante reference narrative with ex-post actor-critic comments, using the 'Drift into failure' lens

4.2.1 Reconstructing the episodes of organisational drift into failure

4.2.1.1 Establishing the key episodes for Pike leading up to the explosion

This section builds on the methodology described in section 3.6. From a risk perspective, ex-post, there are three clear episodes/phase changes identified throughout the life of the Pike project. These have been summed up as:

- **'Getting to the coal, after Pike goes public'**. This episode starts with Pike's public listing and ends with 'first coal', which is only the outer edge of the seam.
- **'Overpromising, underdelivering and understating the problems'**. This episode ends after Pike had worked through a number of unexpected setbacks, such as the collapse of the ventilation shaft during construction and the discovery of the rock graben (shifted rock in an earthquake fault line) where coal should have been. Successfully dealing with all these setbacks was a prerequisite before they could consider ramping up to commercial production.
- **'The desperate need for production'**. This episode was when Pike had arrived in the commercial coal zone and they could finally focus on coal production.

These episodes are set out in Table 4.1, from the sequence of events, showing the descriptions and dates of key events.

Table 4.1: Establishing three episodes of Pike’s organisational drift into failure

Episodes	Getting to the coal, after Pike goes public 1 July 2007 to 30 Sept. 2008 (14 months)	Overpromising, underdelivering and understating the problems 1 Oct. 2008 to 30 June 2010 (21 months)	The desperate need for production 1 July 2010 to 19 Nov. 2010 (5 months)
Key dates within that episode	20th July 2007 - Pike starts as a public company.	17th October 2008 - Date of first coal. 27th November 2008 - formal mine opening. February 2009 – Ventilation shaft collapses. 19 February 2010 - First coal export shipment. Graben (rockfall in path) identified and it took months to penetrate.	5th July 2010 – Board proposes a bonus scheme to get the mine ready for production. 6th September 2010 - second coal export shipment 10 September 2010 – Pike Board dismisses Gordon Ward as CEO and replaces him with Peter Whittall. 19 September 2010 – start of hydro-mining. 19th November 2010 - mine explosion.

The next sections develop the emergent drift charts from ex-ante public records, such as quarterly and annual returns, for the estimated coal reserves/production timetable; the methane risk, the financial estimates/results (i.e., costs/funding) and Pike’s management churn.

4.2.2 The three key decision-makers

4.2.2.1 Background to Pike

In 1988 NZO&G acquired the shell company that owned the licence for the Pike River mine seam. The NZO&G's chair Tony Radford also became Pike's chair. Over subsequent years NZO&G unsuccessfully sought a partner to help develop the coalfield. In 2000, a final feasibility study was prepared and Professor Meyer (deputy chair of NZO&G) was appointed Pike deputy chair. By 2004 an access agreement had been signed with the Department of Conservation. In 2005 Whittall was recruited to help Ward (NZO&G - general manager) develop a business case for the project. Saurashtra Fuels invested \$17 million in return for a shareholding of 10.6 percent, and their representative Dipak Agarwalla joined the Pike board (Macfie, 2013).

In 2006 Pike worked towards getting its share float off the ground. The organising broker, First New Zealand Capital, put pressure on Radford to relinquish the Pike chair and bring in directors who were independent of Pike's major shareholder, NZO&G. This resulted in the appointments of retired investment banker Dennis Wood as chair in April 2006 and investment banker James Ogden as director in June 2006. Soon they had concerns. These revolved around the previous decision that Ward (NZO&G general manager) would be Pike's CEO despite his inexperience in setting up a greenfields mining operation and Pike's limited financial support from NZO&G, which put the directors at personal financial risk by inadequately funding the company. Trust between the two independent directors and Radford collapsed, and in December 2006 Wood and Ogden resigned, as did the long-standing director and mining consultant Graeme Duncan (Director 1999 – 2006) (Macfie, 2013).

Their departure was described as stepping down for 'personal reasons'. Duncan subsequently told Macfie (2013) that he left because NZO&G (through its directors on the Pike board: Radford, Ward and Dr Meyer) had taken direct control of the capital-raising and IPO process and this left him feeling unable to fulfil his obligations as a director. Two new independent directors, with no connections to NZO&G, were recruited - Stuart Nattrass in February 2007 and John Dow (the new chair) in May

2007. Neither Dow nor Nattrass spoke to any of the departing directors to understand the reasons for their sudden resignations. After talking to Radford and Dr Meyer, Dow concluded that the reasons for the three-man 'walkout' k were 'relatively trivial', the sort of thing that 'grown men resolve in an amicable fashion' (Macfie, 2013).

In 2006, Gujarat NRE invested \$20 million in Pike, reducing NZO&G's ownership to 54 percent. In July 2007 their representative Arun Jagatramka joined the board. In January 2007 Ward was appointed CEO of Pike and in June 2007 Pike was publicly listed with an initial public offering which raised \$85 million in capital (Macfie, 2013).

4.2.2.2 Who owned Pike, post listing?

The only time Pike's public financial disclosures detailed the key shareholders was in their 2007 Annual Report (Pike, 2007b). While this will have changed with the share issues in subsequent years, it does provide a clear pattern of ownership and who 'controlled' the directors. A summary of this data is contained in Table 4.2.

The effective control of the board lay in the top three founding shareholders, with four non-executive directors plus the CEO who had come from NZO&G. The 5,057 other public shareholders had 50.4% of the shares and had two independent directors, one who was the chair.

Table 4.2: The key shareholders of Pike (2007b)

Shareholder	Shareholding	% of shares	Directors appointed	Directors
NZO&G Services Ltd The company that founded Pike.	62.3m	31.1	2 x non - executive + 1 x CEO	Prof Ray Meyer Tony Radford Gordon Ward (CEO)
Gujarat NRE Coke Ltd (India) Gujarat invested in Pike as a keen customer who wanted Pike's promised high quality coking coal.	20.0m	10.0	1 x non - executive	Arun Jagatramka
Saurashtra World Holdings Private Ltd (India) Saurashtra, like Gujarat, invested in Pike as a keen customer who wanted Pikes promised high-quality coking coal.	17m	8.5	1x non - executive	Dipak Agarwalla
Top three founding shareholders	99.3	49.6	5	
5,060 (minus 3 above) public shareholders	100.9	50.4	2 x Independent	John Dow (Chair) Stuart Nattrass
Total	200.2m	100	7	

After the 2007 Initial Public Offering (IPO), NZO&G remained Pike's largest shareholder but treated Pike as a separate and independently run entity. Pike relocated its corporate headquarters away from NZO&G's head office, and the two companies ran separate administrative and financial systems. At the October 2009 NZO&G Annual General Meeting, Radford (Chair) was asked why NZO&G still owned shares in Pike, since coal mining was not part of their core business. Radford said the company was a *"holder and supporter of Pike River, which was expected to come into full commercial production by mid-2010 after long delays...But Pike was not a core part of the company. I'd be very surprised if in two to three years it is still part of the [NZO&G] portfolio."* (Weir, October 29 , 2009). Exiting Pike was a challenge for NZO&G, as any buyer who took 20% or more of the shares would be

required under law to launch a takeover offer to all shareholders. NZO&G was therefore probably waiting for the right time to sell down its shareholding.

4.2.2.3 What was the experience of the Pike board?

Table 4.3 lists the Pike Directors (Pike, 2007b), over the three years leading up to the explosion. The only change in this period was the change of CEO in September 2010, when Ward was dismissed and replaced by the General Manager - Mines, Whittall.

Table 4.3: Pike's directors, their qualifications and their main experience as at 3 August 2007

Name	Professional qualifications	Main experience
John Dow (Chair) 2007+	BSc (Hons) Geology	Retired chair and managing director of the Australian branch of one of the largest gold mining companies in the world.
Gordon Ward (CEO) 1998+	BBS – Finance Chartered Accountant	Previously worked for NZO&G, including since 1998 setting up Pike.
Prof Ray Meyer 2000+	PhD – Mechanical engineering	Retired Dean of Engineering and Assistant Vice Chancellor (Auckland). Now professional director, including deputy chair of NZO&G.
Tony Radford 1988+	ACA - Accounting	Wide experience of resource companies. Set up, and was chair of, NZO&G.
Arun Jagatramka 2007+	Chartered Accountant	Senior executive of Gujarat NRE (coal and coke). Previously merchant banking and consulting. Professional director.
Dipak Agarwalla 2005+	BCom - Commerce	Worked for Saurashtra, his family-owned coke-mining company, which is one of the largest in India.
Stuart Natrass 2007+	BAGSci (Hons) – Agricultural science	Experience is in international financial markets. Professional director, including on Fonterra.
Later in September 2010		
Peter Whittall 2005+	BE – Mining MBA Registered mine surveyor and mine manager	Former senior coal mine manager with BHP Billiton Ltd, Australia. Moved to New Zealand, when hired by Pike in 2005.

Source: Pike (2007b)

4.2.2.4 Observations:

The Pike board membership exhibited a knowledge and /skill bias towards accounting and finance, which would have been useful in procuring fundraising from

shareholders and banks. Notably, it appears light on engineers and experience in underground coal mining. The board appears to have relied solely on Whittall for technical mining advice, first as an employee and General Manager – Mines, and subsequently as CEO and Board member. This meant that the Pike board relied solely on Whittall for technical mining advice from 2005 when he became Pike's first employee and General Manager – Mines, until the mine explosion in 2010. This reliance on one key person over a long period of time highlights a potential problem of a lack of cognitive diversity.

Another feature of the Pike board is the long involvement of the two NZO&G members, who were involved in setting Pike up. One is the founding chair of NZO&G (Radford) and the other is the deputy chair (Dr Meyer). Both were also long-term directors of Pike before it became public. Radford was the founding chair and Dr Meyer became a director in 2000. From 1998 Ward, who worked for NZO&G, had been working full-time on the Pike project. In 2005 and 2007 the two Indian companies (coal customers) became involved. This meant five of the seven directors, plus the GM - Mines had been working on the project together, in some cases up to nine years before public listing. Dow joined the board just before Pike's public listing in 2007, so was obviously happy with the fully developed Pike proposition and reference narrative as outlined in the IPO and other documents.

From the date of public listing, it is clear from Pike's public documents that, in Pike's view, the years of 'exploration' (i.e., geology, finance, partners etc) was over, it was now time for 'exploitation' (i.e., dig the coal out).

Another feature of the Pike board was that three (i.e., Radford, Jagatramka and Agarwalla) of the seven directors lived overseas, so they did not always attend meetings in person or by skype. All these factors contributed to increasing the dominant position of the three de facto key decision-makers and their two NZO&G supporting directors.

4.2.2.5 Post listing, Pike's board and top management had almost complete stability

Table 4.4 lists Pike's top eight people, being the Pike Board (Chair and directors), the CEO and the GM – Mines. Over the study period there was almost complete stability, with the only change being two months before the explosion when the CEO Ward was dismissed and replaced with Whittall, who in turn was replaced with Doug White (marked in red) who was a 2010 recruit. For most of the period under review, this group of people appeared to work well together and respect each other.

Table 4.4: Drift time chart – The almost complete stability of Pike's Board, CEO and General Manager Mines - 1 July 2007 to 19 November 2010 (3 years and five months)

Episode	Getting to the coal, after Pike goes public Directors & start dates	Over-promising, underdelivering and understating the problems	The desperate need for production
Position	1 July 2007 to 30 Sept. 2008	1 Oct. 2008 to 30 June 2010	1 July 2010 to 19 Nov. 2010
Board	<p>Independent directors John Dow (<i>Chair</i>, 2007+) Stuart Nattrass (2007+)</p> <p>Approved by major shareholders Tony Radford (<i>NZO&G Ltd</i>) (1988+) Dipak Agarwalla (<i>Saurashtra Fuels Private Ltd</i>) (2005+) Arun Jagatramka (<i>Gujarat NRE Coke Ltd</i>) (2007+) Gordon Ward (<i>CEO</i>) (1998+) Prof. Ray Meyer (<i>NZO&G Ltd</i>) (2000+)</p>	<p>Independent directors John Dow (<i>Chair</i>) Stuart Nattrass</p> <p>Approved by major shareholders Tony Radford (<i>NZO&G Ltd</i>) Dipak Agarwalla (<i>Saurashtra Fuels Private Ltd</i>) Arun Jagatramka (<i>Gujarat NRE Coke Ltd</i>)</p> <p>Gordon Ward (<i>CEO</i>) Prof. Ray Meyer (<i>NZO&G Ltd</i>)</p>	<p>Independent directors John Dow (<i>Chair</i>) Stuart Nattrass</p> <p>Approved by major shareholders Tony Radford (<i>NZO&G Ltd</i>) Dipak Agarwalla (<i>Saurashtra Fuels Private Ltd</i>) Arun Jagatramka (<i>Gujarat NRE Coke Ltd</i>)</p> <p>Gordon Ward (<i>CEO</i>) Prof. Ray Meyer (<i>NZO&G Ltd</i>)</p>
CEO	Gordon Ward (1998+)	Gordon Ward	Gordon Ward (to Sept. 2010) Peter Whittall (Sept 2010+)
General Manager - Mines	Peter Whittall (2005+)	Peter Whittall	Peter Whittall (to Sept 2010) Doug White (Oct 2010+)

Source: Adapted from Macfie (2013)

Tony Radford is presumed to be the key decision-maker before (and probably after) Pike's public listing in both Pike and its parent, NZO&G, which he set up decades earlier and chaired. Radford was described as diminutive, socially reserved, cautious and highly intelligent. In business he was autocratic and controlling; dissent was not welcome and those who challenged his authority didn't last long. He had a strong desire for tight control over all that happened within the companies under his command. *'Radford's style was to give people opportunity, scope and loads of rope, but he would always control from the back'*, said Tony Frankham, former NZO&G director (Macfie, 2013, p. 31, Interview). Radford was described as a stubborn Australian who ruled NZO&G with an iron fist (Gaynor, 2012). Over the years Radford had earned a reputation in the business community for falling short of accepted standards of good corporate governance (Gaynor, 1999). After the Pike mine explosion, Radford wrote a brief submission under a compulsion order from the Royal Commission. He was not called to give testimony and he never made his views public.

4.2.2.6 Personality traits and profiles of Pike's three key decision-makers/risk seekers

4.2.2.6.1 John Dow (*Pike Board Chair from 2007 – Independent director*)

Dow was a New Zealander and the major influence within the Board. He was an ex-gold mining senior executive in Australia and South America. Dow was highly complementary ex-post, of the professionalism of Pike's senior staff, e.g., Ward, Whittall, and Rockhouse. Dow was highly impressed by the personable and highly capable Whittall, the man leading the project and they became very good friends. Dow believed in maximum delegation down to senior management of operational matters, since competent staff should be allowed to get on with the core work. As a consequence, Dow had a reactive approach responding to feedback from management on issues arising from operations or from key strategies and independent reviews. He assumed that if management had important issues that needed Board review, then they would bring the issues up. The problem with this was that if management did not report adverse findings within key strategies and

independent reviews up to the Board, the Board would inevitably have a more rosy or optimistic view of operations than they should have. This is what appears to have happened (Macfie, 2013; RCPRCMT, 2011-2012).

With one exception, Dow said that no one formally or informally warned him ex-ante of their concerns over safety/morale/leadership. The one exception was when senior consultant Les McCracken in partnership with Dave Stewart (another senior consultant), raised with Dow at an August 2009 conference that the mine had serious problems with morale and leadership. McCracken believed that since Whittall's management style was at the core of the problem, it would be pointless going direct to Whittall with these worries. McCracken spoke frankly about his concerns, and recalled saying of Whittall: "*The only way you will sort this out is to get rid of the guy.*" Dow does not remember McCracken expressing such strong views about Whittall, who he described as a good friend. Dow knew that McCracken and Whittall were not getting along and wondered about McCracken's motives for raising these issues. After the conference, Dow met Stewart at the airport and Stewart confirmed everything McCracken said (Macfie, 2013; RCPRCMT, 2011-2012).

For Dow the focus was on poor morale. Dow subsequently told Ward and Whittall of his conversation with McCracken and Stewart – both senior and competent consultants - and that they should engage one of them, or an equivalent, to deal with the matter. Dow then left it to the two men, who were at the heart of the problem, to deal with it. Perhaps naturally, nothing happened for six months. Working with Stewart was one of the first things White who had just arrived at Pike in early 2010, was asked to organise. White wasn't so keen on mentoring staff, as his concern arose from finding basic non-compliance every time, he went into the mine and he wanted to improve that situation. White was keen to improve the level of compliance understanding with staff. Stewart's report, which was finished a few months later, covered numerous problem areas from the poor ventilation system, poor gas monitoring system, poor stone dusting, no second egress, and poor hazard monitoring. The report was given to White and Whittall. Neither Dow nor the board asked to see it, nor were they given a copy or a summary, as Dow regarded morale, working relationships and leadership of the mine as operational matters, purely for

management attention. He trusted Whittall to deal appropriately with the issues raised (Macfie, 2013; RCPRCMT, 2011-2012).

Ex-post, Dow was happy with the way the board had operated ex-ante, with the people it had appointed and with the assumptions the board had made. As to the key geological assumptions which Pike never changed or challenged, Dow said, *“the board was satisfied that competent people under the JORC Code (the Australasian code for reporting coal reserves) with experience and understanding of West Coast coalmining geology, had calculated the resources and reserves that went into the company’s initial public offer (IPO) and that a sufficient level of pre-mining geological enquiry had been undertaken to enable those competent people to reach that conclusion.”* Once you had the confidence of the board, the board did not raise too many questions. For example, the board trusted Ward (CEO), who they considered a very capable and hardworking executive, so it took three years before they seriously questioned his over-optimistic targets which they always accepted (RCPRCMT, 2011-2012, p. 3910 - Dow, December 2011). Overall, Dow had few doubts or regrets ex-ante or ex-post about anything, with only one main exception.

At the Royal commission hearings the only thing Dow would lament, was *“There has been a lot of things that have come out that have horrified me.”... “Many of the safety problems, uncovered by the Commission had been disturbing.”... “There were people on-site who were aware of these issues or must have been because they’re written down. Why didn’t they raise them appropriately to the board?”* (RCPRCMT, 2011-2012, pp. 4105-4108 - Dow, December 2011).

4.2.2.6.2 Gordon Ward *(Pike CEO and director from 2007, until September 2010)*

Ward was a New Zealander who had a background in auditing, who was then the financial controller for NZO&G before helping set up Pike River Coal Ltd. Ward was an acolyte of Radford and the key driver of the project to develop the Pike River mine (called ‘Gordon’s baby’), overseeing planning and regulatory issues from 1998. He was sole employee until he hired Whittall in 2005. Ward was regarded as hard-working, disciplined, ambitious and focused. He was described as driven by numbers rather than relationships, perhaps reflecting his accounting background. Some

considered Ward as not a strong leader and he was seen as slightly colourless, overconfident, haughty, and even arrogant. Ward had an important influence on the company's operations, even though Pike's head office was in Wellington. As CEO, Ward was the author of Pike's optimistic quarterly/annual reports outlining the potential for large volumes of high value coal, with optimistic production deadlines. Ward's job was to sell the dream and get the funding needed. Once he had the confidence of the board, he was given a free hand to get on with it, with minimal further questions (Macfie, 2013; RCPRCMT, 2011-2012).

However, coal production was abysmal, coal quality was less than promised and production timelines kept shifting outwards. The cost delays and overruns required annual financial top-ups from shareholders. As long as shareholders were happy to keep putting money into the company every year, then the risk of a financial blow-up was low. But in the third year of being publicly listed, some investors, including NZO&G, were troubled by the continued lack of production and the continued need for more cash, over and above what was budgeted for (Macfie, 2013; RCPRCMT, 2011-2012).

Ex-post, Dow said that Ward always seemed to use the most optimistic figure. Ward could also be described as suffering from what Kahneman (2011) describes as the planning fallacy (i.e., significantly underestimating costs/time in major capital projects). Pike did not use local (or overseas) mine development benchmarks, such as learning from Solid Energy's troubled Spring Creek mine. Pike relied completely on 'inside' thinking, based on developing just one mine, being Pike River, without any reference to industry base rates. Since Ward did not see a problem in making such 'big promises', he never saw any reason to revise downwards prior assessments of a whole range of critical success factors. This was a significant problem; which Pike only started to address after Ward had left Pike.

In mid-2010, NZO&G put pressure on the Pike Board to improve performance. This led to Ward being dismissed in September 2010. Ward then moved to Australia, before the Pike mine explosion occurred in November 2010. Ward did not attend or participate in the Royal Commission proceedings and legally could not be required to participate. Ward's successor, Whittall did actively participate, which meant Whittall

was the ‘face’ of Pike and was effectively blamed for all the numerous problems at Pike, rather than Ward who had made many of the earlier consequential decisions and judgements. (Macfie, 2013; RCPRCMT, 2011-2012).

6.2.2.6.3 Peter Whittall (*General Manager–Mines from 2005 to 2010, then C.E.O for two months*)

Whittall was an Australian mining engineer who had been a senior BHP manager and in 2005 he became Pike’s technical mining leader. Whittall brought strong technical mining knowledge. He was charming and clever and came with ‘supreme confidence and optimism’. Whittall was a persuasive and positive front man, since he had the ‘gift of the gab’ and was good at explaining technicalities to lay people. These skills complemented Ward’s. He also liked to micro-manage and dominate. He had very strict ideas of what he wanted and sometimes people disagreed. This could come across as dictatorial and arrogant. Except for the last two months, when he was CEO in Wellington, Whittall worked at the mine site as General Manager-Mines, where he was the undisputed boss of the mine project (Macfie, 2013; RCPRCMT, 2011-2012).

During cross-examination, Dow was asked about Whittall. *“Peter is a very capable and competent person. He’s a forthright speaker as I’m sure most people in this Court would appreciate, but I wouldn’t have described it as autocratic, no.”* (RCPRCMT, 2011-2012, p. 3924 - Dow, December 2011).

Whittall brought his Australian attitudes and experience to the project, such as his reliance on standard Australian ‘in-seam’ test drilling, rather than the NZ/West Coast norm of vertical test bore holes. Whittall had no experience with hydro-mining, which is a NZ-Japanese technology. While Pike engaged a wide variety of consultants, Whittall said ex-post that he had not read their reports, as they went directly to the relevant manager. It was up to managers to tell him of anything important (Macfie, 2013; RCPRCMT, 2011-2012).

In mid-2010 Whittall played a leading role in the establishment of a high-profile organisation, known as the Business Leaders Health and Safety Forum, which aimed

at improving workplace health and safety throughout New Zealand. When this organisation was launched by Prime Minister John Key in July 2010, Whittall was a steering group member. The initiative was celebrated as the first of its kind in the world (Macfie, 2013).

Whittall seems to have been held in high regard by the Pike board, as immediately after Ward was dismissed as CEO, Whittall was selected as acting CEO, and then later the Pike board unanimously voted that he become Pike's CEO without seeking other internal/external applications. Whittall was aware that he had been with Pike for five years and that over that time the operations had consistently failed to reach their targets. Whittall was keen to take the job only if he had the full support of the board, which he got, so that he could confidently make the necessary changes. This include revising down the forecasts going forward (RCPRCMT, 2011-2012 - Whittall).

4.2.3 The key uncertainties around Pike's estimated coal reserves/production levels

4.2.3.1 Ex-ante – Pike's reference narrative

Coal production levels - What Pike promised and what Pike delivered

The following Table has been prepared from public documents filed by Pike and it shows:

- The key aspects of Pike's coal – quality, quantity, price and production rates;
- The promise of large coal reserves of high quality and the favourable drift upwards of coal spot prices and the value of the estimated coal reserves; and
- The drift in dates for starting the mine and building up to peak production,

The information contained in each column is the information given to Pike's public shareholders during that period. The table therefore shows the drift in the company targets over time, using Pike's own estimates and disclosures.

Table 4.5: Drift chart - what Pike promised and what Pike actually delivered

Episodes (Data collected as close as possible to episode end points)	Getting to the coal, after Pike goes public		Overpromising, underdelivering and understating the problems	The desperate need for production
	Starting point 1 July 2007	1 July 2007 to 30 Sept. 2008		
Estimated coal reserves				
Estimated reserves of saleable coal	17.6 m tonnes (being 1m tonnes for 18 years) ²	17.6 m tonnes (being 1m tonnes for 18 years) ⁴	17.6 m tonnes (being 1m tonnes for 18 years) ⁸	-
Coal price (spot)	US\$100 per tonne For decade up to 2006, the	US\$300 per tonne ⁴ Commodity boom because	US\$200 per tonne ⁹ Commodity boom because of	US\$225 per tonne ⁹ Commodity boom

Episodes (Data collected as close as possible to episode end points)	Getting to the coal, after Pike goes public		Overpromising, underdelivering and understating the problems	The desperate need for production
	Starting point 1 July 2007	1 July 2007 to 30 Sept. 2008		
	average was US\$50 per tonne ⁴	of demand from China	demand from China	because of demand from China
Estimated value of saleable coal	\$2.3 billion ²	-	\$4 billion ⁸	-
Quality of saleable coal	Premium, hard coking, ultra-low ash of 1% ²	Premium, hard coking ultra-low ash ⁴	Premium, hard coking ultra-low ash ⁸ Actual - 1st shipment - 5% ash, 19 Feb. 2010 ⁹	Premium, hard coking ultra-low ash ¹⁰ Actual - 2nd shipment - 4.7% ash, 6 Sept. 2010 ⁹
The coal production timetable				
Estimated date of 'first coal'	March 2008 ¹	-	Actual 17 Oct 2008 ⁵	-
Estimated date of 'saleable coal'	Year starting 1 April 2008 (240k tonnes) ²	1 st / 2 nd quarters of 2009 ⁵ (200k tonnes)	Recommended June 2009 ⁷	-
Estimated date of export sales	3 rd quarter of 2008 ²	1 st quarter of 2009 ⁴	Actual - 1st shipment 19 Feb. 2010 20k tonnes ⁸	Actual - 2nd shipment 6 Sept. 2010 22k tonnes ⁹ 60k before June 2011 80k before Dec. 2011 ¹⁰
Estimated date of regular (i.e., p.a.) production of 1 million tonnes	Year starting 1 April 2009 ²	Year starting 1 April 2009 ⁵	First half of 2011 ⁸	2012 financial year ¹⁰

Sources:

¹- (Pike, 2007a), ²- (Pike, 2007b), ³- (Pike, 2008b), ⁴- (Pike, 2008c), ⁵- (Pike, 2008a), ⁶- (Pike, 2008d), ⁷- (Pike, 2009a), ⁸- (Pike, 2009b), ⁹- (Pike, 2010b), ¹⁰- (Pike, 2010a)

Actual coal returns and quality

Actual coal sales at the time of the explosion, were NZ\$9 million, being NZ\$3 million for the first shipment of 20,000 tonnes in February 2010 and NZ\$6 million for the second shipment of 22,000 tonnes in September 2010. There were only two shipments made before the mine explosion. While Pike promised only 1% ash, these shipments had 5% and 4.7% ash levels, so the coal had to be sold at a discount, as it was higher ash than the contract specified (Pike, 2010b).

What wasn't mentioned in Pike's public documents was that the second shipment in September 2010 was to its shareholder and customer Gujarat NRE, who told Pike it would not take any more out-of-specification coal until at least the following year (Macfie, 2013).

4.2.3.2 What Pike promised in their coal production timetable

Overall, the drift in target dates reflects the numerous unforeseen production difficulties. These caused an escalation of times for all key activities, but due to complexity, those sequential in the production chain had a greater escalation in delays. E.g.,

- 'first coal', from March to October 2008, being up to 7 months delay;
- 'saleable coal', from 1 April 2008 to 31 May 2009, being up to 13 months delay;
- 'export sales', from the 3rd quarter of 2008 to 19th February 2010, being up to 19 months delay; and
- 'full production of 1 million tonnes p.a.,' from the year starting 1 April 2009 to the 2012 financial year, being up to 32 months delay, and this date was still in the future.

These delays are summarised in Table 4.6.

Table 4.6: Summary of delays as outlined in Pike’s public documents

	2008				2009				2010				2011			
‘First Coal’																
‘Saleable coal’																
‘Export sales’																
‘Full production’																

At the date of the explosion ‘first coal’, ‘saleable coal’ and the first shipments had occurred, but full production was still some way out.

Pike started to publicly revise its inherently optimistic forecasting process after Ward (CEO) was dismissed in September 2010, when Pike reported, *“This is a more conservative approach than we have taken in the past and is designed to provide shareholders with as realistic a time frame and production schedule as possible while preserving a measure of upside capacity.”* Whittall advised that from now on forecasts would be ‘achievable’ rather than ‘best case’ scenarios. Previously he conceded Pike’s forecasts had ‘consistently proved to be at the upper end of the range while operations performed at the lower end’. It was now time to be more realistic (Pike, 2010a). The report was dated 25 October 2010.

4.2.3.3 At the time of the explosion, Pike was actively searching for coal seams

Pike was the only coal mining company in New Zealand to use ‘in-seam directional drilling’ to drill long-distance holes hundreds of metres ahead of each working coal face. In September 2010 Pike announced, it *“intended to expand and intensify its programme of in-seam drilling to cover 11 kilometres over the year ended 30 June 2011 at a budgeted cost of \$7 million. This would ensure the capacity of 12 months of hydro-mining is covered in advance by in-seam drilling. Pike believed that since the mining operation has moved away from the Hawera fault and adjacent graben*

zone, the risk of a major geological surprise is considerably diminished. In-seam drilling is used to increase certainty of geological conditions and reduce mine planning and scheduling risks” (Pike, 2010b). The following diagram shows an indicative mine plan showing in-seam exploratory drill holes.

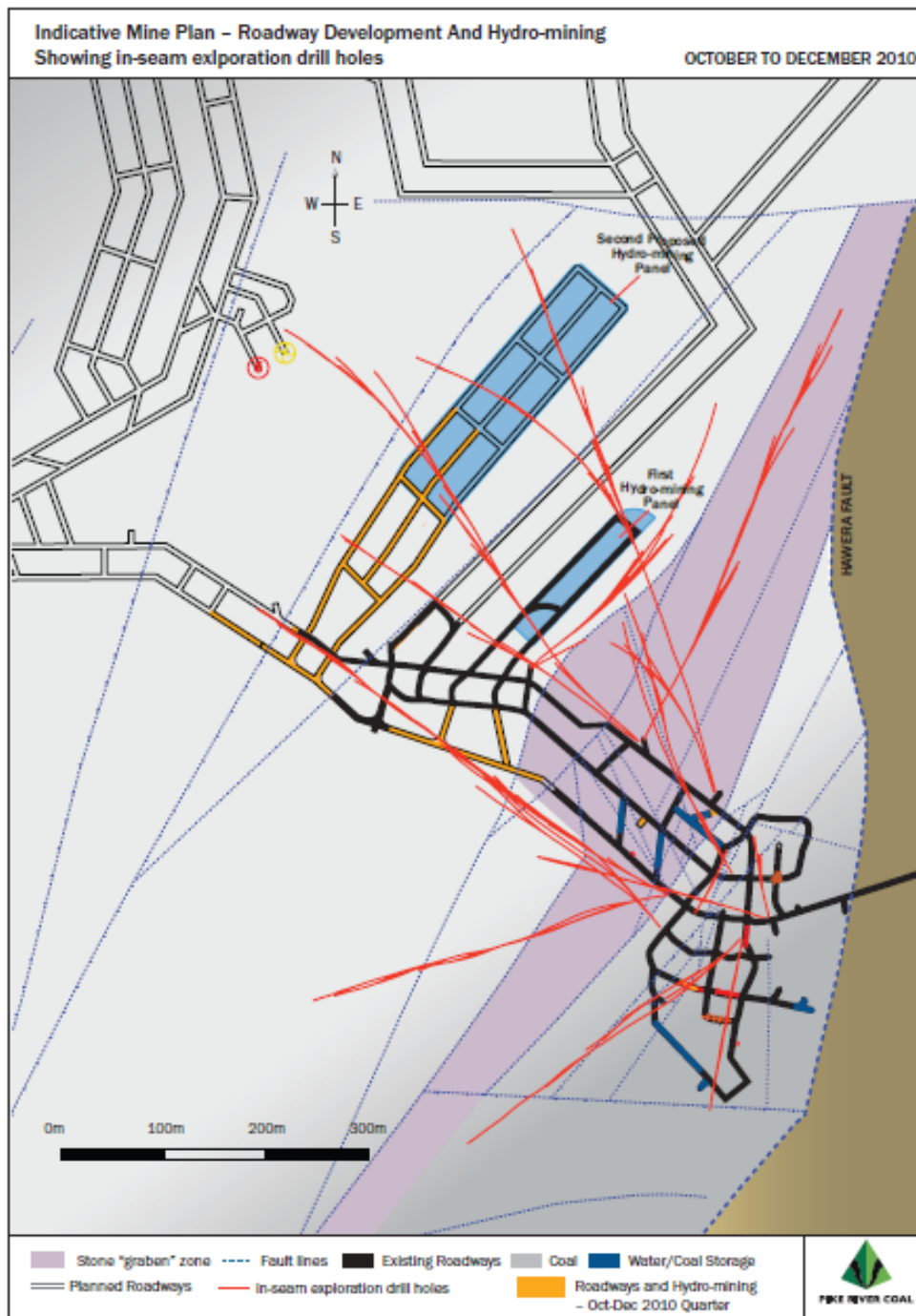


Figure 4.6: Indicative mine plan showing proposed in-seam exploration drill holes

Source: Pike (2010a), dated at 25 October 2010

4.2.3.4 Ex-post comments: Actor-critics challenge Pike's reference narrative

While prior subsections have related to Pike's ex-ante information provided to its shareholders, this subsection sets out comments made ex-post in 2011 at the hearings of the Royal Commission. They are in approximate chronological order.

4.2.3.4.1 Masaoki (Oki) Nishioka (Japanese consultant and expert on hydro-mining)

Nishioka was a leading engineer at Mitsui Mining, who in 1993 drilled seven boreholes to find out about the geology of the Brunner coalfield, sharing this information with Dr Newman and her Greymouth Coal Research Group. Nishioka's assessment was that while the coal had valuable characteristics, he recommended to the Mitsui board that they should not get involved. He believed there were difficulties actually getting to the coal seam, the level of gas and the high levels of sulphur (up to 7%) in the upper layer of the seam which would make it useless as a coking coal for the steel industry. Nishioka calculated that Pike would produce only five or six million tonnes of saleable coking coal (compared to Pike's later target of eighteen million tonnes), not enough to justify the significant investment that would be required to develop the mine. Ex-post, in 2012, he still believed his original estimate was close to reality (Macfie, 2013; RCPRCMT, 2011-2012).

4.2.3.4.2 Dr Murry Cave (Consultant geologist who had acted for the Department of Conservation (DOC) between 2000-2004, in reviewing the geological aspects of Pike proposal for mining)

Dr Cave had a detailed knowledge of New Zealand's coalfields from decades of working in the industry (Macfie, 2013). Dr Cave was deeply unimpressed with the level of information that had been supplied in support of the Pike access arrangement. He expected it to consist of a large volume of technical material – including the results from borehole drilling, comprehensive geotechnical data, field mapping, analysis of the geological structure, and so on. He thought he would need to set aside a secure room at DOC head office to work through the data. Instead, the material he was asked to assess was handed to him in an A4 envelope. Dr Cave

thought the documents were inadequate. There was a lack of detailed analysis that is expected for a complex underground mining proposal, and the borehole data was sparse. In late 2000, Dr Cave told DOC that Pike's promoters didn't seem to have adequate information on which the department could base a decision regarding access. There were critical gaps in the Pike database – the company had not drilled enough exploration boreholes, didn't have enough accurate gas data, and didn't know enough about surface subsidence caused by mining. Dr Cave recommended the application be turned down. He believed more boreholes needed to be drilled from the surface to gather further information. But Pike's promoters told the department that the plan was to gather the necessary geological information by in-seam drilling, rather than by costly vertical drilling. Dr Cave perceived that DOC was under pressure to make a favourable decision for Pike (Macfie, 2013). When Dr Cave raised his concerns with Pike in October 2000, Pike told DOC that it felt DOC was overreaching in telling Pike about good practice (RCPRCMT, 2011-2012 - Dr Cave).

4.2.3.4.3 Harry Bell (New Zealand mining consultant and former Chief Inspector of Mines)

Bell was an experienced but retired miner of six decades. Bell became involved with the Pike project and quickly had deep concerns about the mine's operations. In mid-2006 he was part of a team that collected coal samples, but they were explicitly told not to sample the top five metres, since that sample would be high in sulphur and therefore unsuitable for steelmaking. Bell was not happy with this instruction on a number of levels and he said so, but this was ignored. To Bell, Pike's options for dealing with this sulphur layer problem seemed unworkable (since top layers always fall), time consuming and costly. He advised friends not to invest in Pike as he couldn't see how it would make money (Macfie, 2013; RCPRCMT, 2011-2012).

Bell commented on the Royal Commission hearings, that the '*Pike mine was planned by Australian mining consultants and managed by Australian and other overseas managers, none of whom had experience of our local mining conditions or the processes involved in hydraulic mining. It seems ironic that an Australian mining*

expert said that they would never develop a mine like that in Australia.’ (Ewen, 2014, p. 7).

4.2.3.4.4 Dr Jane Newman (Professor of Geology and specialist in West Coast geology at the University of Canterbury)

Dr Newman had helped in the initial test drilling on the Brunner coal seam in 1980-1984 as a PhD geology student. She became an expert on the Pike coal seam and she led the Canterbury Coal Research Group in the 1980s and had an extensive database on the Greymouth coal seam reserves. She undertook more test drilling in 1990.

In August 2001 Dr Newman was asked by Pike to help study the potential for acid mine drainage. In reviewing Pike’s documentation, she was immediately struck by how sketchy the study was, and how inadequate the geological knowledge underpinning it. The cross-sectional diagrams depicting the geological make-up of the coalfields were, to her mind, merely ‘cartoons’ and the diagrams provided a misleading impression that the seam was uniformly thick and unaffected by sedimentary partings. This had profound implications for potential coal reserves. She believed Pike did not understand this risk or that the coal seams on the West Coast are very different to those in Australia and the Australian approach of in-seam drilling was not suited for identifying sandstone. Newman made her views known to Ward in late 2001. The Pike retort was that Newman had been hired to help with the acid mine drainage issue and she had overstepped her brief by criticising the geological content of the feasibility study. Newman was very uneasy about the lack of geological evidence and the lack of a comprehensive set of test drills (Macfie, 2013; RCPRCMT, 2011-2012).

Dr Newman worked on and off with Pike through 2006 to 2009, by answering email and phone questions as to how her model might answer some current question, but she increasingly become concerned. *“I was being frequently asked to make statements that I considered poorly founded. By, I think, August 2009 I ... said I’m not going to respond informally from now on because any response I make might be taken to be my professionally judged opinion and it’s not, it is in my view not*

adequate because the geological information to hand from drilling mining and the stratigraphic studies I felt did not define the geological complexity in sufficient detail. From the time that I made that statement I did not answer any more questions. I was not asked any more so it was taken to heart.” In all these conversations Newman expressed her geology concerns with Pike’s geology and mining engineer’s staff, but never to senior management (RCPRCMT, 2011-2012, pp. 169-197 - Dr Newman, July 2011).

4.2.3.4.5 Les McCracken (Senior mining consultant and project manager)

McCracken was increasingly concerned about the wide gulf between Pike’s public statements about the rate of progress and forecast coal production, and the repeated delays and cost blow-outs that were occurring at the site. In April 2008 he upbraided Whittall by email following the release of a public statement predicting that coal would be produced by July that year. Whittall defended the statement, replying in an email: *“It doesn’t say full production, it says production. We are a coal mine and will mine coal. That is a true statement.”* McCracken replied: *“(The) issue is an ethical one Peter. You know the assumptions that will be made by an average investor reading the statement and that is why the statements are being made. At best, that is skating on the edge of unethical behaviour”* (Macfie, 2013, pp. 94-95).

McCracken was troubled by the personal dominance that Whittall exerted over the project, and his tendency to reject advice he didn’t agree with. From McCracken’s years of involvement with complex projects, he knew that forceful, persuasive leaders such as Whittall sometimes created a climate where debate was stifled and those with contrary views were driven out. He was also concerned about what he perceived to be a bullying style of management. *‘People would be asked to go away and come up with a solution for something, and when they came back with their proposal and costings they would be told, “That’s simply not good enough. Go away and do it again”. Instead of building an environment where people work collaboratively to achieve the best outcome, you tend to end up with a whole lot of subordinates who will just give you what you want’* (Macfie, 2013, pp. 106-108, Interview). McCracken believed that since Whittall’s management style was at the core of the problem, it would be pointless going direct to Whittall with these worries,

so in August 2009 he approached Dow (board chair) at a conference, and expressed his concerns. This resulted in the Stewart report (2010) which went to Ward and Whittall.

4.2.3.4.6 Quintin Rawiri (Australian-based trouble-shooter of underperforming mines)

When Doug White (Production Manager) arrived at Pike, he got Rawiri to review Pike's operations to see why it was failing. In early February 2010, Rawiri arrived, reviewed the operations and talked to those underground and then went out for a meal in Greymouth with White and Whittall (Macfie, 2013).

Rawiri recalls, *'We talked for a while and then Peter (Whittall) said, "So, what do you think of the operation? We've got pretty tough conditions." I said, "It's actually a pretty good operation." He said, "What about the men?" I said, "You've got good boys there, and they've been putting up with equipment that's not fit for purpose for a long time". "I saw Doug look across the table at me as if to say, "Don't go there". Peter said, "What do you mean?" I said, "Your biggest issue is that you've got the wrong equipment." "He then got quite cranky and talked about how they'd spent a lot of time speccking those machines, and how a lot of thought had gone into them and that they'd cost a lot of money to build. In the end I said, "Look, this is how it is: Doug has asked me to come over here and look at your operation. I can sit here and tell you what you want to hear and make you feel warm and fuzzy, or I can do what you pay me to do, which is to tell you exactly what I think. And I'm telling you the gear you've got is wrong, and you need to get an ABM20 in there" (Macfie, 2013, pp. 132-134, Interview).*

"He said, "That'll never work in New Zealand. That'll never happen." 'I said, "If you're happy to keep doing what you're doing with your equipment getting one or two metre a shift, then carry on. It's not my business. I'm going to get on a plane back to Australia tomorrow." I just carried on eating my steak. The guy just would not listen" (Macfie, 2013, pp. 132-134, Interview).

By June 2010 Rawiri, working with White had located a ABM20 – a 100-tonne machine in Australia, that could be leased. After months of staff and managers trying to convince Whittall that the equipment was a failure (which was identified on the first day), Whittall eventually yielded, telling White he could go ahead and lease the ABM20, but he'd be held accountable if it didn't work. It arrived in August and was immediately far superior in achieving productivity than existing machinery (Macfie, 2013).

4.2.3.4.7 Solid Energy's peer review of Pike's hydro-mining

Hydro-mining production was so bad at Pike that on 3 November 2010 Matt Cole an engineer working for Pike, contacted staff at Spring Creek, where he had previously worked and asked if that organisation could help give Pike advice. Solid Energy, who had 20 years of experience in hydro-mining, agreed on an informal collegial basis to have four senior staff observe the hydraulic monitor in operation and see if it could offer any advice as to why there was such a slow coal cutting rate. They observed serious problems in technique and approach and they offered various suggestions. *'Solid Energy group's impression was that the equipment was larger and more complex in its design than necessary and the Pike staff lacked experience with it. This was likely to make the set up prone to downtime and slow production. Pike was trying to extract coal without fully understanding the conditions or investing in necessary development and infrastructure'* (RCPRCMT, 2011-2012, p. 3426 - Solid Energy, November 2011).

Ex-post, Solid Energy saw a copy of the email sent by Whittall to the directors of Pike on 4 November 2010. In this email Whittall wrote, *'Main production issue being addressed is the tonnes per hour output of coal from the hydro-monitor. System operation is good and availability higher than forecast. But actual coal output from the face is well down on expectation in these early cuts as the nice hard coal just wants to stay there. We had a visit from the senior Spring Creek management and hydro team yesterday who inspected the face and observed operations. They concluded that our systems and cutting techniques were consistent with their own and had no significant advice to offer at this stage. We are working on techniques and observing roof falls et cetera and learning. Signed, Peter'*. The Solid Energy

group strongly disagreed with these comments (RCPRCMT, 2011-2012, p. 3427 - Solid Energy, November 2011).

4.2.3.4.8 Dr Elder (CEO Solid Energy, the state-owned mining company, that was at that time the biggest coal miner in NZ and on the West Coast.)

Dr Elder first met Pike CEO Gordon Ward in 2000, when Ward gave a presentation of the planned Pike River mine to Solid Energy. *‘From 2000 onwards I and my Solid Energy colleagues increasingly held the view that the Pike River Mine would experience significant development and production issues, was unlikely to achieve most of its production and financial targets and that this would result in major financial issues. We believe the commercial risk associated with the Pike River development was very high’* (RCPRCMT, 2011-2012, pp. 5-6 - Dr Elder, July 2011).

Ex-post, Dr Elder challenged many aspects of Pike’s reference narrative. For example:

- Solid Energy believed Pike’s management underestimated the geological challenges of mining on the West Coast, compared to Australian conditions, which many of Pike’s advisers were familiar with. For example, in the West Coast, *‘Coal seams are often not continuous even over moderate distances but instead are disrupted by faults that have vertical and horizontal displacements often far larger than seam thicknesses. All these factors significantly increase both costs and risks.’* But, by comparison, *‘In Queensland there are very big continuous coal seams for many, many kilometres, it might actually be relatively straightforward if the seam is very quickly understood from a small number of drill holes.’* (RCPRCMT, 2011-2012, pp. 10, 120 - Dr Elder, July 2011).
- Solid Energy believed Pike management were too dismissive of Solid Energy and its efforts to deal with its troubled Spring Creek mine (which is less than 30km from Pike), while subsequently encountering practically all the same problems of poor production, unexpected difficulties, difficult geology and high methane.

- Solid Energy believed Pike seriously lacked basic geological information. For example, Pike had 28 bore holes done between 2000 and 2007. *‘This compared to the Spring Creek mine that started in around 2000 with around 115 bore holes which we considered inadequate in a similar resource size. As of today, we have something like 360 to 400’ ... ‘However, it remained compromised by the original mine development options chosen and by insufficient geological information. Unexpected geological and mining surprises continued to occur. In mining where certainty of geological information is the key to good mine planning and operations the unexpected only ever has negative consequences. So, it was with Spring Creek ... the mine struggled and repeatedly failed to meet its production and financial plans.’* (RCPRCMT, 2011-2012, pp. 17, 64 - Dr Elder, July 2011).
- *‘In the very difficult geological conditions of West Coast coalfields, Solid Energy’s experience is that to define a coal resource to JORC measured status requires high-quality drill holes at aerial density no less than 100 metre spacing on average and even at this spacing a mine plan will still have significant uncertainty and mining and financial risk.’* (RCPRCMT, 2011-2012, p. 20 - Dr Elder, July 2011). The ‘JORC Code’ is the Australasian professional code for public reporting of exploration results, mineral resources and ore reserves.
- Solid Energy believed Pike seriously overestimated the quality of the Pike coal. Due to the impurities, *‘On average the Pike River coal was likely at best to qualify only as semi-hard coking coal ... which sells internationally at prices discounted significantly below premium hard coking coal ... and that view was confirmed by coal technologists inside and outside Solid Energy and by customers in the market to us’* (RCPRCMT, 2011-2012, pp. 92-93 - Dr Elder, July 2011).
- Solid Energy believed Pike seriously overestimated the potential production levels of one million tonnes per year. *‘In practice, in West Coast conditions, the constraints on development required to support this and the need to repeatedly move extraction equipment and infrastructure make it very difficult to achieve*

production rates above 600,000 tonnes per year even when a mine is operating well.' (RCPRCMT, 2011-2012, p. 12 - Dr Elder, July 2011).

- Dr Elder believed that Pike's proposed mining development rate of 7.2 metres per shift, *'had never been achieved anywhere in New Zealand, so was anything but conservative, being hugely aspirational and very optimistic, but potentially conservative in Australian conditions'* (RCPRCMT, 2011-2012, pp. 153-154 - Dr Elder, July 2011).

'I should perhaps make clear ... that Gordon Ward was the person who always made it abundantly clear that Solid Energy's view on the status and the progress of Pike River wasn't of particular interest.' (RCPRCMT, 2011-2012, p. 49 - Dr Elder, July 2011).

Dr Elder said, *'I have the greatest admiration for Mr Dow' ...* and Dow was asked by Dr Elder to be Straterra's foundation chairman, *'because I very much respected his position in the industry'*. They were both on the Straterra Board together for around two-and-a-half years, just before the explosion. The question was asked of Dr Elder, if he had such concerns, why didn't he raise these directly with Dow. *"By the time Mr Dow and I were working together on Straterra, the entire industry was aware that Pike were having significant difficulties with production. It didn't need me to tell them that"* (RCPRCMT, 2011-2012, p. 76 - Dr Elder, July 2011).

4.2.4 The key uncertainties around Pike's methane risk

4.2.4.1 What is methane and why is it a problem?

Methane is a product of the same geological process that creates coal. It is a gas held within the microscopic pores of the coal, which serve as a highly efficient storage system. When mining or drilling exposes the coal to the atmosphere, the gas migrates out. As methane is lighter than air, it rises. One of the key hazards in underground mining is 'layering', being the tendency for gas to collect along the roof of the mine, forming a path for flames to propagate along. If methane collects in the air at concentrations of between five and fifteen percent, it will explode in the presence of even a tiny source of ignition – the friction of metal picks on rock or the spark from a machine (Macfie, 2013; RCPRCMT, 2012).

Methane explosions are a major risk for coal mines. Within the Grey District are the memorials of the different mining catastrophes: 65 dead in the Brunner explosion in 1896; nine dead in the Dobson mine in 1926; five dead at an explosion at Kaye's mine in 1940; 19 dead at Strongman in 1967; four dead in the Boatman's mine in 1985; three dead at Mt Davy in 1998; two dead at Roa and Black Reef mines in 2006. Figure 4.7 shows a map of the Grey District and the sites of these mines and their relative closeness to the Pike River mine (Macfie, 2013; RCPRCMT, 2012).

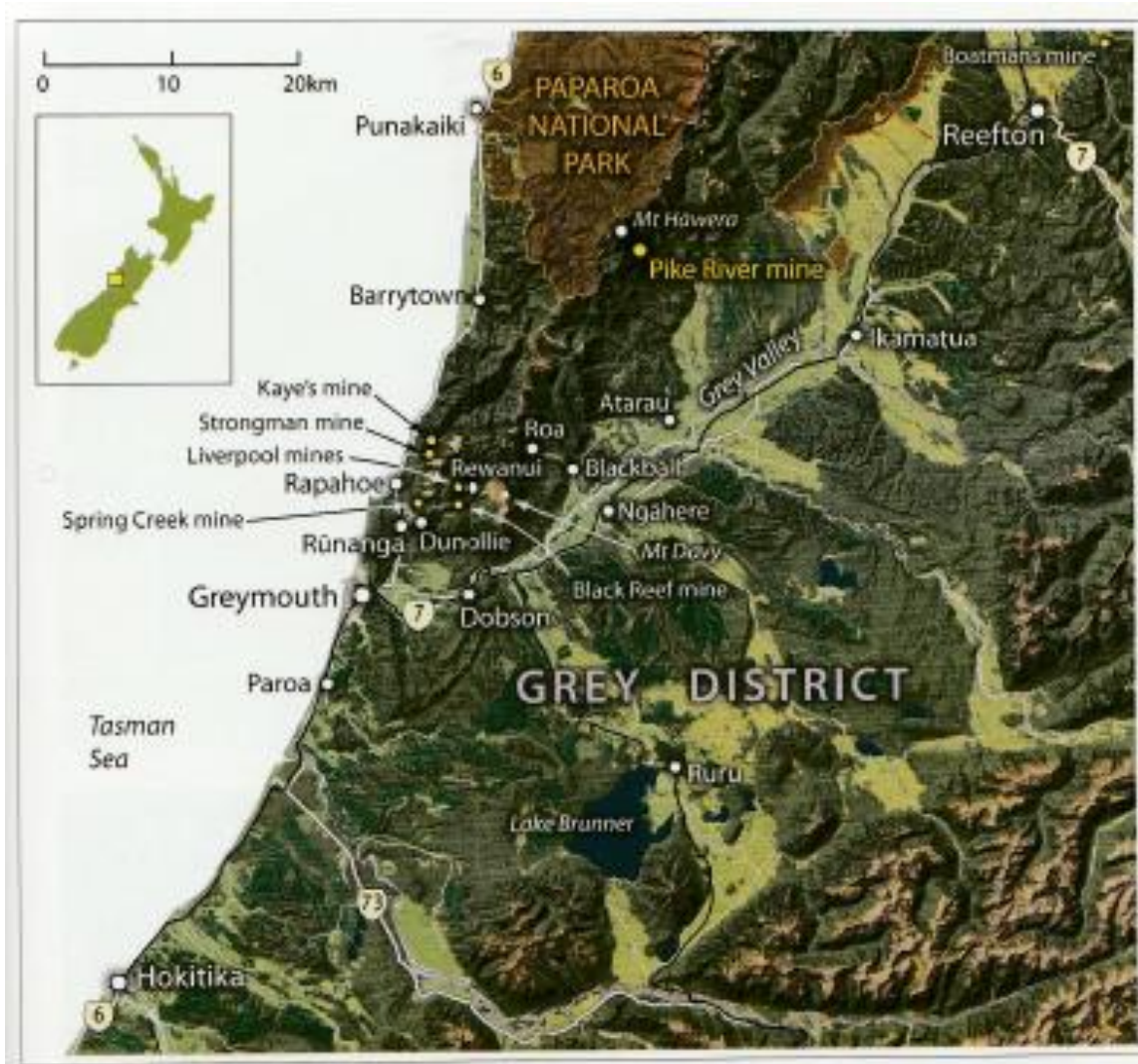


Figure 4.7: Map of Grey District, showing the main towns and mine sites

Source: (Macfie, 2013)/Geographx)

4.2.4.2 What the Royal Commission suggested as the probable cause of the explosion

Based on expert evidence, since the mine site could not be physically examined, the Royal Commission suggested that one of the possible scenarios for the explosion was an enormous volume of methane had exploded, perhaps 2,000 cubic metres. The area most likely to contain this amount of gas was the goaf (being a void created by coal extraction) formed during mining of the **hydro panel**. The area was also intersected by an **in-seam borehole**, and this would have added to the volume of methane bleeding from the seam. The Royal Commission concluded that the most

likely scenario was a roof collapse in the goaf that had **suddenly expelled** a huge amount of methane into the mine roadway and knocked over a nearby temporary ventilation stopping, with the gas becoming diluted to within the explosive range of five to 15 percent. Given that a pump had been switched on at about the same time as the explosion, the ignition may have been a single electrical spark (Macfie, 2013; RCPRCMT, 2012).

This explanation directly or indirectly covers all the main causes for increasing the levels of methane above natural seepage and conventional mining. These causes were due to mining through hydro-mining, in-seam drilling and cave-in/outbursts, and each cause can by itself increase methane levels exponentially.

4.2.4.3 Ex-ante – Pike’s reference narrative and experience

Table 4.7: Understanding the causes for increased levels of methane

Episodes	Getting to the coal, after Pike goes public 1 July 2007 to 30 Sept. 2008	Overpromising, underdelivering and understating the problems 1 Oct. 2008 to 30 June 2010	The desperate need for production 1 July 2010 to 19 Nov. 2010
What Pike management publicly stated	<p>2007 prospectus - Pike has ‘only low to moderate’ levels of methane’</p> <p>June 2007 & June 2008 - Pike has considerably lower methane gas levels than is commonly found in other underground mines.</p>	<p>June 2009 - Pike has considerably lower methane gas levels than is commonly found in other underground mines.</p>	Nothing mentioned
In seam drilling	-	<p>December 2008 - In-seam drilling programme starts</p> <p>June 2009 - Programme starts again after</p>	Late 2010 and early 2011 - Intention to dramatically ramp up the programme

Episodes	Getting to the coal, after Pike goes public 1 July 2007 to 30 Sept. 2008	Overpromising, underdelivering and understating the problems 1 Oct. 2008 to 30 June 2010	The desperate need for production 1 July 2010 to 19 Nov. 2010
		ventilation was restored	
Hydro-mining	-	-	<p>19 September 2010 - Start of hydro-mining.</p> <p>A pattern developed where shortly after the hydro-mining starts, the machinery would automatically turn off as methane levels hit the machine threshold.</p> <p>Late Oct/+ November 2010 - Start of 24-hour, 7-day-a-week hydro-mining</p> <p>Late 2010 and early 2011 - Intention to dramatically ramp up the programme</p>
Actual ignitions, outbursts, cave-ins	-	<p>17th October 2008 - Date of first coal</p> <p>November 2008 - Ten ignitions in the rock in the tunnel (Macfie, 2013)</p>	<p>200 incident/accident reports waiting follow up (Macfie, 2013)</p> <p>October 2010 - Roof collapse in goaf – no investigation (Macfie, 2013)</p> <p>Ex-post analysis showed that in the last 48 days before the explosion, 21 days had explosive methane levels and 27 days had lower but dangerous levels (Macfie, 2013)</p> <p>19th November 2010 - Mine explosion</p>

In its 2007 prospectus, Pike had publicly minimised the risks presented by gas, claiming the Brunner coal seam contained only 'low to moderate' levels of methane. Pike's public documents throughout 2007, 2008 and 2009 also downplayed the risk. For example, Pike told shareholders that *'the Brunner coal seam contains considerably lower methane gas levels than usually found in an underground mine. This is due to the seam being exposed to the atmosphere for millions of years along the entire western escarpment resulting in natural methane gas leakage into the atmosphere'* (Pike, 2007a, 2007c, 2008c, 2009a).

The first ignitions for Pike occurred when the tunnel was being constructed. In early November 2008 there were 10 ignitions in a few days. This included a rolling ball of flame that rushed across the tunnel roof. The ignitions were caused by a roadheader, one of Pike's brand-new mining machines. The machine's steel picks were sparking against the hard, abrasive sandstone layer and igniting methane that had seeped from the rock. It was reported to both management and to the DOL Mine inspectorate (Macfie, 2013).

Despite early plans to pre-drain methane from the surface (i.e., vertical drilling), as recommended by good practice, this did not happen. The in-seam (i.e., horizontal) drilling programme (a method for finding where the coal is) started in December 2008, and this had the complication that its long drill holes of hundreds of metres forward from the coal face will release large volumes of pressurised methane gas into the mine from the coal seam (Macfie, 2013).

Hydro-mining is a specialised mining system that carved coal from the face with a laser-like jet of water. Where other methods of mining would tend to leave large volumes of valuable coal behind in the geologically disturbed seams of the mountainous terrain, the hydro method could flush out virtually the full height of a coal seam. It was thought that this method would be particularly suited to Pike's thick and steeply dipping seam and Pike had very high hopes for this technique which they projected would extract 80% of the coal (Macfie, 2013).

On 19 September 2010 hydro-mining started briefly. In the days that followed the hydro-mining monitor was started but almost immediately the methane content of the

atmosphere shot up to five percent (explosive range) and kicked out power to the system. The only way they could keep working was to dial back the water pressure and cut less coal. Hydro-mining was then put on hold until the new main ventilation fan was installed (Macfie, 2013; RCPRCMT, 2012).

Despite these problems, in October 2010 Pike's management were upbeat with hydro-mining. They publicly reported, '*This past quarter has seen the achievement of a significant milestone for Pike River: the successful start to our hydro-mining operations. Commissioning started on 20 September 2010 with no significant system or component failures.*' (Pike, 2010a).

Pike's policy was to avoid surface subsidence under its agreement with DOC, so they did not plan to induce cave-ins; they expected the roof to remain intact. On 30 October 2010 a section of the roof in the hydro-mining area collapsed unexpectedly and methane levels rose into the explosive range. It was a major event, but there was no internal investigation. At the time there were 200 unresolved incident or accident reports on Pike's books (Macfie, 2013).

4.2.4.4 Ex-post comments, actor-critics challenge Pike's reference narrative

The Royal Commission noted that using information from the mine deputies' reports, from the start of October until 19 November 2010 miners reported, 21 instances in those 48 days where methane rose to explosive levels, and 27 instances of lower, but still potentially dangerous, volumes of gas (RCPRCMT, 2012).

4.2.4.4.1 Dr Murry Cave (Consultant geologist who had acted for DOC 2000-2004, in reviewing the Pike proposal for mining)

In 2007 Dr Cave read Pike's IPO and was surprised at the casual reference in the document to the methane risk. After 48 pages of glowing testimony about expected coal production levels and lucrative export returns, the document stated that the Brunner seam had 'low to moderate' gas content, although high enough in some isolated areas to warrant pre-drainage. Dr Cave was not impressed and thought the

promoters were encouraging a false sense of security about the gas risk, since the 'pit bottom in coal' would be highly gassy, with an associated risk of explosive and potentially fatal outbursts. When approached for advice by prospective investors, he made his concerns known and this was picked up by the media. The public response from Whittall was swift and angry. Whittall accused Dr Cave of 'inaccurate, inappropriate and ill-formed' comments and said that the independent experts who were advising the company were far better acquainted with the risks and benefits of the project than Dr Cave. Ex-post, Dow's comment on Dr Cave's expert evidence, was, 'He's expressed an opinion. It's easy to express an opinion.' (Macfie, 2013).

4.2.4.4.2 Harry Bell (New Zealand consultant and former Chief Inspector of Mines)

In August 2009, Bell was the course examiner for the mining course at Greymouth's Tai Poutini Polytechnic, that new members (including foreign miners) of Pike had to attend. Bell started to become deeply disturbed by what the miners were telling him in one-to-one conversations and in their coursework. They detailed unsafe practices at the mine, issues around gas management and the fact that reported hazards were not being followed up. Some of these things were illegal. Bell marked the papers, and then picked up the phone to call Whittall. To Bell, these matters were too serious to ignore. He felt compelled to reassure himself that the mine's senior manager was aware of the issues. Bell said, "*I can listen to tittle tattle, but when it's down in writing I have to do something about it.*" Whittall replied, "*Sometimes your officials let you down.*" He thanked Bell and said he would deal with the matters. Since Bell had received the information in his privileged role, he did not want his role or those involved revealed. Whittall agreed to keep the conversation confidential. Soon after Bell heard from his nephew who worked at Pike, that the promise of confidentiality had been broken and Bell had been revealed as the source of the information. For Bell, the most important thing was that the mine boss knew what was going on (Macfie, 2013, pp. 109-112, Interview; RCPRCMT, 2011-2012).

"I could see they were going to have a problem, but no-one would listen." Bell's testimony on Pike's inadequate ventilation, repeated gas ignitions and flawed mine design (RCPRCMT, 2011-2012, pp. 338-341 - Bell, July 2011).

4.2.4.4.3 Masaoki (Oki) Nishioka (Japanese consultant and expert on hydro-mining)

Whittall invited Nishioka to come to Pike to commission the hydro-mining in July 2010. Nishioka knew the West Coast well and was involved in the early drilling at Pike in the 1990's.

Once he arrived, he found that the choice of location for hydro-mining had been decided, as well as the machinery. He found that the machinery wasn't what he had specified and worse, it didn't work effectively. He was also unhappy about the location for hydro-mining. It was too close to pit bottom in coal, and too close to the Hawera Fault, an area high in methane gas. Once the area had been mined out, methane would still be emitted and the goaf would become a huge pocket of gas close to the nerve centre of the mine. For Nishioka, this was not sound or conservative mine planning (Macfie, 2013; RCPRCMT, 2012).

Nishioka also feared that Pike did not have a sound appreciation of the particular risks associated with hydro-mining, and how those risks differed from other forms of mechanical mining. Mechanical mining has knowable production rates. Assuming the methane content per tonne of coal has been properly assessed, the amount of gas that will be released into the mine atmosphere can be calculated, and the amount of ventilation required to keep gas to a safe level can therefore be worked out. But hydro-mining can cut through very large volumes of coal quickly, resulting in big surges of methane that need to be flushed away by the ventilation circuit and diluted to a safe concentration as they are carried out of the mine (Macfie, 2013; RCPRCMT, 2011-2012).

Nishioka left three months later, when his contract expired, fearing the mine could explode at any time. The polite and deferential Nishioka told White that he would not send men underground without adequate ventilation and a second means of exit, and he spoke 'strongly' to Whittall of his concerns about ventilation and the design failings of the hydro system. These concerns were unheard by either White or Whittall, who both denied that he had raised them with them. The exchange was

possibly lost in cross culture misunderstanding (Macfie, 2013; RCPRCMT, 2011-2012).

When cross-examined Nishioka said, *"I didn't feel confident at all, you know, I really wanted to get out, you know, that operation."*

Examining lawyer: "Did you have any concerns about what might happen?"

Nishioka: *"Well, the worst case, that is everybody knew, the worst thing could happen, could happen in that operation. That's why, you know, I told – I gave, you know, strong words to Peter Whittall when I met him last time in my office. Well, he stepped in my office and he asked me, you know, how the things are going and I told him, you know, strongly, you know – 'Everything wrong. Everything wrong. This mine wouldn't go.' And he asked me why and I said, you know – 'Lots of methane coming out and ventilation system is not running properly.'" (RCPRCMT, 2011-2012, p. 3361 - Oki, November 2011).*

Nishioka told the Royal Commission that Pike had the gassiest coal he'd seen in 40 or 45 years of mining throughout the world (RCPRCMT, 2011-2012).

Nishioka left before the main fan was commissioned, and before the hydro monitor was pressed into constant service 24 hours a day, seven days week. A decision was also made to widen the panel being mined by 50 percent, instead of spanning 30 metres, the roof of the goaf would now have to span 45 metres. These actions added considerably to the existing high risks. Nishioka had mixed feelings about being safely far away, while his mining friends were working in such a situation (Macfie, 2013).

In an email to a colleague in October 2010, Nishioka wrote, *'It is much worse than I thought. I am now happy heading back to Tokyo tomorrow. I would think we should stay away from this project as it would not fly I am afraid.'* (Macfie, 2013, p. 146)

Nishioka believed that the only way for Pike to be successful in hydro-mining was to start again, by getting the right equipment and getting people who were experienced in using it. Nishioka kept his own professional diary which included the daily gas readings at the hydro-mining face, which showed high gas readings. This diary and

his critical comments and observations were discussed in depth at the ex-post hearings.

In a reply email to his friend Matt Coll (Pike engineer) on Tuesday 23 November which told Nishioka that he was safe, Nishioka replied, *'It is very sad what had happened but it was expected as you know and we have been afraid of.'* (Macfie, 2013, p. 3366, November 2011; RCPRCMT, 2011-2012).

4.2.4.4.4 Dr Elder (CEO – Solid Energy)

The major risk for hydraulic mining is very big, sudden unexpected surges of gas. ***'You need to always assume there are things you don't know and there are places that could be gas build-ups that you're not monitoring. You need to try and anticipate those and the process ... risk assessment is critical for that. Risk assessment is the tool for saying, not what do we know, but where is there a risk there might be a gas issue.'*** (RCPRCMT, 2011-2012, p. 127 - Dr Elder, 2011).

4.2.5 The key uncertainties around Pike's financial position

4.2.5.1 Ex-ante, Pike's reference narrative

Pike's financial position - What Pike promised and what Pike delivered

The following Table has been prepared from public documents filed by Pike and it shows:

- the escalation in mine development costs and the perennial requests for money from investors: and
- the unexpected problems encountered.

Table 4.8: Drift chart of finance estimates (costs/funding) - what Pike promised and what Pike actually delivered

Episodes (Data collected as close as possible to episode end points)	Getting to the coal, after Pike goes public		Overpromising, underdelivering and understating the problems	The desperate need for production
	Starting point 1 July 2007	1 July 2007 to 30 Sept. 2008	1 Oct. 2008 to 30 June 2010	1 July 2010 to 19 Nov. 2010
Costs of mine development \$m	As at 31 July 2007, \$81m spent of the \$174m mine development budget. ²	The total mine development budget is \$240 million. ⁴	The total investment in mine assets is valued at 30 June 2010 at \$288.1m after additions of \$25.2m and minus \$11.2m depreciation. ⁹	The receivers later reported the mine had a book value of \$340m. (Macfie, 2013)
Fundraising from shareholders \$m	\$85m (includes \$20m of over subscriptions) raised in the IPO that closed in July 2007. \$71m original shareholders.	\$97.4m funding package in March 2008 comprising of \$60m from existing shareholders. ³	\$45m capital raised from shareholders in March 2009. ⁶ \$50m equity issue announced in February 2010. Completed in April 2010. ⁸	At the time of the mine explosion, Pike was seeking to raise another \$70m from shareholders. (Macfie, 2013)
Fundraising from borrowings \$m	Needed to complete a \$65m debt facility by the	\$97.4m funding package in March 2008 comprising of a convertible	\$40m of convertible bonds held by Liberty Harbor refinanced from	Since loan default, cornerstone shareholder

	end of January 2008. ²	bond issue of \$37.4m from Liberty Harbor LLC (part of Goldman Sachs Asset Management). ³	cornerstone shareholder NZO&G in April 2010. ⁹	NZO&G is Pike's effective banker.
Reasons for the delays		Rock conditions in the tunnel worse than expected. ⁵	The unexpected collapse of the lower part of the ventilation shaft and unexpectedly finding a large rock graben, rather than coal. ⁹	Machinery problems ⁹

Sources:

¹– (Pike, 2007a), ²– (Pike, 2007b), ³– (Pike, 2008b), ⁴– (Pike, 2008c), ⁵– (Pike, 2008a), ⁶– (Pike, 2008d), ⁷– (Pike, 2009a), ⁸– (Pike, 2009b), ⁹– (Pike, 2010b), ¹⁰– (Pike, 2010a)

Total mine development costs rose from an estimated \$174m in 2007 to well over a reducing total of \$288m in mid-2010, three years later. A difference of at least \$114m and a 65% increase. At the time of the explosion, the mine had a book value of \$340m (Macfie, 2013).

After the initial IPO in July 2007 of \$85m, public shareholders were asked for a further \$155m in three more instalments (of \$60m in 2008, \$45m in 2009, and \$50m in 2010). At the time of the mine explosion in November 2010, there was a further request for equity funds of \$70m.

In September 2010, Pike breached terms of debt with both the Bank of New Zealand and NZO&G, but both lenders agreed to waive the breach as it was in their financial interests to do so (Macfie, 2013).

4.2.5.2 Ex-post, actor-critics challenge Pike's reference narrative

The previous subsection outlines Pike's reference narrative around its ex-ante financial position from Pike's public documents. This section provides ex-post comments from two actor-critics, being David Salisbury (Managing director of NZO&G, being Pike's largest shareholder) and from Dr Elder (CEO of Solid Energy, being the largest coal miner in NZ/West coast).

4.2.5.2.1 David Salisbury (Managing director of NZO&G)

In April 2010 NZO&G (Pike's parent company) was forced to take over Pike's \$40m loan from Liberty Harbor as well as effectively becoming Pike's banker for paying its bills. In the discussions leading up to that point, Salisbury and his fellow executives arrived at the conclusion that the Pike mine was being hopelessly mismanaged. NZO&G called in consultants to help figure out exactly what was wrong (Macfie, 2013).

Behre Dolbear Australia (BDA) were selected and in May 2010 produced a two-part report documenting the flaws and failings at Pike. This included comment on the poor equipment, poor morale, high turnover of management, deep flaws in the processing plant, and doubts about achieving the promised one percent ash content. It reported that the geological complexity of the coal deposit was still largely undefined and, as a consequence, the mine plan remained in a state of flux. They considered the project was still freighted with significant risk. The report also suggested that since, '*Current senior management has not been able to deliver the Pike River Coal project on schedule or budget ... and in BDA's opinion this level of performance may be expected to continue unless there is a change in senior management direction.*' '*That Pike could consider hiring an underground contractor to take over running the mine.*' These were all high-level governance questions (RCPRCMT, 2011-2012, pp. 4048-4050 - Dow, December 2011).

This report only went to NZO&G, who now had this source of inside information rather than having to rely on Pike's public documents with their optimistic targets. The report confirmed their worst fears. The information in the report was now used

by NZO&G to put heat on the Pike Board for improved performance and for Dow (Chair) to take on a more hands-on approach. From mid-June 2010, NZO&G executives met weekly with Ward and Whittall and heard details of operational progress, including the number of metres that had been advanced through the coal seam. In August 2010 Salisbury and NZO&G chairman Radford told Dow NZO&G had lost confidence in Ward, the Pike CEO (Ewen, 2014; Macfie, 2013; RCPRCMT, 2011-2012).

When the Pike board dismissed Ward as CEO in September 2010, this was met with approval by NZO&G., but four days later Salisbury was caught off guard by the news that Whittall would take his place. Salisbury was astonished, as he considered Whittall and Ward equally responsible for Pike's chaotic history of mistakes and failures. Ex-post, both Dow and Whittall denied hearing Salisbury say they had lost confidence in Whittall (Macfie, 2013; RCPRCMT, 2011-2012).

4.2.5.2.2 Dr Elder (CEO – Solid Energy)

Dr Elder noted a defining difference in risk profiles depending on whether a loss-making mine was part of a wider group or not. For example, the financial losses of Solid Energy's Spring Creek mine were covered by Solid Energy's other mines whereas Pike only had one mine and that was its sole source of income. This makes it especially financially vulnerable (RCPRCMT, 2011-2012 - Dr Elder).

'Our view formed in 2002 was that Pike River was a very risky commercial development that had a high chance of eventual failure and that Pike River would therefore be a high-risk business partner. This view remained and increased through meetings and briefings with Pike River's management, discussions with our own staff and from our observations of public information released by Pike River from time to time. We therefore avoided any early commitments to working with them on transport or other proposed co-operative ventures. This did not concern Pike, who stated that they didn't need Solid Energy support for any of their activities' (RCPRCMT, 2011-2012, p. 23 - Dr Elder, July 2011).

'I think it was early 2010, it may have been late 2009 a fairly significant event occurred which was quite a major surprise to me and to our management team. The former Pike River CEO approached Solid Energy and proposed that we work together on new mine developments and I recall, because it was quite surprising, almost verbatim the words that were used to me at the time. It was something like this, "We're essentially now through the development phase and from here on it's pretty straight forward and easy. We're looking for new opportunities to use the expertise we now have." I discussed that with my management team and they unanimously shared my view that that statement was unfortunately pretty naïve and didn't have any credibility and we never even considered taking up that proposal.' (RCPRCMT, 2011-2012, p. 33 - Dr Elder, July 2011).

4.2.5.3 The subsequent crash in world coal prices

In July 2011 Dr Elder said, *'Even at very high current international coal prices we believe the economics of mining the Pike River coalfield are marginal'* (RCPRCMT, 2011-2012, p. 24 - Dr Elder, July 2011). Just how marginal was revealed in mid-2012, when the international price of coal fell by 30% (i.e., US\$315/t to US\$225/t). The demand from China had cooled. This drop in the value of coal had a negative impact on Solid Energy and ultimately put them into receivership. Pike as a one-mine operation was lucky to go public in the boom times but was every bit as financially vulnerable as Solid Energy when the coal price boom fell back to historical levels. There was an industry pull-back from underground mining in New Zealand towards lower-cost, open-cast operations, and most underground mines were then closed.

4.2.6 The key uncertainties around Pike's human resources

At the time of the explosion the Pike operations had 180 people employed, of which 114 were staff and 66 were contractors (Macfie, 2013).

4.2.6.1 Ex-ante, Pike's reference narrative

Pike's management churn

Table 4.9 relates to the churn of the four senior and critical decision-making managers below Whittall. For example, the position of statutory mine manager was filled by seven people in just over two years, the technical manager was filled by four people, the production manager was filled with three people plus a long period with no one in place, and the engineering manager position had three people. These senior technical managers came from many countries and often left within months. This senior management team was in constant flux and it never became a tight collaborative team of technical leaders able to drive the project forward (Macfie, 2013).

Table 4.9: Drift time chart – Pike's management churn - 1 July 2007 to 19 November 2010 (3 years and five months)

Episode	Getting to the coal, after Pike goes public	Over-promising, underdelivering and understating the problems	The desperate need for production
Position	1 July 2007 to 30 Sept. 2008	1 Oct. 2008 to 30 June 2010	1 July 2010 to 19 Nov. 2010
Statutory Mine Manager	No position as mine still to open	Kobus Louw <i>(Oct. 2008 – Feb. 2009)</i> Mick Bevan <i>(2009)</i> Nigel Slonker <i>(April 2009 – Sept. 2009)</i> Peter Whittall (Acting) <i>(Sept. 2009 – Dec. 2009)</i> Mick Lerch <i>(Jan.2010 – June 2010)</i>	Doug White <i>(June 2010+)</i> Steve Ellis <i>(Informally acting pre-Nov. 2010)</i>

Episode	Getting to the coal, after Pike goes public	Over-promising, underdelivering and understating the problems	The desperate need for production
Position	1 July 2007 to 30 Sept. 2008	1 Oct. 2008 to 30 June 2010	1 July 2010 to 19 Nov. 2010
Technical Manager	Guy Boaz <i>(Less than a year pre-2007)</i> Udo Renk <i>(Jan. 2007 – May 2008)</i>	Kobus Louw <i>(Acting in)</i> Terence Moynihan <i>(2008/09)</i> Pieter van Rooyen <i>(Feb. 2009+)</i>	Pieter van Rooyen <i>(To early Nov. 2010)</i>
Production Manager	Kobus Louw <i>(May 2007 – Oct. 2008)</i>	Kobus Louw <i>(To Oct. 2008)</i> No-one <i>(Oct. 2008 to May 2010)</i>	Bernie Lambley <i>(Act.)</i> <i>(June 2010 – Sept. 2010)</i> Steve Ellis <i>(Oct. – Nov. 2010)</i>
Engineering Manager	Tony Goodwin <i>(2005 – March 2009)</i>	Tony Goodwin <i>(To March 2009)</i> Nick Gribble <i>(April 2009 – Aug. 2010)</i>	Nick Gribble <i>(To Aug. 2010)</i> Robb Ridl <i>(Aug 2010+)</i>

Source: Adapted from Macfie (2013)

Pike's senior management churn was not of concern to Dow (Board Chair), as he assumed that this rapid churn was a result of the Australian mining boom and the tough competition for skilled mining personnel (Macfie, 2013; RCPRCMT, 2011-2012). While at the macro level that would have been true, at the individual level the actual reasons were quite different, as outlined below, where Macfie interviewed various managers and senior consultants to understand why they left. All the examples found have the same trend - all are critical of Whittall. No examples of positive comments, apart from Dow's, were found in any of the various sources available.

4.2.6.2 Ex-post, actor-critics challenge Pike's reference narrative

The previous subsection outlines Pike's reference narrative around its ex-ante management churn from Pike's public documents. This section provides ex-post comments from different actor-critics, including many of the senior managers mentioned in the previous subsection, who put their views into the public domain.

Ex-post explanations of why senior managers left

4.2.6.2.1 Denise Weir (Human resources manager 2007)

Weir was an Australian who admired Whittall's sharp mind and enormous capacity for hard work, said, "*Peter worked every hour that God sent. He had very strict ideas of what he wanted and sometimes people disagreed. He is not an easy person, and sometimes he would flare up. He was fairly dictatorial, but I was always able to go to his office and speak to him, he is a man whose style you either liked or you didn't, but he was the boss. He probably was arrogant, but he had the weight of responsibility on his shoulders, and he was trying to pull together people from the four corners of the earth*". (Macfie, 2013, pp. 93-94, Interview).

4.2.6.2.2 Guy Boaz (Technical Services Manager 2007)

Boaz was a New Zealand mining engineer who did not agree with the idea of putting fans underground and he thought that the decision to do so was taken without full consideration of the risks involved. He described the concept as 'ground breaking', because he had not '*heard of it ever occurring in any underground coal mine in the world*', he raised his concerns with Whittall. However, ex-post, Whittall had 'absolutely no recollection' of this conversation (RCPRCMT, 2012, p. 86, Volume 2). Boaz resigned.

4.2.6.2.3 Udo Renk (Technical Services Manager 2007-2008)

Renk was German and unhappy with the lack of geological exploration that had been done and was concerned about the ventilation design. Renk had been in conflict with Whittall, whom he considered a ‘control freak’ who often ignored advice and insisted on making every decision (Macfie, 2013).

Renk was involved in a professionally facilitated risk assessment process in February 2007 into the placement of the main fans underground. The fourth version of the assessment report was distributed to managers in early July 2007 for completion. Renk tried several times with Rockhouse to finalise it, but said Whittall disagreed *‘with some of the risk ratings and wording of the report and we were not able to finalise it’*. Ex-post, Whittall did not recall any such approaches. He said he was not on the risk assessment team and it could finalise the assessment without reference to him (RCPRCMT, 2012, p. 86, Volume 2).

Renk e-mailed Whittall in October 2007 to say he ‘strongly believed’ a forcing fan at the portal was preferable to an underground fan. Renk said he was told it was too late as the decision had already been made. Ex-post, Whittall could not recall saying this, but said that in any event a forcing fan was ruled out as impracticable at Pike River (RCPRCMT, 2012). Renk resigned in 2008.

4.2.6.2.4 Kobus Louw (Production Manager/Statutory Mine Manager 2007-2009)

Louw was South African and unhappy with several of the key decisions made. He was not happy with the decision to place the mine’s main ventilation fan underground. He thought it crazy that a greenfield project like Pike should buy expensive prototype machinery from an Australian company that had never made these machines before. This view clashed with the Engineering manager, Tony Goodwin who, with Whittall had ordered them. Louw was surprised that Pike was reliant on a single-entry tunnel and he thought there should be two parallel drifts to ensure an adequate ventilation circuit, as well as provide a secondary means of exit from the mine. Louw’s idea was dismissed without debate. The final straw for Louw was the ventilation shaft and his concern about the stability of the shaft’s top 35

metres. He wrote a paper to the Pike Board outlining his concerns, which the board agreed with. However, in his absence while on holiday, Whittall convened a meeting of experts and when Louw returned to work, he found a handwritten instruction from Whittall explaining they were using a larger bore (which increased the risk of collapse). He went to Whittall and told him the decision would force him to look for another job as he disagreed with the company's business risk appetite. Louw predicted that if the raise bore failed, then it would take six months to re-establish ventilation underground, and that turned out to be what happened. The larger bore was used and the shaft wall failed and this was a major setback for the project. Deeply stressed and feeling that his professional input had been ignored, he resigned (Macfie, 2013).

4.2.6.2.5 Nigel Slonker (Statutory Mine Manager 2009)

Slonker was South African and quickly became aware that Pike's promises to the sharemarket bore little resemblance to reality. There were numerous problems and technical setbacks. By July 2009 he had completely lost confidence in the project and told Whittall so. Slonker told Whittall that full production was at least two years away and that the current expensive mining machines were a waste of time. He further told Whittall he should order machines that worked, but they would take a year to be delivered. Slonker said *'that the look on Whittall's face was very strange. I didn't know if he was going to hit me or cry. Then he said that he didn't agree with me, as these machines will do the job, as the machines had been specified for the job'*. That was it for Slonker, who then resigned (Macfie, 2013, pp. 102, 106, Interview).

4.2.6.2.6 Doug White (Operations Manager/General Manager 2010, effectively 2-I-C)

White was a Scottish miner, who had then worked at senior levels in the mining industry in Australia. To many staff, White *'was the only manager who made the effort to improve morale, which was abysmal, to change attitudes ... and he went out of his way to improve as he should've done, defective health and safety deficiencies'* (RCPRCMT, 2011-2012, p. 5613 - White, April 2012).

Quite quickly after joining Pike in January 2010, White believed that Pike needed a tube-bundle system, being a comprehensive online, real-time gas sampling system, used widely in Australian mines. He raised this with Whittall who said he would put it in the budget, but he didn't and their discussions continued and the issue didn't progress. Once White realised there were going to be significant delays, in June 2010 he started writing to SIMTARS in Queensland about a leasing programme and there is correspondence back and forth. There were costings given and then he received the letter from SIMTARS saying it's been quashed by senior management or someone above White. Whittall had blocked that move, as a decision about the tube bundle was 'some way off', with January 2011 being a possible purchase date for the system. To buy the tube bundle system costs approximately one million dollars, which Pike didn't have, hence White's subsequent response in trying to obtain a lease, with a buyout provision. He was not happy about the delay at any point, especially as the leased option would have meant it could be installed almost immediately. Ex-post, White regretted the fact that Pike did not have this system to monitor gas levels throughout the mine, before and after the explosion (RCPRCMT, 2011-2012 - White).

White was also very keen to advance a second egress/entrance to improve the supply of fresh air. This had been planned, but not started and was scheduled to be completed, by round about May to September of 2011, along with a further exit for the second fan (RCPRCMT, 2011-2012 - White).

White told the Royal Commission of Inquiry that Whittall could be '*overbearing, quite dictatorial*', but he also said of Whittall, '*To talk to the bloke one on one he was the nicest bloke to meet in the world*' (RCPRCMT, 2011-2012, pp. 5062, 5126 - White, February 2012).

White believed that when Whittall was the mine boss, his management meetings were always looking back at what hadn't been achieved and Whittall told managers in no uncertain terms that wasn't satisfactory. '*There was a definite air about the management meetings when Mr Whittall was present ... There was not a great deal of love lost between the team of managers and Peter Whittall who called him a megalomaniac and dictatorial ... Whittall dominated the meetings and what he*

wanted or said went.' This approach annoyed many staff. *'There was a blame culture when I arrived at Pike River Coal. I tried to, as far as practicable, get rid of that culture, but it certainly existed. It was always someone's fault. Rather than looking to find a remedy it was easier to blame people'* (RCPRCMT, 2011-2012, pp. 5056, 5062 - White, February 2012).

When White started to run the management team, he changed how meetings were run and conducted. He set meeting etiquette rules and changed the meetings to a forward future-looking style, where the focus shifted to what was actually happening. Everyone needed a three-month work plan, then they could focus on the plan that they had and measure themselves against that plan instead of looking backwards. This improved morale (RCPRCMT, 2011-2012 - White).

In November 2010, at the time Pike was raising \$70m in share capital, Whittall (and ex-post Dow) accused White of causing a seven percent drop in Pike's share value, after White had made some honest but (what Whittall considered) commercially unsophisticated comments to questions from some share brokers after a tour of the Pike mine. *'I couldn't argue (with Whittall) because at the time I didn't have any evidence to hand. He asked me what I'd said to the stockbrokers. I indicated that I'd said nothing that would've been commercially sensitive, that when they asked a question they were given the honest answer as far as what was happening at the mine, the state of development in the mine, the state of production in hydro and so on, they asked a whole number of questions which they were given honest answers to. He asked what I'd said to them that might've caused this and I said to Peter at the time I said, "The only thing that I have said was that given the question, 'What were we doing about things and how we were going to remedy this,' I'd gone through the fact that we were trying different remedies but also that it was the first time in 30-odd years that I'd been stumped for an answer." That was then put back to me as being enough for a bunch of stockbrokers to then set the market into a spin, as such. I then went home and checked the share tables. The shares had dropped 3 cents the day before the stockbrokers came. It dropped 1 cent the day they were there and 3 cents the day after. So, the shares were well and truly on the slide long before I even said anything.'* White resented the entire accusation of being 'unsophisticated' in his

comments, causing the share price to fall and for Dow to repeat Whittall's opinion ex-post, as if true (RCPRCMT, 2011-2012, pp. 4844-4850 - White, February 2012).

After ten months at Pike many issues had miffed White, including the recent accusation of causing the share price drop and being given a 2½% annual bonus, while others who he thought had done a lot less were given up to 10% bonus. He had lost trust in Whittall. On 14 November 2010 White emailed an Australian coal recruitment executive that he wanted out of Pike. This became public during the inquiry. In the subject line he wrote; *'They won't be making me the scapegoat'*. It then went on to say that in the previous two days he had seen the *'true colours of the senior leadership here and (I) don't like what I have seen.'* Two days later, he emailed a friend and included the following phrases. *'He tells lies too.'* He now referred to Whittall as a *'dodgy git'* and he found it very hard *'to work for someone who has made or overseen so many stuff ups and blames everyone else'* (Macfie, 2013, pp. 174, 5021-5022 - White, February 2012; RCPRCMT, 2011-2012).

White reflected ex-post on the change of CEO *'There was a lot of speculation around the workforce around about that time. The company was, let's say, struggling, and there was speculation and Peter had said himself he wasn't sure if he was going to keep his job. He said that on a number of occasions. There was speculation as to who was actually going to go and I think it's fair to say there's a number of managers were surprised in the turn of events'* (RCPRCMT, 2011-2012, p. 5129, February 2012).

4.2.6.2.7 Neville Rockhouse (Safety and Training Manager 2006-2011)

Rockhouse was Australian and had a very difficult and tense time with Whittall. Colleagues worried that Rockhouse might have a heart attack or breakdown because of the stress he was under. Whittall blocked Rockhouse's requests for more staff and resources to help develop the mine's health and safety systems. On one occasion Whittall humiliated Rockhouse in front of his peers while he was giving a presentation on hazard identification. Whittall had objected to a couple of typographical mistakes, and when Rockhouse couldn't see them Whittall rose to his feet and began yelling and slapping at the wall to indicate the location of the errors on the screen.

Rockhouse was so shocked he tried to resign – not for the first time – but, was dissuaded by his management colleagues. Rockhouse was persuaded by White to stay and to ‘toughen up and take concrete pills.’ Rockhouse’s assistant thought he should resign to save his health, as she thought he was at great risk of a heart attack or breakdown because of the stress he was under (Macfie, 2013 - Rockhouse; RCPRCMT, 2011-2012).

Rockhouse believed Whittall was a very intelligent man. *‘I didn’t agree with some of his leadership decisions, that’s all at a professional level’, and ... ‘it was Whittall’s way or the highway’* and that *‘Whittall was a micro-manager’*. Rockhouse described Whittall’s management style as; autocratic, hierarchical, an “us and them” mentality in the management team, wanting to control all aspects of the operation, having meetings that were negative, backward looking and inquisitorial in nature and there was a reactive approach to safety. In hindsight, he believes Whittall was intimidating. This culture only changed when White arrived and the management meetings started to be more forward-looking with a planning focus (RCPRCMT, 2011-2012, p. 5541 - Rockhouse and Dow, April 2012).

When Rockhouse was vocal in raising safety concerns, for example the absence of a second means of egress and the need for a refuge chamber, his concerns were not addressed (RCPRCMT, 2012).

Rockhouse was involved in the risk assessment of the emergency evacuation using the ventilation shaft (Alimak raise – refer Figure 4.8 and description in 4.4.1.2). Rockhouse had serious concerns over the practicality of using this as the mine’s second egress. To prove his point to Whittall, in late October or early November 2009 Rockhouse set up a test run in an attempt to prove at a practical level how difficult the ascent would be under perfect conditions. Whittall was invited, along with Couchman (training and safety co-ordinator), Gribble (engineering manager), and Coll (representing Mines Rescue Service). Whittall failed to show because he received unexpected priority work, but the other four continued (RCPRCMT, 2011-2012 - Rockhouse).

Couchman and Gribble were the first two of this group to climb the ladder. When they got back, they informed the others that they had decided not to go all the way to the surface of the mine. It was extremely physically demanding, just climbing up the ladder. Gribble said to them that after going the first 50 metres vertically that he was convinced this should not be declared as a second means of egress from the mine. Both men were so exhausted when they returned that no one else even wanted to go up the ladder. In Rockhouse's view this test proved beyond all doubt that these men were barely able to use the ladder and escape in what were perfect but very wet conditions. They acknowledged that if there was some type of disaster, it would have been impossible to take injured people up that ladder. Added to this was the fact that only eight people at a time could climb that ladder according to the manufacturer's safe working load. This would mean that the remainder had to wait in a highly dangerous bottleneck under the ladder while their self-rescue units were being depleted (RCPRCMT, 2011-2012 - Rockhouse).

Rockhouse later updated Whittall and explained what they had done, and expressed their belief that the shaft should not be classified as a second means of egress. Rockhouse wanted a refuge chamber (\$300,000) as the backup in the interim before a second egress could be built. Whittall declined that proposal as he believed the Alimak shaft would suffice as a second means of egress in the interim. It was at about this time that Rockhouse's personal relationship with Whittall began to deteriorate. Rockhouse was '*pretty much getting ready to resign until Doug (White) came and I saw in Doug a light at the end of the tunnel, if you like, given time*' (RCPRCMT, 2011-2012, p. 1384 - Rockhouse, September 2011).

In the subsequent risk assessment process involving many staff, Rockhouse said, '*it concluded that the Alimak raise was not suitable as a second means of egress from the mine in an irrespirable atmosphere. The report was sent out for comment but still required Mr Whittall's approval and sign-off and he failed to do that*' (RCPRCMT, 2011-2012, p. 1366 - Rockhouse, September 2011).

Rockhouse then raised the issue with White (who had just joined Pike) who told him that he would seek the opinion of the mine's inspector on his next visit. Rockhouse was confident with such strong management (peer level) support that the inspector

would endorse their conclusions and thought that this would finally put enough pressure on Whittall to consider an effective alternative and sign off the risk assessment. The DOL mines inspector visited. Rockhouse was not invited to go underground with them, but White told him that the DOL mines inspector checked the Alimak raise and they thought the Alimak raise was an adequate means of escape as a second means of egress from the mine. Rockhouse was shocked. He could not believe it, nor could Watts, head of the Mine Rescue Service (RCPRCMT, 2011-2012 - Rockhouse).

Ex-post, Whittall was dismissive of Rockhouse's comments and interprets it as, *'Oh, I thought I heard that two people did climb it and then chose not to climb up the rest of the main shaft, but I didn't hear that they tried to climb it and didn't ... I think their main intent of it was to climb the Alimak, so once they got to the bottom of the main shaft which had the staged ladderway in it, they didn't see the need to climb up another 50-odd metres just to say they'd climbed up the 50 metres'* (RCPRCMT, 2011-2012, p. 2732 - Whittall, September 2011).

In an interview on 22 July 2011, Whittall was interviewed by John Campbell on the TV programme *Campbell Live*. Whittall said that one of the three escape scenarios from the mine was to be by the use of the ventilation shaft and that was deemed satisfactory by the statutory mine manager, safety management on site, as well as the Mines Rescue Service and Department of Labour Mines Inspectors. Both Rockhouse ('safety management on site') and Watts (Mines Rescue Service) refuted that they ever supported this scenario; in fact quite the reverse. The DOL Mines Inspector actually agreed with the Rockhouse view, but reluctantly accepted it as a temporary measure as they had a weak regulatory hand due to a 'reasonable' steps clause. To not endorse it would have meant Pike could legally challenge DOL, with DOL having to prove the shaft was a danger and that Pike had not acted reasonably. Rockhouse was shocked watching the interview, especially as his opposition to using the shaft should be stated by Whittall as support. He never *'deemed it satisfactory'*, ever. The Mine Inspector also said he never said it was 'adequate' (RCPRCMT, 2011-2012 - Rockhouse).

Rockhouse wanted a proactive systems approach to health and safety, and as part of that he wanted a just culture. *'I'm not into the blame culture, never have been. I'm into the – where did the system let these guys down. You know 29 good men are dead, my son included, you know the system of work has failed here. I'm not going to blame individuals, sorry'* (RCPRCMT, 2011-2012 - Rockhouse).

4.2.6.2.8 Pieter van Rooyen (Technical services manager February 2009 until early November 2010)

When the South African van Rooyen, who was tasked with forward mine design, started at the mine he said there was no master mine plan, only an overall concept plan, which proved to be inadequate because there were constant changes needed. *'I found it difficult to develop an integrated plan for the mine due to the limited and emerging geological knowledge leading to constantly changing mine designs which were made in a piecemeal fashion. In addition, these changes had a down-stream effect and required necessary changes to other elements such as ventilation and gas drainage ... I consider that too much of my time and that of consultants was focused on crises management arising from constant design changes ... As new geological information was secured at the mine, design changes were required. In many ways I felt that my design was being affected on the run with little by way of co-ordinated overall planning ... It would have been beneficial to have had a documented overarching design plan that integrated mine design, ventilation, gas drainage, outburst management and gas monitoring to take advantage of potential synergies because all of these elements are complementary'* (RCPRCMT, 2011-2012, pp. 5181-5183 - Van Rooyen, February 2012).

Asked about Whittall's 'micro-management' style, Van Rooyen said, *'he did sometimes find it frustrating. He wanted to know everything ... Mr Whittall did on occasion make it clear his decisions were final ... When errors were made, Mr Whittall often blamed them on others.'* Van Rooyen agreed there was a blame culture at Pike River (RCPRCMT, 2011-2012, pp. 5283-5284 - Van Rooyen, February 2012).

Van Rooyen, who was a geologist was pushing for a ventilation officer or someone from his team who could be trained up to do that job. This request to Whittall was not approved. The reasons given included suggestions that having a ventilation officer is not required in New Zealand legislation; the mine was too small at that stage, and some of the functions were not within the technical services function (RCPRCMT, 2011-2012 - Van Rooyen).

‘The company focus, as conveyed to me by Gordon Ward and Peter Whittall, was on the need to produce coal as soon as possible. There was no way the company would delay coal production’ (RCPRCMT, 2011-2012, p. 5311 - Van Rooyen, February 2012).

Van Rooyen testified that workers had given him notice of inadequate methane drainage pipes, requesting that drilling cease until rectified. Despite passing that on in writing to senior operational managers, nothing was done. Van Rooyen said the decision to begin hydro-mining deep within the shaft without constructing a second exit – and in an area of high methane gas build-up – was strictly for ‘cash-flow purposes’ (RCPRCMT, 2011-2012 - Van Rooyen).

Van Rooyen said he did not suggest a second escapeway should be built before hydro-mining began because he *‘knew what the answer would be’*. But van Rooyen was aware that this was a lost strategic choice that could have been made, *“If at the beginning in July 2010, the focus had been on driving towards the surface egress point rather than on developing the hydro-panel, it may have been possible to reach the egress point in the quarter ending 31 December 2010”* (RCPRCMT, 2011-2012, p. 4524 - Van Rooyen, February 2012).

Van Rooyen left Pike on 3 November 2010, 16 days before the explosion. Van Rooyen said, *‘I was not afraid to go down in Pike River, not ever’* (RCPRCMT, 2011-2012, p. 5272 - Van Rooyen, February 2012).

4.2.6.2.9 Bernie Lambley (Acting Production Manager 2010)

Lambley described Pike as having a culture of blame, and the first reaction to a problem was to finger a culprit rather than search for solutions (Macfie, 2013). At the inquiry many witnesses said *'that Mr Whittall's management style was unpleasant and obstructive, and the management style of Mr Whittall seeped down through the company and infected it'* (RCPRCMT, 2011-2012, p. 5541 - Closing statements, April 2012).

Pike's lack of requisite variety meant there were no successful challenges to Pike's three key decision-makers

In summary, the management churn worked against any successful challenge to the dominant reference narrative of Pike's three key decision-makers. Without diversity of thinking, Pike was able to focus uncritically on exploitation of what they think they know. Little else will be explored and nothing new will be learned; existing knowledge will be used to drive through decisions (Dekker, 2011).

4.3 Ex-post assessment of Pike's key uncertainties using the 'forced scenario process' lens

This section is the second of two micro approaches used to separate Pike's ex-ante reference narrative from the ex-post actor-critics. Whilst section 4.2 uses a drift over time analysis (i.e., 2007 to 2010), this section is based on analysis at the time of the explosion in November 2010. Much of the final data from the previous section is therefore used in this section.

4.3.1 Defining Pike's key uncertainties and those who are risk seekers/averse

4.3.1.1 Description of approach

This sub section takes a different interpretive lens to understanding the complexity of Pike. It involves a three-step process as outlined in Maani and Cavana (2000), but modified to reflect this study's qualitative, rather than their quantitative focus.

The interpretative analysis is inherently an ex-post assessment based on the collective knowledge gained through the Royal Commission process. Ex-ante, without that process, there would be no comparative public data relevant to an examination of Pike's official public statements.

- **Step 1: Defining the key uncertainties**

Maani and Cavana (2000) classify the different uncertainties into a forced scenario process. With some modifications, this produces Tables 4.10, 4.11, 4.12 and 4.13. This is an efficient way of cutting through large amounts of data. Because some of this data duplicates what is in the earlier drift over time charts and sections, summarised facts are included.

- **Step 2: Defining who were the risk seekers and who were risk averse**

This section continues the flow of logic from one table to the next. Table 4.14, places people into the two forced scenarios. The aim of using this process is

to clearly identify ‘who’ is in each of the two plausible learning scenarios, i.e., who are the risk averse and who are the risk seekers.

- **Step 3: Understand why the key decision-makers chose to be risk seekers**

This is covered later in Chapter 5: Synthesis, where this question is considered against the uncertainty spectrum conceptual framework that was developed in earlier sections.

4.3.1.2 Defining the key uncertainties

There are a large number of uncertainties that were raised during the Royal Commission witness proceedings, whose resolution significantly affected the variables that are of interest. This approach of defining the uncertainties and the potential ranges of those variables is based on the method outlined by Schoemaker (1993, 1995) and Maani and Cavana (2000). Table 4.10 defines Pike’s various uncertainties, the variables of interest (which are coded and which are used consistently throughout the following tables), as well as the potential range of outcomes.

Table 4.10: Uncertainty factors affecting Pike at the time of the explosion

Code	Uncertainty factors	Range of outcomes
Mk-1a	Market factors (Mk) Reliance on the strong coal demand (‘commodity boom’) from one market China.	- Demand/price crash, status quo, boom prices increase
Mk-1b	International coal demand/price.	- Sharp decline, status quo, sharp increase.
Op-1a	Operational factors (Op) Total coal reserves.	- Significantly less than forecast, forecast, significantly more than forecast.
Op-1b	Coal quality.	- Significantly lower quality than forecast or forecast. There is nothing higher than forecast, since Pike was already promising premium, hard coking, ultra-low ash.

Code	Uncertainty factors	Range of outcomes
Op-1c	Coal production.	- Significantly less than forecast, forecast, significantly more than forecast.
Op-2a Op-2b	Inherent level of methane in coal Methane monitoring.	- Not 'gassy', 'gassy', highly 'gassy'. - Sufficient to have some monitoring via hand-held and fixed meters or comprehensive real-time monitoring from the control room.
Op-2c	Methane reduction/extraction process.	- Not able to handle high volume methane surges, just able to handle methane surges, easily handles methane surges
Op-3 Op-4	Appropriate mining equipment. The overall mining development plan fits with best international practice.	- Not appropriate, sufficient, well suited - Non-compliance with unique features, complies, is regarded as an exemplar of best practice
HR-1a HR-1b HR-1c HR-1d HR-1e HR-1f HR-2a HR-2b HR-2c HR-3a HR-3b HR-3c	Human relations (HR) factors Skilled mining labour availability. Experience in N.Z./West coast coal mining conditions. Experience in N.Z./West coast coal mining conditions at senior management/board level. Labour resources. Labour relations and morale. Management/staff experience in hydro-mining. Turnover of Board members Turnover of top management. Turnover of middle management. Quality of Board members Quality of top management Quality of middle management	- Short supply, sufficient, oversupply. - None, modest, or considerable. - None, modest, or considerable. - Contractors or staff. - Poor, good, very good. - None, modest, or considerable. - Too high/low, ideal middle. - Too high/low, ideal middle. - Too high/low, ideal middle. - Weak, good, strong performance. - Weak, good, strong performance. - Weak, good, strong performance.
Fin-1 Fin-2 Fin-3 Fin-3a Fin-3b	Finance (Fin) factors One option/no portfolio. Mine setup costs forecast. Effectively all the high capital costs are incurred in the project set-up phase, before any revenue is created. Funding sources. Funding setup cash shortfalls via share issues. Funding setup cash shortfalls via borrowings.	- Everything depends on just one undeveloped mine site for all the future profits/losses, with no alternative cash flow options. - These costs being significantly more than forecast, forecast, significantly less than expected. - Complete reliance on funding the setup costs from shareholders and/or borrowing. - Undersubscribed, subscribed, oversubscribed. - Banks will either decline or approve additional loans.

Code	Uncertainty factors	Range of outcomes
Com-1	Combined (Com) factors Pike's market reputation as to delivering on promises.	- Overpromise/underdeliver, achieves targets, overachieves.
Com-2	Financial 'blow-up' from a combination of factors.	- Likely, moderate, unlikely.
Com-3	Methane 'blow-up' from a combination of factors.	- Likely, moderate, unlikely.

Since Table 4.10 has identified a large number of possible factors relating to each uncertainty faced by Pike at the time of the explosion, Schoemaker (1993) suggests you reduce the large number of potential future outcomes to a few plausible scenarios. In a case like this, he suggests having just two, being scenarios that represents an optimistic and a pessimistic view of the future. In this approach, assigning probabilities is avoided as that gives a misleading sense of precision. What quickly became apparent during this process was that the status-quo or 'surprise-free' scenario was in fact the most optimistic scenario, mainly because the company forecasts had an inherent 'optimism' bias resulting in overpromising and underdelivering. The different actor-critic's concerns, both ex-ante and ex-post, but only publicly known ex-post, were by contrast always pessimistic of the senior management's forecasts and assumptions.

Table 4.11: Forced scenarios for Pike just before the explosion

Code	Uncertainty factors	Forced scenarios	
		Pessimistic	Optimistic
Mk-1a	Market (Mk) factors Reliance on continued strong coal demand from China	Demand slows	Status quo or demand increases
Mk-1b		Sharp decline	Status quo/sharp increase
Op-1a	Operational (Op) factors Total coal reserves forecasts Coal quality forecasts Coal production forecasts Coal methane levels Methane monitoring	Significantly less	Significantly more
Op-1b		Significantly lower	Premium
Op-1c		Significantly less	Significantly more
Op-2a		Highly 'gassy'	Not 'gassy'
Op-2b		Monitoring insufficient (e.g., needs a	Monitoring sufficient (e.g., hand-held and fixed meters)

Code	Uncertainty factors	Forced scenarios	
		Pessimistic	Optimistic
Op-2c	Methane reduction/extraction process for high volume surges Appropriate specialist mining equipment	comprehensive real time system)	Easily able to handle methane surges
Op-3		Not able to handle Not appropriate	Well suited
Op-4	The overall mining development plan fits with best international practice	It has unique non-complying features	Complies or is regarded as an exemplar of best practice
HR-1a	Human resource (HR) factors Skilled mining labour availability	Support supply	Oversupply
HR-1b	Experience in N.Z./West coast coal mining conditions	None	Considerable
HR-1c	Experience in N.Z./West Coast coal mining conditions at senior management/board level	None	Considerable
HR-1d	Labour resources – Is having a high level of contractors to staff a problem?	High level of contractors to staff	Low/medium level of contractors to staff
HR-1e	Labour relations and morale	Poor	Very good
HR-1f	Management/staff experience in hydro-mining	None	Considerable
HR-2a	Turnover of Board members	Too high/low	Ideal middle
HR-2b	Turnover of top management	Too high/low	Ideal middle
HR-2c	Turnover of middle management	Too high/low	Ideal middle
HR-3a	Quality of Board members	Weak	Strong
HR-3b	Quality of top management	Weak	Strong
HR-3c	Quality of middle management	Weak	Strong
Fin-1	Finance (Fin) factors Reliance on just one mine proposal/no portfolio of mines	Actual situation, a problem	No problem if managed
Fin-2	Mine setup cost forecast	Significantly more than forecast	Forecast/significantly less than forecast
Fin-3a	Funding mine setup cash shortfalls through share issues	Undersubscribed	Actual - Subscribed or oversubscribed
Fin-3b	Funding mine setup cash shortfalls through borrowing	Declined	Approved
Com-1	Combined (Com) factors Pike's market reputation as to delivering on promises	Overpromise/under deliver	Achieves targets or over achieves

Code	Uncertainty factors	Forced scenarios	
		Pessimistic	Optimistic
Com-2	Financial 'blow-up' from a combination of factors	High probability or likely	Low probability/unlikely
Com-3	Methane 'blow-up' from a combination of factors	High probability or likely	Low probability/unlikely

The next stage in step 1 is to add in any data (ex-ante or ex-post) that relates to the two forced scenarios. (See Table 4.12). This data is summarised.

Table 4.12: Adding ex-post data to the forced scenarios for Pike at the time of the explosion

Code	Uncertainty factors	Forced plausible scenarios	
		Pessimistic	Optimistic
	Market (Mk) factors	<i>Refer section 4.3.2</i>	<i>Company targets</i>
Mk-1	Reliance on continued strong coal demand from China	Achieved NZ\$167 per tonne (June 2010). The coal price crashed in 2012.	NZ\$225 per tonne, based on \$4,000m, divided by 18m tonnes.
	Operational (Op) factors	<i>Refer sections 4.3.2 & 4.3.3</i>	<i>Company targets</i>
Op-1	Coal reserves/production	Reserves = 5m to 6m tonnes Achieving 4.7% to 5% ash Achieved 0.044m tonnes	Reserves = 17.6m tonnes Less than 1% ash 1m tonnes p.a. for 18 years
Op-2	Methane management	Highly 'gassy' Monitoring insufficient, e.g., need tube bundle. Not able to handle surges of any volume.	Low to moderate Monitoring sufficient, e.g., hand held and fixed meters. Easily able to handle methane surges
Op-3	Appropriate specialist mining equipment	Prototype specialist machinery failed, especially, the hydro-mining system.	Well suited
Op-4	The overall mining development plan fits	It had unique non-complying features	<i>'A showpiece of modern mining'.</i>




Code	Uncertainty factors	Forced plausible scenarios	
		Pessimistic	Optimistic
	with best international practice		
HR-1a	Human resource (HR) factors Skilled mining labour availability	The ideal ratio is 1 new for every 4 experienced miners, not the reverse as at Pike.	No problem if managed.
HR-1b	Experience in N.Z./ West coast coal mining conditions	None - There were problems between the different foreign nationals.	As above
HR-1c	Experience in N.Z./ West Coast coal mining conditions at senior management/ board level	None - Complete reliance on one person – Whittall, with no NZ experience. Contractors were 37% (or 66/180) of the workforce.	As above
HR-1d	Labour resources - percentage of contractors	Poor – as evidenced by the Stewart report (2010)	As above
HR-1e	Labour relations and morale	None - Complete lack of experience by staff/ management.	As above
HR-1f	Management/staff experience in hydro-mining	Too low - Not enough challenge to the reference narrative.	As above
HR-2a	Turnover of board members	Too low - Not enough challenge to the reference narrative.	As above
HR-2b	Turnover of top management	Too high - A problem, because most resigned because of disagreements with senior management. Refer section 4.3.4	As above
HR-2c	Turnover of middle management	Weak – no challenge to reference narrative	As above
HR-3a	Quality of Board members	Weak - no challenge to reference narrative	As above
HR-3b			As above



Code	Uncertainty factors	Forced plausible scenarios	
		Pessimistic	Optimistic
HR-3c	Quality of top management Quality of middle management	Strong, but high turnover	As above
Fin-1 to Fin-3	Finance (Fin) factors Finance factors	<i>Refer section 4.3.5</i> Actual - Only one mine/ income source. Development costs at least \$100m overbudget. Pike went back three times in three years to shareholders for more funds, plus a fourth was planned at the time of the explosion. \$40m loan defaults, May 2010, which is picked up by NZO&G.	No problem if managed. Problems encountered and overcome. All issues subscribed or oversubscribed. Normal establishment problems.
Com-1 Com-2 Com-3	Combined (Com) factors Pike's market reputation Risk of financial 'blow-up' Risk of methane 'blow-up'	Overpromised/under delivered. High probability/likely. High probability/likely.	No problem if managed. Low probability/unlikely Low probability/unlikely.

There are two clear sets of outcomes based on assessment of Table 4.12. One is the number of items that ex-post can be seen to have high uncertainty of achieving Pike's objectives/best case. These are summarised in Table 4.13, which shows red flags against all five factor areas used above. The pessimistic case is almost always the actual situation that Pike was operating in. The second set of outcomes from Table 4.12 is contained in Table 4.14, which inserts the different actor-critics and key decision-makers into the table of forced scenarios. This identifies the pessimistic people as risk averse and the optimistic people as risk seekers. There is an apparent

split between the actor-critics and middle management who are risk averse and the three key decision-makers who are classified as risk seekers/ takers.

Table 4.13: A summary of red flag warnings of high uncertainty of achieving objectives

Uncertainty factors	Assessing which of the five factor areas of the forced scenarios, has high uncertainty of achieving objectives	
		Red flags
Market factors	During and after a world recession (2007-9) coal prices were booming (opposite to economic trends) due to the one-off temporary demand from China. There was a high risk of a cooling coal market at some point.	
Operational factors	<p>Pike operated in a challenging physical environment and was still in its set-up development mode.</p> <p>Pike was too confident and optimistic in its promises over coal reserves, coal quality and coal production. In September 2010 Pike started a \$7m search (called in-seam drilling) to find out exactly where the coal was, because previously they had found unexpected rock. From the start, Pike took the position that the coal was much less gassy than it really was and this attitude of assuming the methane risk was lower than it was flowed into subsequent decisions and priorities.</p> <p>There were unresolved issues around the methane monitoring and reporting system. Information was not being received/asked for by senior management and the board. There were unresolved issues identified around the extraction of methane.</p> <p>Pike had unique features in the overall design of the mine that would not be allowed in other OECD countries, such as only one entrance and having the main fan underground.</p> <p>The unique unproven specialist mining equipment failed to perform.</p>	
Human resource factors	<p>There were high levels of inexperience in mining, high levels of inexperience in local mining conditions, high levels of management churn and high levels of contractors as a percentage of the workforce. All these factors plus poor machinery meant poor production, which management blamed the workers for, rather than the poor equipment. This meant poor morale. There was unsafe supervision due to a shortage of skilled supervisors.</p> <p>While Pike promised great things once the hydro-mining began, the reality was that Pike's staff and management had no previous experience in hydro-mining, so production difficulties occurred immediately hydro-mining started.</p>	

Uncertainty factors	Assessing which of the five factor areas of the forced scenarios, has high uncertainty of achieving objectives	
		Red flags
Finance factors	The long delays in production and large cost overruns meant Pike always needed new cash from shareholders. During 2010, Pike defaulted on the conditions of its loans and Pike's parent NZO&G took over a \$40m loan. Without this transfer of the loan to NZO&G, Pike would have been put into receivership.	
Combined factors	Both a financial 'blow-up' and/or a methane 'blow-up' were highly probable/likely.	

4.3.1.3 Determining who were the risk takers and who were risk averse

The three key decision-makers, being Dow (Board chair), Ward (CEO/Board member) and Whittall (mostly GM-Mines), are coloured red in Table 4.14 and their views reflect Pike's official positions. Actor-critics who challenged aspects of this narrative are coloured in blue. Overall, a clear and consistent pattern emerges.

Table 4.14: Placing people into the two forced scenarios of Pike at the time of the explosion

Code	Key uncertainties	Forced scenarios	
		Pessimistic Risk averse	Optimistic Risk takers
Mk-1	Market factors Reliance on China	-	Company targets Dow, Ward, and Whittall
Op-1	Operational factors Coal reserves/ production	Bell, Nishioka, McCracken, Dr Newman, Dr Cave, Dr Elder, Rawiri, and Gujarat (Owner/customer)	Company targets Dow, Ward, Whittall, based on earlier Australian consultants
Op-2	Methane management	Bell, Nishioka, Dr Newman, Dr Cave, Pike staff and middle management, including White	Dow, Ward, but mostly Whittall

Code	Key uncertainties	Forced scenarios	
		Pessimistic Risk averse	Optimistic Risk takers
Op-3 Op-4	Appropriate equipment and mine is best practice	Pike staff and middle management, including White	Dow, Ward, but mostly Whittall
HR-1	Human factors Workforce issues	Bell, Nishioka, McCracken, many Pike staff, consultants and middle management	Dow, Ward, but mostly Whittall
HR-2	Board/management issues	Many Pike staff, consultants and especially middle management	Dow, Ward, but mostly Whittall
Fin-1 to Fin-3	Finance factors Financial factors	Dr Elder, Bell, and Salisbury	Dow, Whittall but mostly Ward
Com-1 Com-2	Combined factors Market reputation Financial 'blow-up'	Bell, Dr Elder, Nishioka, Dr Cave, and key shareholder NZO&G	Dow, Whittall but mostly Ward
Com-3	Methane 'blow-up'	Dr Newman, Bell, Dr Cave and Nishioka	Dow and Whittall

The next sub section analyses the four unexpected events that had a significant negative financial and operational impact on Pike, before Pike experienced an unexpected methane mine explosion.

4.4 The consequence of hedgehog thinking is being surprised by the unexpected

This sub section analyses the four surprise events (plus the methane explosion) that had a significant negative financial/ operational impact on Pike from the date of public listing in 2007 to the methane mine explosion in 2010. In all examples, Pike's ex-ante reference narrative is compared to ex-post public comments from actor-critics.

4.4.1 Pike's three key decision-makers were continually being surprised by the unexpected

The Behre Dolbear Australia 2010 report, prepared for NZO&G and given to Dow and Whittall, stated that the Pike project had experienced a suite of unexpected technical and operational difficulties. This included the unexpectedly more difficult geotechnical conditions in the access tunnel; the unexpected cost and time overruns for completing the tunnel; the unexpected collapse and subsequent recovery of the main ventilation shaft; the unexpected graben or up-thrust stone block in the mine path; and the unexpected machinery problems. Each of those factors had affected the ability of the company to deliver on its objectives (RCPRCMT, 2011-2012 - Whittall).

Whittall's ex-post response to these unexpected technical delays was to say, *'I've never worked at a coal mine that didn't have a suite of unexpected technical or other issues to deal with. That's the nature of mining. You're dealing with nature and then quite complex mining equipment'* (RCPRCMT, 2011-2012 - Whittall).

This sub section looks at four of these unexpected events, plus the explosion itself, to understand Pike management's way of operating. All of these examples show different aspects of short-term expediency and the fact that they did not seem to learn any lessons as they went along, since there is commonality of issues in all the examples of poor knowledge, understatement of costs, blame of others etc.

4.4.1.1 The ‘unexpected’ poor quality rock in building the 2.3 km entrance tunnel (September 2006 to October 2008)

Pike’s May 2007 prospectus, which was published when they were about a third of the way through the tunnel, said, ‘*The tunnel is being constructed in hard rock type (gneiss) and is expected to be predominantly self-supporting over large sections.*’ Pike had estimated that 90 percent of the tunnel would be built through rock that required little or no support, with only three percent in poor rock requiring intensive support. This was based on a 2004 exercise of surface mapping the very steep bush-covered escarpments, despite the geologists wanting exploratory drill holes, since Pike was clear that drilling was not an option. The contractors for the tunnel, McConnell Dowell and its geotechnical advisers, URS New Zealand also recommended that Pike sink four boreholes, at a cost of \$500,000, along the tunnel route, but that was not done. There was an assumption within the Pike management team that the Department of Conservation (DOC), as landlord, would have automatically disallowed it, although DOC was never asked. DOC said they always considered all applications and they had a history of approving most applications. Les McCracken (consultant project manager) believed that since tunnels were notoriously difficult to budget with precision, even in benign conditions, plenty of budgetary slack needed to be built in, recognising the risk of surprises and cost blowouts. He built a ten to fifteen percent contingency into his proposed budget, but this was stripped out by Ward after instructions from the board. McCracken called the desire to reduce the apparent capital cost of the project a ‘strategy of hope’ (Macfie, 2013).

As it turned out, right from the first day in 2006, the ground conditions were worse than expected. Rather than the hard, self-supporting rock that had been anticipated, it was rotten, broken, crumbly and wet. Unexpectedly, for Pike management, nearly 80 per cent of the tunnel was in poor rock requiring maximum bolting and shotcreting – almost the exact opposite of what had been predicted. The tunnelling cost twice as much as expected and took twice as long. Since the contractors were paid according to the quality of rock, Pike paid dearly for these overruns, which Pike blamed on the consultants (Macfie, 2013).

Despite these setbacks, in September 2008 Pike was upbeat and reported that, *‘The financial impact of the progress made in **de-risking** the mine development is reflected in the 30 June 2008 results with a number of one-off items; including recruitment of management and a skilled mine workforce and transition into new coal transport arrangements’* (Pike, 2008c). In the financial statements for that period, Pike said, *‘The thoroughness of the **de-risking**, both operational and financial, has put the company into a strong position for making good progress once coal has been reached’*.

4.4.1.2 The ‘unexpected’ shaft collapse when building the 111-metre ventilation shaft (mid 2008 to June 2009)

The ventilation shaft was a fundamental element of Pike’s mine design. Like everything else, the geography and geology of its placement was complicated. The top third of the shaft would pass through faulted ground, and the bottom section would be in soft coal measures. There were three possible methods for building the 4.2-metre diameter shaft.

The first was ‘blind sinking’. This was probably the safest choice, where you start from the surface and work down in stages as you reinforce. As the shaft was on DOC land, it was problematic as to how the debris would then be removed and so this method was deemed not feasible.

The second option was a method called an Alimak raise. This used a specialist platform that started the shaft from underground, with sides of the vertical hole being reinforced as it progressed. It was a slow method, but one favoured by the McConnell Dowell team as prudent for the ground conditions.

The third method was to ‘raise bore’. This involved drilling a small hole from the surface to the tunnel below. Then an enormous round steel reamer head would be brought into the tunnel and attached to a long steel rod lowered from the surface. The reamer would be drawn up to the top, boring out the full 4.2-metre hole. The rock spoil would fall to the tunnel floor, to be mucked out by loaders and conveyed out of

the mine. Once the hole was completed, the reamer head would be lowered back into the shaft base, removed and transported out of the tunnel. Only then could the sides of the hole be supported all the way from the top to the bottom with bolts and mesh by workers operating from a platform suspended from the top.

A fourth option was Louw's idea of eliminating the ventilation shaft and building a second tunnel for both ventilation and as a second entrance. This was rejected immediately (Macfie, 2013).

Pike management chose the raise bore method, as it was theoretically the fastest option. Just before the raise bore rig started in December 2008, geotechnical advisers URS New Zealand, who acted outside of their scope, analysed the core sample and applied an internationally recognised analytical technique to it. They found that the top section of the shaft was capable of standing unsupported for about a month, but the bottom 17 metres would stand for only a week. This was reported to Whittall and Ward, but as the raise bore rig was already on site and costing \$22,500 per day, the pressure was on to get the job done. All alternative approaches would take months and were quickly dismissed. Despite the concerns about stability of the bottom section, Pike chose to take the risk on the raise bore method. Instead of using the recommended 14-metre bolts to lock the lower section of ground together, they used 8-metre bolts they had on hand. 'Speed was of the essence'. The reamer took 18 days to reach the surface and even larger rocks started falling below it. The reamer had to be lowered to the shaft base and be removed, along with all the fallen rock (Macfie, 2013).

Starting from the top, workers were installing rock bolts and mesh. They had completed the top 70-metres when 'unexpectedly', the bottom section broke away leaving a 12-metre void. The bottom half of the shaft had to be abandoned. The only solution was to fill the lower section with concrete. It took over a thousand helicopter flights dropping 800 cubic metres of concrete down the hole to plug the failed section. Since no mining could occur until the ventilation shaft was working, Pike now ironically used the Alimak raise method to create a dog-legged section that would bypass the collapsed section. It took until June 2009, a five-month delay, to complete this work. Once again, Pike had suffered a massive setback in time and money. Pike

management unsuccessfully tried to blame URS and McConnell Dowell for the collapse (Macfie, 2013). Refer Figure 4.8.

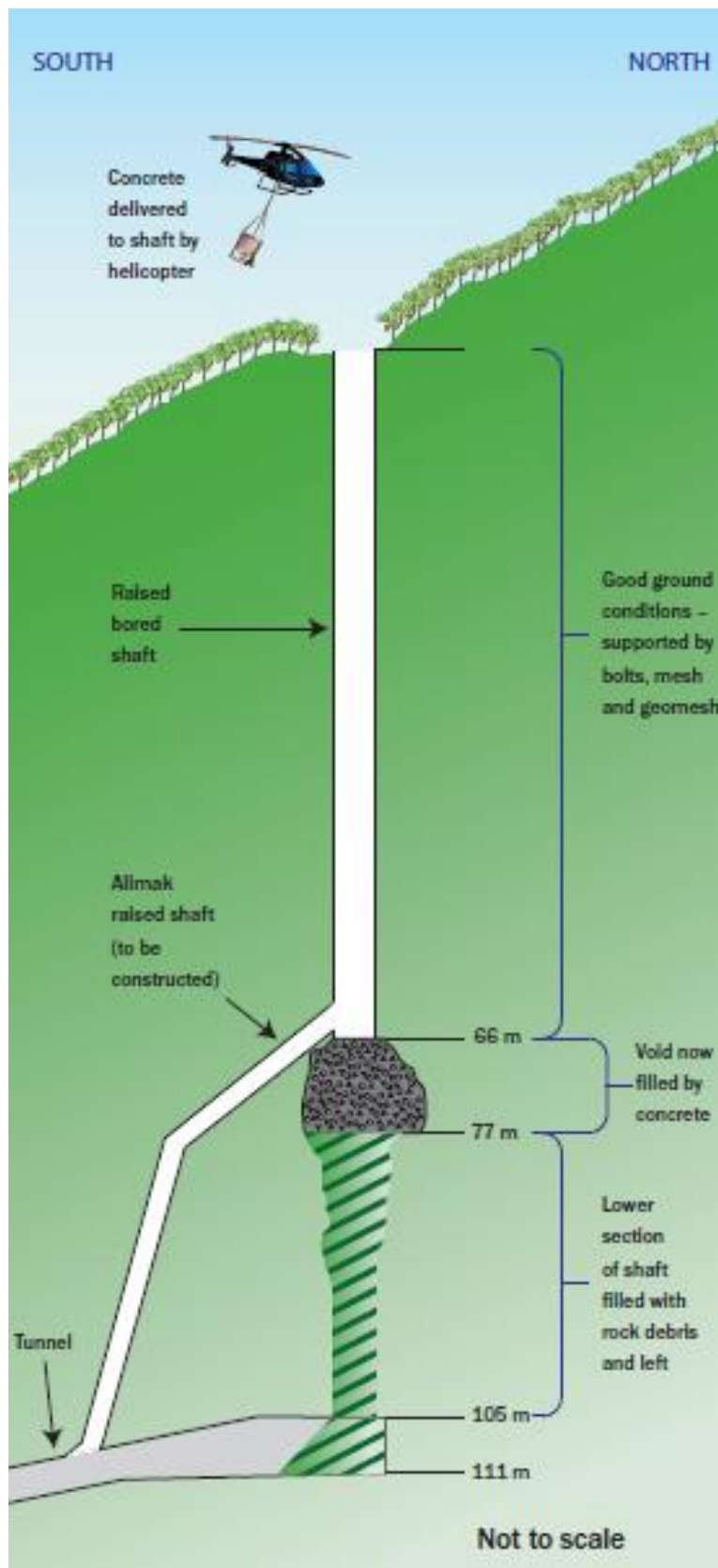


Figure 4.8: Ventilation shaft schematic Source: RCPRCMT (2012, p. 39, Vol 2, Fig 3.7)

4.4.1.3 The ‘unexpected’ graben/rock fall where there was meant to be coal

From June 2009, after ventilation was restored, Pike’s in-seam drilling contractor, Australian company Valley Longwall, was able to get to work. Because Pike had drilled so few exploratory boreholes from the surface, mine planning was heavily reliant on the long horizontal drill rods that would probe into the coal hundreds of metres ahead (Macfie, 2013).

Management had been expecting to find coal, but instead found a 200-metre zone of shattered rock. Right at the point they had expected to start mining coal, the seam simply vanished. It had been forced down between two faults. No one had known about this feature, known as a ‘graben’. Pike’s scanty exploratory surface drilling hadn’t picked it up, as it fell precisely between two widely spaced boreholes. Getting through the faulted rock graben zone proved to be a big challenge for Pike as it blocked the way to the coal. It took several months longer than initially expected and months of difficult and costly blasting and excavation (Macfie, 2013). Refer Figure 4.9.

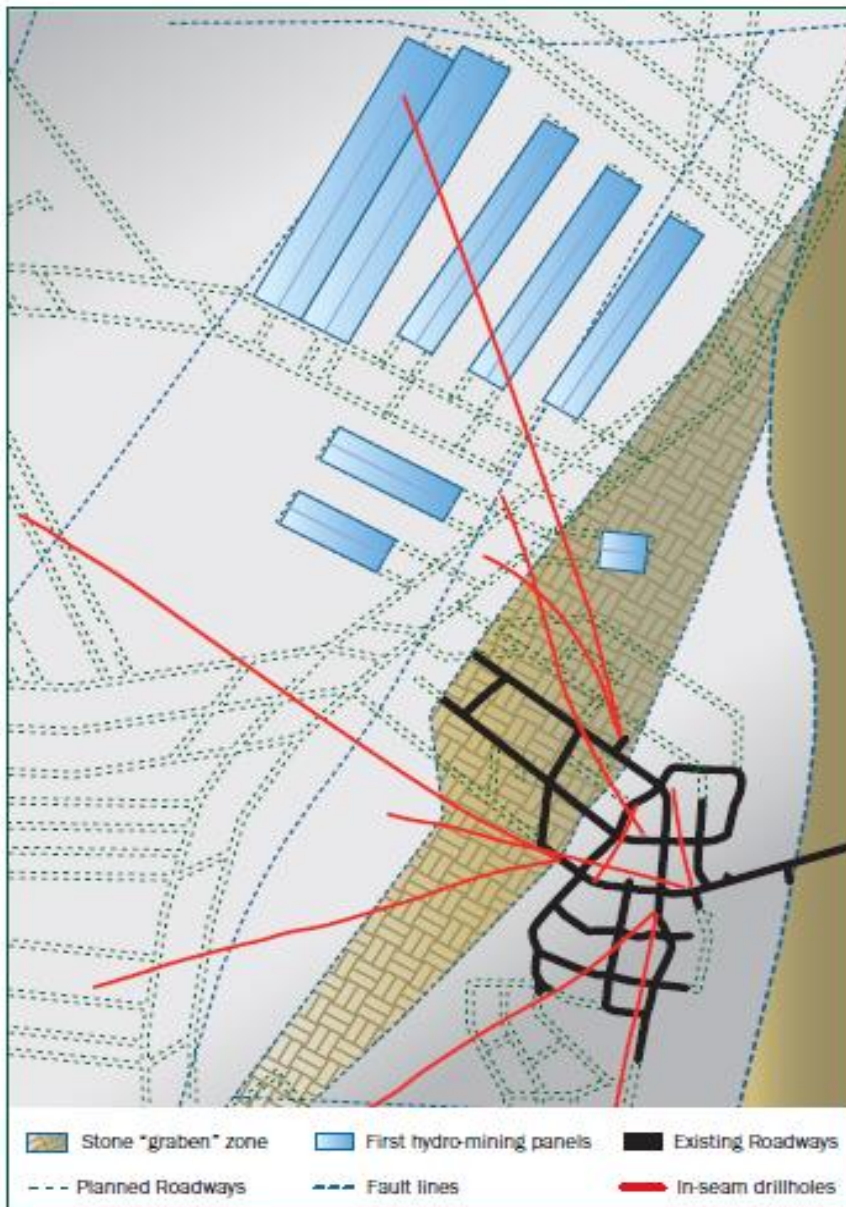


Figure 4.9: Schematic showing the significance of the 205-metre-wide stone 'graben' zone

Source: Pike (2009b) dated as at 23 March 2010

Despite these setbacks Pike was upbeat, and in September 2010 reported that, 'Now the mining operation has moved away from the Hawera fault and adjacent graben zone, the risk of a major geological surprise is considerably diminished. In-seam drilling is used to increase certainty of geological conditions and reduce mine planning and scheduling risks' (Pike, 2010b).

4.4.1.4 The unexpectedly hardness of the coal

Ex-post we learn of another significant unexpected surprise, being the actual hardness of the coal itself, being difficult to physically mine. This was hinted at by Whittall (refer section 4.2.3) and White (refer section 4.2.6). White wasn't sure how to deal with the problem and got into trouble for being open to sharebrokers about this difficulty. This unexpected problem had not yet been reported to the shareholders and would need to happen perhaps as early as the next quarter (early 2012) as part of Pike's explanation of the continued low coal productivity. This would be especially important as Whittall was so proud of the new machinery in his last shareholder report. Low production and its significant consequential financial reality would soon catch up with Pike, but documentation showed that they seemed in no rush to be open and honest with their shareholders about it.

4.4.1.5 Pike's three key decision-makers were completely surprised by the 19 November 2010 methane explosion

The Pike board, its chair - Dow, CEO - Whittall and other senior managers all gave evidence that they had no awareness at all of anything being wrong with the health and safety at the mine. They were completely surprised both about the explosion and the post-explosion information received by the Inquiry. It was a complete black swan for them, even though many of them had previous coal mining experience (RCPRCMT, 2012).

When the senior managers were questioned as to their perception of the risk of a methane explosion, they gave the following answers:

Whittall was asked whether he had ever contemplated an explosion. He gave a long answer, which included these words: *'you always hope for the best and plan for the worst ... What I would say is that the – I would not expect rather than contemplate an explosion occurring ... So to say that it wasn't contemplated, not at all. The emergency response management plan was there for that. I had*

managed mines that had had explosions in them. I was familiar with explosions, Moura, many others' (RCPRCMT, 2012, p. 177, Volume 2)

White (Operations Manager, 2010) was questioned on the value of the ventilation shaft as an escapeway, and replied, *'I think it's fair to say that having never actually considered the possibility of the mine blowing up ... it was not a matter that overly concerned me'* (RCPRCMT, 2012, p. 177, Volume 2).

Ellis (Coal Manager, October 2010) was questioned on the first few hours of the emergency response, and he ended his response, *'We don't expect an explosion of that magnitude at a mine site'* (RCPRCMT, 2012, p. 177, Volume 2).

What was even more alarming is the fact the emergency response management plan essentially discounted the risk of an explosion. What this indicates was management's lack of appreciation of the explosion risk at Pike River, despite the history of methane explosions in mining on the West Coast and methane issues at Pike River (RCPRCMT, 2012).

4.4.1.6 Most stakeholders were completely surprised by the explosion and then by the ex-post information

Most stakeholders would have relied on Pike's optimistic public disclosures and been unaware of the explosion risk. This would have included most shareholders, most staff, the Pike Board, the public, the Government, DOL, and for much of the time up to the explosion, the main shareholder NZO&G. Examples of their views are set out below:

Pike's Safety and Training Manager, *'Mr Rockhouse told the Commission at no stage would he have allowed anyone to go into the mine if he'd thought it was unsafe or if he'd appreciated the full extent of the problems we now know about. Mr Rockhouse unfortunately was not privy to some terrible shortcomings that permeated throughout the company ... Mr Rockhouse himself didn't learn of the unsafe practices underground until after the explosion which ...his lawyer referred to Mr Rockhouse's*

shock and dismay' (RCPRCMT, 2011-2012, p. 5544 - Closing addresses, April 2012).

Contractors, 'McConnell Dowell had four men leave the mine three minutes before it blew up ... Now it's with sadness that McConnell Dowell has to say it has no understanding or idea why the mine exploded. We've seen the evidenceas to the recollection of the men underground. None of them saw anything that they thought was unusual that day. Nobody that they spoke to communicated any concerns to them that day and when they left the mine they had no idea how lucky they were about to become ... There is a divide really within the mine between the coal measures and the stone measures and so when you've got a contract like McConnell Dowell who was working very much in stone, with a very limited role to play in coal, it isn't in a position to comment on what was being done up in those areas, in the areas where McConnell Dowell wasn't working' (RCPRCMT, 2011-2012, pp. 5445-5449, April 2012).

4.4.1.7 Some actor-critics were NOT completely surprised by the explosion and then by the ex-post information

This category includes a number of internal actor-critics, such as senior managers and consultant geologists who for a number of reasons believed that something was wrong with the Pike Rive mine project and said so before or after the explosion. This may be termed the whistle-blower category, which would include the various internal/external geologists such as Dr Cave, Dr Newman, Bell, and Nishioka, and the various senior managers who left for different reasons, such as Renk, Louw, Slonker, and contractors McCracken and Stewart. Two sets of external stakeholders are also included here. One is Dr Elder and his Solid Energy management team, who believed from 2000 (a full 10 years before the explosion) that Pike was a high commercial risk based on the fundamentals and that Pike needed to expect lots of geological/financial surprises. The second is Salisbury and his colleagues at NZO&G, who from mid-2010 became aware through the Behre Dolbear Australia Report of the deep problems within Pike.

Dr Newman provided the Royal Commission with a good example of professional foresight. After 2009 Dr Newman had no involvement with Pike but noted from newspaper articles the change of CEO. *'This made me anxious ... changes in management. That was when the alarm bells really began to ring for me ... I already, as you know, had concerns about the geology not being sufficiently defined and these were my professional opinions. After being able to review the database in 2001 and 2008 I had no direct access after that, but I – there was one occasion, I knew that my husband was going to be visiting the West Coast, he would often – this is Nigel Newman, he would quite often go and provide some assistance in the Pike River wash plant because making wash plant operation successfully separate the clean coal was something that he had experience in. He told me that he was going over, this would've been approximately July/August 2010. I said, "Are you going to Pike River?" He said, "Yes." I said, "Well you know I'd just rather you didn't go in the mine." ... He asked me why not to go in the mine and I said, "Well, you know, it's just everything really, it's the geology." I wasn't really very specific. It was just my feeling at that stage that things were converging on a situation that I wasn't happy about'* (RCPRCMT, 2011-2012, pp. 197-198 - Dr Newman, July 2011).

Dr Elder (CEO - Solid Energy) was also not convinced that the explosion at Pike River was a surprise black swan. *'I was aware of in the media and elsewhere, that perhaps this tragedy was simply the result of a number of rare and isolated circumstances, all of which simply happened to occur at the same time and the same place with tragic consequences. In effect, a very unlikely set of coincidences that were tragic but unforeseeable ... but I don't believe it's an acceptable explanation for what happened in any way. Underground mining has many challenges and modern mining is very complex. But incidents like this with catastrophic consequences shouldn't be able to occur in modern mining. I don't ...believe it was remotely likely that this event could have occurred with the tragic deaths that occurred if all practicable steps had been taken'* (RCPRCMT, 2011-2012, pp. 31-32 - Dr Elder, July 2011).

The Pike River explosion *'was not an accident in the sense, it was neither unforeseeable nor unpreventable and there had been certainly back at that time some suggestions that it was, there was simply some very tragic alignment of the*

planets but the risks of methane, of source of ignition in underground coal mines is something that was well understood and it should be able to be mined, that's coal should be able to be mined on the West Coast including using hydraulic mining methods and should be able to be mined safely' (RCPRCMT, 2011-2012, p. 5451 - Dr Elder, April 2012).

4.4.1.8 Summarising the different levels of surprise to the black swan event

The explosion was a black swan event to everyone, but there are four different levels of surprise to it. The first reaction was of complete surprise by the three key decision-makers and their supporting in-group, who believed Pike had good systems of control that would block any black swan event. (See section 4.4.1.5 above). The second reaction was also complete surprise. This group included most investors, many/most staff, and most politicians. Stakeholders in this category relied on the public statements from the three key decision-makers for their information. Since Pike had always said that they had good systems of control and in the absence of any other information, this was what most people believed. Numerically this is the largest group by far. (See section 4.4.1.6 above).

A third group were surprised by the black swan event, those being mostly managers, staff or contractors. They believed that Pike's systems of control were good or adequate, except for 'some specific issues', which troubled them. Included in this group would be people like White (regretting not having a tube-bundle gas monitoring system or second egress), Rockhouse (regretting they only had a shaft as a second exit), or Van Rooyen (regretting the lack of a comprehensive mine master plan that linked gas drainage, geology, etc). While all these people would have been surprised by the explosion, they all had different, but equally important, aspects of Pike's operations that deeply concerned them, which, if addressed, could have prevented the explosion. Each of these examples is a strong hint that the system could be in trouble. (See section 4.4.1.7 above).

The fourth category is a subset of those described in section 4.4.1.7 above. They were the few internal/external actor-critics, who were often frustrated or marginalised

by decisions, and were deeply troubled with a bad feeling about Pike in a holistic sense. This group understood that the parts that concerned them linked to other parts and that would affect the whole system and therefore they expected or were concerned that a system's failure would occur. This group included Dr Newman, Bell, Dr Cave, Nishioka, and Dr Elder. These groupings are summarised in Table 4.15.

Table 4.15: The different levels of surprise caused by the 2010 Pike mine explosion

	Level of surprise	Category of stakeholder	Attitude to Pike's reference narrative
1	A complete surprise	The decision-making 'in-group'	It is their reference narrative and it reflects their view that problems were being managed effectively.
2	A complete surprise	Passive stakeholders, probably the majority of internal/external stakeholders	Ex-ante, these stakeholders were relatively passive recipients of Pike's reference narrative, as that was their prime source of information on Pike.
3	A surprise, but were aware of problems	Informed, mostly active internal stakeholders	Ex-ante, these stakeholders were troubled by specific aspects of Pike's reference narrative.
4	A surprise, but were aware of deep problems	Informed, mostly 'out-group'	Ex-ante, these stakeholders were troubled about Pike's operation in a specific and holistic sense. They therefore believed Pike's reference narrative was seriously flawed.

Throughout all of Pike's five unexpected events, actor-critics had been suggesting to Pike's three key decision-makers that Pike was understating the uncertainties/risks and overstating their confidence. The next section explores why Pike's three key decision-makers seemed to be blind and deaf to the suggestions by these actor-critics that Pike's reference narrative was in different ways flawed.

5 Synthesis: Pike's three key decision-makers applied a hedgehog cognitive thinking style

Synthesis is the process of combining ideas into a coherent whole. This is opposite to analysis which breaks the complex whole down into component parts. This chapter seeks to synthesise an understanding based on the different threads of evidence. In particular, the focus of Chapter 5 is to understand why the key decision-makers were blind to the potential black swan events, for example, an underground methane explosion, and any subsequent effects on the mine's viability, Pike River's reputation, and of course the community and families.

The following three sections of 5.1 to 5.3 compare the attitudes of Pike's three key decision-makers to the three-hedgehog cognitive blindneses which effectively lock the focus of decision-makers to just the known and certain. Each section considers one of these cognitive blindneses.

5.1 Pike's three key decision-makers were blinded by the illusion of certainty

5.1.1 Pike's three key decision-makers believed the risks were low

Ex-post, Dr Kathleen Callaghan (University of Auckland) believed Pike's management and board focus was exclusively on high-frequency, relatively low severity personal safety events, rather than low-frequency, high-severity safety events. Each type of safety needs to be addressed differently. For low-frequency, high-severity events, it is important to monitor near misses. Dr Callaghan's observations also applied to her observations of DOL's national health and safety agenda and monitoring system (RCPRCMT, 2011-2012 - Dr Callaghan).

Whittall (CEO) seems to have equated 'low' frequency with 'no' frequency, which is a cognitive simplification called probability neglect (Kahneman, 2011). When Dr Callaghan was asked ex-post to comment on Whittall's comments in her cross-examination, she said, *'We know, you know, mining is an industry that is associated with low frequency, high consequent events' ... 'He responds by reference to 911*

and 747s flying into buildings. He goes on to say that the proposed scenario is extremely strange and unlikely. It's happened obviously. I guess my concern when I read that is, he's been asked what consideration he gave to a well-known process safety event, i.e., a mine exploding and he says, it's unlikely. Well, it is unlikely by definition of a process safety event is of low frequency, i.e., unlikely. That's the definition of a process safety event. You can't use the definition as a justification for saying that you haven't given it consideration' (RCPRCMT, 2011-2012, p. 3260 - Dr Callaghan, November 2011).

Perhaps this rounding down of low frequency, high consequence events to zero explains why Whittall downplayed the risks around methane that were being raised by his staff and consultants, and why it was not one of the risks identified in Pike's emergency response management plan.

5.1.1.1 Lining up cherries on a slot machine, a wrong metaphor for the wrong domain

Whittall gave another example of where he thought he was operating in the 'ordered' world and he gave a metaphor of a slot machine that would be appropriate for that domain. The metaphor gives a misleading description. Whittall was interviewed after the explosion, for TV One's *Sunday* programme, which screened on 28 November 2010. Part of the interview is below.

Interviewer: *"This obviously will weigh on your mind, but can you say hand on heart, that everything was done that could be done to make that mine safe?"*

Whittall: *"That's a really difficult question to answer because obviously an unsafe condition did occur, an explosion did occur, so at the time that occurred absolutely there was some unsafe condition occurred, so otherwise there wouldn't have been an explosion. Like anything it's a matter of lining up, the cherries on the slot machine or something else. A number of factors would have occurred that had one of those factors not been there, we would have had a very large miss, that we would have learnt from, investigated and everything else and we would have breathed a sigh of*

relief that nothing actually happened, but in this case all the cherries did line up and something did occur.” (Ewen, 2014, pp. 55, 58).

In the ‘ordered’ world of resolvable uncertainty where known distribution systems apply, factors can be correctly assumed to be statistically independent of each other, such as in a mechanical and controllable slot machine. In the above metaphor, Whittall assumes he was unlucky because all the cherries lined up, say five out of five, rather than one less, being a near miss (as might be the case in the independent layers of the Swiss cheese model). Whittall may not have thought about this example too deeply, because with fixed and independent probabilities in slot machines, it is certain that at some stage all the cherries will come up as they are independent events. Likewise, if the slot machine is a metaphor for the mining environment and the jackpot corresponds to an explosion, it implies that an explosion has a small but certain probability that shouldn’t surprise anyone. It will happen, but it is unknown when. Whittall may not have meant to imply that. A more troubling problem with this metaphor is the underlying unsurfaced assumption that the probabilities remain unchanged over time, which they do not, which means the simplistic assumption of independence is violated.

A second interpretation is that Pike was operating in a complex environment of radical uncertainty, underpinned by unknown non-linear statistical systems where factors are inter-related rather than independent. In complex situations, the difference between whether a system failure results in a minor or catastrophic outcome is an unknown chance. With multiple interdependent risk factors, there is a high chance of an accident that combines some of these factors. In that situation, if it had not been this particular accident event, then it would have been some other. It is purely a factor of which dynamic risk factors combine at which time. A proactive approach to risk assessment and management of critical systems is essential. Pike was a workplace accident that was more than just a mining accident (RCPRCMT, 2011-2012 - Dr Callaghan).

5.1.2 Ex-post assessment of the increasing level of uncertainty in achieving Pike's reference narrative

This section builds on previous sections, especially Table 4.13 (A summary of red flag warnings of high uncertainty of achieving objectives) and Table 4.14 (Placing people into the two forced scenarios of Pike at the time of the explosion). These tables highlighted the high uncertainty of achieving Pike's objectives across multiple areas. There was consistency across these areas, with the actor-critics being more risk averse and Pike's three decision-makers being risk seekers or takers. One of the things this section adds is the dynamic of time, as the level of uncertainty changes over time due to changes/additions of machinery/technology/policies etc.

The following table is an ex-post assessment of the changing levels of uncertainty to achieve Pike's reference narrative over the three episodes used in Pike's 'drift over time' charts. It compares the attitude of Pike's three key decision-makers with a synthesis of the attitudes of the actor-critics.

Table 5.1: Ex-post assessment of the level of uncertainty achieving Pike's reference narrative (e.g., coal reserves/production and methane safety)

Episodes	Getting to the coal, after Pike goes public 1 July 2007 to 30 Sept. 2008 (14 months)	Overpromising, underdelivering and understating the problems 1 Oct. 2008 to 30 June 2010 (21 months)	The desperate need for production 1 July 2010 to 19 Nov. 2010 (5 months)
a) Pike's estimated coal reserves and the coal production timetable			
Ex-post assessment of the level of uncertainty in achieving Pike's reference narrative			
Attitude of Pike's three key decision-makers Based on the research Pike had commissioned;	Low uncertainty , as there was very little new evidence to counter the reference narrative. This was a period when Pike's focus	Moderate uncertainty , as serious problems were emerging in coal production and coal quality. The	High uncertainty , as the serious problems in coal production and coal quality were the norm and it is unclear how or if they could be resolved. Different remedies would

Episodes	Getting to the coal, after Pike goes public 1 July 2007 to 30 Sept. 2008 (14 months)	Overpromising, underdelivering and understating the problems 1 Oct. 2008 to 30 June 2010 (21 months)	The desperate need for production 1 July 2010 to 19 Nov. 2010 (5 months)
they believed they had a very strong reference narrative that there were very large amounts of premium coking coal in the Pike mine, that was commercially viable and safely able to be extracted. At all times they assumed that the uncertainty was low and resolvable.	was getting to the coal.	mine was still in the setup phase, so there was stakeholder tolerance and hope that the two key critical commercial aspects of the coal mine would improve to the levels promised.	each take considerable time and money, but each would not in itself solve the situation. It was no longer a solvable puzzle but a complex mystery of radical uncertainty. This view radically differs from the official reference narrative.

b) Pike's methane safety target

Ex-post assessment of the level of uncertainty in achieving Pike's reference narrative

<p>Attitude of Pike's three key decision-makers</p> <p>Throughout the entire ex-ante period, Pike believed they had a very strong reference narrative that the Pike mine was completely safe to mine, with very low levels of manageable methane.</p>	<p>Low uncertainty, as there was very little new evidence to counter the reference narrative. This was a period when Pike's focus was getting to the coal through rock with little or no methane.</p>	<p>Moderate uncertainty, as serious problems were emerging around methane levels, but since the mine was still in the setup phase, there was an expectation that as key aspects were added, such as the ventilation shaft, these problems would be resolved.</p>	<p>High uncertainty, as the serious problems in methane had become the norm. It was unclear how or if they could be resolved without considerable money and time, which was not available at that time. The uncertainty had clearly moved from resolvable to radical.</p> <p>This high uncertainty of achieving Pike's reference narrative, is in stark contrast to the attitude of Pike's three key decision-makers who believed at all times ex-ante and ex-post, that the mine was completely safe.</p>
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5.1.3 Five key factors

There are five key factors that relate to Pike's three key decision-makers being affected by the illusion of certainty. These are:

- **Factor 1: Pike's three key decision-makers** were risk seekers or takers who consciously or unconsciously defaulted to greater certainty (i.e., illusion of certainty), and they assumed (incorrectly) that they were operating in an ordered low-risk environment. This meant they oversimplified and/or underestimated the uncertainty they encountered. They were expecting the 'expected'. They were confident and optimistic, and they acted rationally within their risk mindset of their reference narrative. Within that mindset, they believed that they were acting prudently and would have objected to the risk-seeking label being applied to them. They consistently applied a policy of short-term expediency (i.e., a blend of the least cost, minimum required knowledge, urgency and pragmatism). This came across as 'cheap', living on a shoestring, quick and dirty, doing the bare minimum, back of envelope calculations just to get to the next stage (Macfie, 2013).
- **Factor 2:** As understood with ex-post knowledge, **the various actor-critics** (including staff, senior managers and consultants who were risk averse) were actually realistic in taking a pessimistic attitude to Pike's key decision-maker's pronouncements. In their different ways the actor-critics all believed that Pike's risk profile was not accurately considering all the risks, as they saw (but Pike's three key decision-makers did not) unrecognised risks and unknowns. That worried them. There is a gap between the unknown uncertainties identified by this group and the known uncertainties of the three key decision-makers.
- **Factor 3:** The consequence of operating in the unordered domains is that **Black swan events** should not be ruled out, but be expected, as they are a feature of that domain (i.e., unknowns and unknowables). Pike's three key decision-makers were continually being blindsided by unexpected black swan

events. For example: The ‘unexpected’ poor-quality rock in the 2.3 km entrance tunnel (2008), the ‘unexpected’ ventilation shaft collapse (2008-2009), the ‘unexpected’ graben (rockfall in path) (2009), the ‘unexpected’ hardness of the coal (mid-2010), and the ‘unexpected’ methane explosions that killed 29 (19 November 2010).

The natural consequence of these surprise events was to create a negative feedback cycle of significant cost and time overruns in initial aspects of the project. This meant that budgets/funds available were severely constrained for the subsequent stages of the project and there was greater urgency to recover lost time, from what was initially promised. The inherent problem for Pike in this process was that the problems were getting progressively more complex and interconnected as the mine was developed. Flawed risk assessments on each aspect, plus constraints of time and money from previous activities having overrun their budgets, meant that Pike created an inherently unstable environment that was highly prone to dangerous unexpected events. This risk was not recognised by Pike’s three key decision-makers.

- **Factor 4: To reduce the unknowns to knowns** Pike needed to do a number of things. This included using and applying more science (especially geology), improving its data collection/management information systems and improving its engineering solutions. All of these factors would have reduced the level of uncertainty. Pike did not do all it could/should have. Pike’s three key decision-makers failed to increase Pike’s collective knowledge from the known and, as far as possible, through what is knowable. Doing this would have meant that their reference narrative would have had to move to better align with the physical and scientific reality, and their policy of short-term expediency was the exact opposite of what they should have been doing.
- **Factor 5: It is highly probable that deep residual uncertainties still remain**, e.g., the timing and amount of methane surges. If the decision is made to persist with mining coal, these residual uncertainties need to be acknowledged and made explicit, rather than ignoring them. If the uncertainties cannot be managed, the key decision-makers may have to walk

away from the project to avoid a financial or safety blow-up. Since Pike's three key decision-makers believed that everything was manageable, it may be presumed that they never acknowledged the unknowns/unknowables, they never considered this option as having any relevance. By contrast, this thought did cross their minds some actor-critics.

Level of uncertainty	Simplified Cynefin Domains	Simplified states of knowing	The gap between the two perceptions of reality	What Pike should have done
High Low	<i>Unordered domains</i>	Unknownable Unknowns	Actor-critics view <div style="border: 1px solid green; padding: 5px; margin-bottom: 10px;">Unknown uncertainties</div> <div style="display: flex; align-items: center; justify-content: center;"> ↕ </div> <div style="border: 1px solid green; padding: 5px; margin-top: 10px;">Known uncertainties</div> <p>Pike's view</p>	Unknownable <div style="border: 1px solid green; padding: 10px; width: fit-content; margin: auto;">Unknown uncertainties</div> Knowable
	<i>Ordered domains</i>	Knowable Knowns		

Pike's three key decision-makers (and their supporting 'in-group') were stuck in the 'known' zone, as they were blinded by the illusion of certainty, which meant they were 'strong hedgehogs' throughout the entire process of setting up Pike. In their minds they were 'unlucky' with the various 'unexpected' surprise events that just kept happening. To have avoided this illusion of certainty, they needed to increase their awareness of the organisation's inherent knowledge deficit and the inherent uncertainty within all aspects of Pike's operations. This may have reduced their overconfidence, hubris and the surprise of unexpected black swan events.

5.2 Pike's three key decision-makers were blinded by induction and inductive cognitive biases

This section considers the effect of various inductive cognitive biases such as the hindsight bias, optimism bias, overconfidence and the resulting planning fallacy bias (i.e., overpromise and/or underdeliver) on the three key decision-makers. Being affected by these cognitive biases, meant there was an oversimplification of the complexity involved and then actions were taken in a created environment of simplified or unrecognised risks.

5.2.1 Exaggerated optimism, as evidenced by the unrealistic use of stretch targets

Ward (an accountant by profession) consistently used ambitious 'stretch' objectives for practically all indicators all of the time. This was in contrast to the actor-critics who consistently wanted more modest 'fit objectives', being ones that could be achieved in the difficult circumstances that Pike was operating under. Ward's use of stretch objectives was a de facto default to various System 1 cognitive simplifications within what Kahneman (2011) describes as 'What You See Is All There Is' or WYSIATI. This gives decision-makers the hedgehog overconfidence in the limited amount they know, and it overlooks what they do not know. They confidently 'join the dots' from what they see and these dots relate only to their own experience and project.

Under cross examination, Dow (Board Chair), referring to the period mid-2010, said, *'But as I've said, we did have issues with overpromising and under-delivering and that meant that from time to time the company had to go to the market for additional development capital'.*

Question: 'Do you have a view as to why the company had that issue?'

'Yes. I think that the challenge really came for Mr Ward as the CEO to balance the realities of the development schedule, to develop the realities of the time it would take, and therefore how much capital would be required before the mine was in steady state operations and generating its own revenue. I think the challenge he had

was to be possibly always on the optimistic end of a range of likely outcomes' (RCPRCMT, 2011-2012, p. 3931 - Dow, December 2011).

'Now my understanding was that Mr Ward was being provided with a wider range of alternative outcomes but was electing at the more optimistic end of performance in factoring that performance into his predictions of overall company performance and so it became clear to me that he had a view of the ability of the company to do some things and to achieve certain levels of production, a tunnel advance, roadway development that was at the more optimistic end of the schedule and when asked were these rates of advance feasible or possible, the answer on site was, "Yes of course but everything will have to go right to achieve them," and up until that point that had not been the case for some of these bits of equipment and so I think the problem was, it being over optimistic and a bit unrealistic about using site estimates in forecasting company performance. It became pretty clear to me that he wasn't perhaps taking into account the experience of people on site, saying yeah well if everything goes well this is what we can achieve but so far it hasn't gone that well, so perhaps you don't want to use such an optimistic view of things and I for the life of me couldn't really understand why it was so important to Mr Ward to keep assuming or factoring in performance at the more optimistic end of the likely range of outcomes' (RCPRCMT, 2011-2012, p. 3959 - Dow, December 2011).

It is clear from Dow's explanation above that Ward, the long-time CEO, was operating in an unchallenged environment (i.e., unchallenged project risk assumptions, unchallenged optimism bias, too trusting in Ward's judgement, and the 'halo' effect). But it would be unfair to assume that he was the only one of the three key decision-makers to have this optimism bias when all key decisions would have been negotiated and agreed between them. Otherwise, it begs the question as to why it took three years for the Board Chair to realise that all Pike's key targets were never being achieved. At the Pike AGM of 15 November 2010, which was after Ward had been dismissed, Whittall advised from then on forecasts would be *'achievable' rather than 'best case' scenarios. Previously Pike's forecasts had consistently proved to be at the upper end of the range while our operations performed at the lower end. It was now time to be 'more realistic'* (Macfie, 2013). There was a revision downwards of the production targets, so it was 'more realistic',

but this research is arguing that it still wasn't 'realistic'. In all probability Pike would not have achieved even the reduced targets - which were still optimistic, compared to industry standards for that location and situation, as opposed to extremely optimistic. Whittall and Dow's own optimism bias shows in the September quarterly report to shareholders which was written after Ward had left Pike (RCPRCMT, 2011-2012 - Dow).

Another example, of Whittall wanting to distance himself from his predecessor was in a newspaper report from 23 October 2010, which stated that Pike's new CEO (Whittall) was bringing a more conservative style to its forecasts. Whittall believed that Pike had only a 10% chance of meeting the previous forecast, even though he had prepared previous forecasts. Board and higher management tended to choose the upper end scenario. Commenting on this ex-post, Dow said the board did not seek the most optimistic option, they accepted Ward's assessments, because they had confidence and trust in him. Surprisingly, since it is not a good estimate of success, Dow was not fazed by Whittall's low expectation of success (i.e., 10%), and he treated that as Whittall's judgement call or opinion (RCPRCMT, 2011-2012 - Dow).

Ward as CEO demonstrated several factors/traits that contributed to what Heffernan (2011) calls willful blindness. This is caused by a combination of power, optimism and abstract thinking that comes from working in a small corporate head office in Wellington, while all the staff and the focus of the company's activity is in Greymouth. This distance gap makes it easier to simplify the complexity as the information he received was filtered through his reporting staff. Being cut off from others, this reduced the possibility of disconfirming information and this reinforced his own sense of importance, expertise, and confidence that he was right. This is a common problem in such circumstances.

Another serious problem that Ward did not address is what Rumelt (2011) calls bad strategy. Ward had various targets and goals which he thought was all Pike needed to succeed. This seemed to be more financial forecasting rather than strategic planning. Rumelt believes a good strategy is where you deal with the inherent challenges of the situation. Pike lacked any systematic strategy to deal with the

numerous challenges facing it. It seems that the targets were developed in complete isolation from Pike's physical operations and the industry norms/benchmarks. While Ward was in a sense a master of optimism, so too were Whittall and Dow.

5.2.2 Exaggerated optimism, as evidenced by the words they used in public reporting

Pike management (with Whittall as CEO) exhibited exaggerated optimism right until the November 2010 explosion, as evidenced by the very upbeat and reassuring nature of its final report to shareholders - *Pike River Coal Limited Activities Report Quarter ended 30 September 2010* (Pike, 2010a), which included updates to 25 October 2010 where relevant. Pike was obviously mindful of the need to prepare shareholders for yet another share issue.

In the four pages of text in that document, the following is the frequency of positive or reassuring words: success/successful (7x), positive (3x), happy (2x), very (4x), well (2x), allow (4x), consistent (1x), no/not (5x), improvement (1x), good (1x), progress (1x), significant (7x), milestone (2x), and pleased (1x). Detailed below is a condensed version of the text, with many of these positive words highlighted in red.

'Pike River Coal Limited Activities Report Quarter ended 30 September 2010'

(Large print quote) **Successful** Commissioning of Hydro-Mining Equipment

Key Points

- **Successful** start to hydro-mining operations
- **Positive** results from ABM20 Continuous miner
- Appointment of new CEO

(Large side quote) This past quarter has seen the achievement of a **significant milestone** for Pike River: the **successful** start to our hydro-mining operations

*This past quarter has seen the achievement of a **significant milestone** for Pike River: the **successful** start to our hydro-mining operations. Commissioning started on 20 September 2010 with **no significant** system or component failures. The hydro-mining system has synchronized together **very well** and all components of the hydro-mining system are now in place ... It is important to note that our previous and current mine and production schedules have **allowed** for this ramp-up of hydro-mining to full capacity ... Hydro-monitor extraction is therefore scheduled to keep pace with development of the mining areas. This is also **consistent** with current plans.*

Ramp Up and Production Forecast

*Commissioning of the first underground ventilation fan has now been completed which will provide greater ventilation capacity underground and **allow** for faster dilution of gases liberated during the mining process ... Complete installation of the water system to **allow** the hydro-mining system to ramp up from its current capacity (about 50%) to its full 9,000 litres per minute design capacity ... The revised forecast does **not** alter the capacity of the mine to eventually become a million tonne a year operation.*

Positive results from ABM20 continuous miner

*Pike River is **very happy** with the **success** of our leased, reconditioned, Sandvik ABM20 continuous mining machine that began operating underground in August 2010. The machine made an immediate and **positive** impact on roadway development rates and, therefore, the mine's ability to more accurately forecast and schedule mine operations. The ABM20, which has been achieving average development rates of more than 13 metres per day ... a **significant improvement** compared to the capacity of our existing machines. On the strength of this **success**, the company has purchased a second similar machine that will be ready for operation early in 2011.*

Shipments

(Large side quote) *Pike River is **very happy** with the **success** of the Sandvik ABM20 continuous mining machine that began operating underground in August 2010*

Pike River welcomes new CEO

*On 10 September 2010 the company announced the resignation of Chief Executive Gordon Ward. ... who made a **significant** contribution to the company's development. Pike River is **very pleased** to welcome his replacement, Peter Whittall, ... He is **well**-placed to lead the company through this next important phase into steady-state production.*

Financing

*... While the company noted **good progress** during the September 2010 quarter with the installation of hydro-mining equipment and improving roadway development rates,...*

Observations

What is interesting about this report to shareholders is that it is so positive and plausible. A number of issues are raised that hint at deep problems, but these concerns are surrounded by reassuring and positive comments.

It is ironic that this report is so positive of the ABM20 Continuous miner, when the report was prepared by the new CEO, Whittall, who for over a year was so bitterly opposed to buying or leasing the ABM20. With the help of the hindsight bias, he saw only the final result which can be perceived as certain and known, which was his preferred thinking style.

5.2.3 The resulting planning fallacy bias

This bias is essentially taking the best-case scenario, which for complex projects means underestimating costs/completion times and overestimating benefits (Kahneman, 2011). It also assumes events are independent, not complex interdependent systematic intertwining that can lead to strong reinforcing loops, such as downward spirals and uncontrollable escalations. At 19 November 2010 (date of explosion) Pike had experienced significant unexpected cost overruns, significant unexpected delays in production (by years) despite tremendous effort, achieved low production volumes (hence minimal returns), achieved lower quality of coal than promised, and always needed more finance from shareholders. In Pike's public documents, they put a positive spin on the setbacks and cost overruns, plus counter balanced this essentially very bad news with 'hope of the benefits' by reminding the reader of the potentially wonderful things at the bottom of the mine just waiting for them to get to it. For example, an estimated \$4b of coal reserves, additional reserves in another seam (Paparoa) 200m below the seam being mined (Brunner), premium coking coal with very low ash, and extolling how the hydro-water method would greatly increase production once it started.

The benefit of being so optimistic was that it helped with fundraising and being resilient through all the many difficulties. Since the company was still in the set-up phase, it seems most external parties were tolerant of Pike having to deal with numerous unexpected issues. At the time of the explosion no one had publicly questioned the accuracy of Pike's public statements, even those on notice, such as the banks and cornerstone shareholder NZO&G. It is noted, that with a share issue coming up, critical comments would have been extremely unhelpful and those parties were acutely well aware of that. It is of course not unusual to represent the rosier picture you can. But it also had a serious downside in not communicating to the reader/investor the serious difficulties being encountered.

5.2.4 Sunk cost fallacy

Pike's narrative was simpler and tidier than it should have been. Ex-ante, the investors had accepted the reasons for the delays and the promises of better times

sometime in the future. A lot of money had been sunk into Pike and some investors, like its biggest shareholder NZO&G, were waiting for a good time to sell its shares, once all the additional shareholder funding had finished. At a number of levels different stakeholders were effectively locked in and wondering what their options were (Macfie, 2013).

At the time of the explosion, the big promise or ray of hope for the Pike shareholders was the hydro-water mining. In many ways it was a desperate gamble (i.e., fourth quadrant of prospect theory). What wasn't stressed ex-ante was that hydro-mining will extract more coal than other mining methods, but it equally produces dramatically increased levels of methane because of increased coal surfaces being opened up very quickly. It is not just unlucky that a methane explosion occurred once Pike started hydro-mining. Unfortunately for Pike the production from hydro-mining wasn't as good as they promised, so if the explosion had not occurred in November 2010, the results for the half year to December 2010 would have reflected this and critical questions would no doubt have been asked by key shareholders, the Pike Board and others. The methane explosion occurred just before the financial blow-up/crunch.

Pons (2016) suggested ex-post, the 'ideal' response was that instead of persisting in trying to achieve its stated production outcomes, Pike should have done a thinking reset. When the high methane levels became apparent, Pike should have stopped operations and taken time out to re-examine the situational risks and the business case. Other experts could have been brought in to avoid being caught in the sunk cost fallacy, and a consensus forged as to how to proceed with the development, as opposed to the key decision-makers persisting with their pre-existing views (i.e., confirmation bias).

Since Pike was subject to the planning fallacy and the consequential sunk cost fallacy, it is difficult to see how the Pike's three key decision-makers (now minus Ward) who developed, approved and defended Pike's reference narrative, would have dealt with the potential need to admit that key assumptions were invalid. This would cut across the deep sunk costs of their professional commitment and reputation.

Ex-post, Dr Elder (CEO-Solid Energy) offered the following comments on his experience of the sunk cost fallacy. *'Back analysis that Solid Energy has carried out of a number of historical and recent underground mines in New Zealand shows a similar pattern to that of Spring Creek. Geology and mining conditions are always different and more variable than expected. Investment needed is always significantly greater than planned. Hindsight often shows that the best decision would have been to close the mine significantly earlier or never to have opened it'* (RCPRCMT, 2011-2012, p. 19 - Dr Elder, July 2011).

5.2.5 Post explosion, the optimism bias continued and led to false hope

After the explosion, the Police took control and fronted the media on operational matters and Whittall became the spokesperson on technical matters. The two senior police officers involved (being Assistant Commissioner Nicholls and Superintendent Knowles) both deferred to Whittall and his 35 years of mining experience and were careful not to contradict him (RCPRCMT, 2011-2012 - Police).

After the first explosion and before the second explosion, Whittall/Dow made a number of optimistic statements to the media and the families of the missing miners, such as:

- *'That fresh air was being pumped into the mine and that it was quite conceivable that there was a large number of men sitting around the end of an open pipe, waiting and wondering why we're taking our time to get to them.'* (Whittall)
- *'That the boys would be brought home for Christmas.'* (Whittall)
- *'They could be in a fresh air base with access to oxygen waiting for rescue.'* (Whittall) (RCPRCMT, 2011-2012, p. 1706, September 2011)
- *'Those are not parameters we are testing for.'* (Whittall, in response to a question on the temperature inside the ventilation shaft. Whittall believed there might be heat, others including the Prime Minister thought it was a fire and this helped

create an environment, that mining families thought Pike/Police were withholding information.) (RCPRCMT, 2011-2012, p. 2582, September 2011)

- *'I was absolutely gobsmacked when Peter Whittall walked into the hall with a mine map under his arm and proceeded to tell the families that the men could be at one of the fresh air bases and would be hungry when they came out.'* (Relative of missing miner) (RCPRCMT, 2011-2012, p. 2583, September 2011)
- *'That there was enough rescuers or self-rescuers in the mine for people to have survived for several days.'* (Dow) (RCPRCMT, 2011-2012, p. 1652, September 2011).

These views were also held by Pike managers White and Ellis, and others. They genuinely believed that all or some of the men could have survived. These managers believed they needed to continue to plan for any possible survivors until there was no hope of survival. Afterall, two people had walked out, but they were the closest to the entrance. This view brought up in people's minds the recently trapped goldminers in Chile who were successfully rescued, which optimistically raised expectations of a favourable outcome. In the initial stages (when there was no evidence), there was no evidence to suggest that all the men had died. The Police accepted this advice, but were aware of other views (RCPRCMT, 2011-2012).

John Key (Prime Minister) described his first visit to the Pike mine ex-explosion on 20 November where he was given the same hopeful message as the families, *'So they could be alive?' he asked Whittall. 'Yes,' Whittall said, 'they could be alive – some could be dead and some could be alive. It's a big space down there and it depends where they were in the explosion, and these two guys had walked out and its's a solid structure and it depends where the explosion took place ...'* (Macfie, 2013, p. 207, Interview).

The mining families considered Whittall a very effective communicator. Later comments to the Royal Commission from representatives of the families of the missing miners included: *'In my opinion he (Whittall) talked the talk and never missed*

a beat. He seemed to have the majority of the meeting in the palm of his hand.' Bernie Monk said, *'As for Peter Whittall, he spoke well. He was convincing. We found his explanations plausible. We wanted to hang off every word he said. He was certainly an effective communicator and he appeared to be empathetic towards the families.'* *'Peter Whittall came across as very credible'* (RCPRCMT, 2011-2012, p. 2604 - Families, September 2011).

There was a second view that many of the mining families were aware of which, surprisingly, Whittall later said he was completely unaware of because he was not in any of the technical groups and no one told him. This counterview, was held by the Mines Rescue team that had immediately formed the view that the initial shockwave of the first explosion would probably have killed most of the men immediately or rendered them unconscious. If any of the men had not been killed immediately then they would have been quickly overcome by noxious gases or lack of oxygen within minutes. This view was mindful of that organisation's 81 years of operation, where they had rarely rescued coal miners after a methane explosion, but had instead often undertaken a recovery of victims. Survival in such conditions was extremely low, possible, but close to zero. The Pike video evidence that was available on the first evening showed that there was a large explosion that lasted for 52 seconds, and this was happening in a small mine. From the outset, the fire service agreed with the view that they were dealing with a massive fatality situation. All the indicators were negative. The miracle for them was that two people survived a methane explosion and walked out (RCPRCMT, 2011-2012 - Watts).

The Prime Minister returned to Pike on 22 November where he was asked if he had seen the CCTV footage of the explosion. It was the first he'd heard of it and he asked to be shown it. Whittall was in the control room with Key as it was played. *'I just went 'Hell!' because it was pretty obvious from the video that the explosion was massive'*, Key would recall. Shocked, he asked for the footage to be played again a number of times. He couldn't see how anyone could have survived the blast. The Pike officials continued to maintain that the footage didn't eliminate the chance that men could still be alive. Key told them they had to show the footage to the families and the media. *'I said, 'I'm the prime minister'*. There was quite a bit of debate, but that request didn't happen, until late the following day, being four days after the explosion (Macfie,

2013, pp. 214-215, Interview). When Whittall was asked why the video hadn't been shown earlier, Whittall said, the *'piece of information just hasn't been relevant to doing a rescue operation'* (Masters, 2010).

Once the second explosion occurred, all hope of survival was lost. Whittall and other Pike managers had to adjust their thinking. Then came the most unfortunate statement explaining this change of position. At the public meeting of media and families of miners, Whittall, who was struggling with the implication of the explosion, stood up and he announced to the families that he had just come from the mine and they were about to mount a rescue operation (RCPRCMT, 2011-2012).

'People stood and clapped. It then became apparent that the wrong message had been given and it should not have been given that way and I had to interject ... 'I do not blame Mr Whittall for the way the message came out. To his best ability and based on the emotion and the knowledge that we'd both just faced, it is my belief it resulted in Peter being unable to confront the task in front of him. It took a lot of convincing for him to even admit that they had gone' (RCPRCMT, 2011-2012, p. 1897 - Knowles, September 2011). So then, Police Superintendent Knowles stepped forward and relayed that there'd been another explosion and that it was not survivable.

This reversal of statements resulted in absolute pandemonium. People were screaming and yelling and directing abuse towards the Police. One woman collapsed and had to be taken away in an ambulance. After this, Whittall and the Police came under severe criticism, once the reality became apparent with no further survivors, and no fresh air in the mine, no fresh air bases, no real chance of climbing out the ventilation shaft that the blast was also using and no working self-rescuers. There were either plans for these things to happen or they were decommissioned, but they weren't the reality at the time of the explosion (RCPRCMT, 2011-2012).

When Whittall was later questioned as to his statements, which seemed to many as giving false hope/optimism, he said, *'I suppose it was personally very difficult because I didn't want to let go of that hope myself ... I still have not changed my opinion that I genuinely believed there was an opportunity for some men, at least, to*

have survived and to come back to us ... I would certainly say that I shared my hope ... until the second explosion, I don't think I was overly optimistic, but I certainly was optimistic. ... In hindsight, it was certainly unfulfilled optimism, as I said, unfulfilled hope. I'm optimistic by nature, and Steve Ellis described himself as an "optimistic realist," I think was his term. I'm not sure that anyone would progress in the mining industry or stay in the mining industry if they weren't in some way optimistic. It's an industry that requires - you're dealing with difficult issues, nature and high hazard environments. You wouldn't work there if you weren't an optimistic person, and I am definitely an optimistic person. But I have also spent my whole career in the industry. I've studied and gained a large number of qualifications. I'm not naive in my knowledge of mining' (RCPRCMT, 2011-2012, pp. 2718-2719 - Whittall, September 2011).

5.2.6 Four key factors

There are four key factors that relate to Pike's three decision-makers being affected by induction and inductive biases. These are:

- **Factor 1: Pike's view - Time 1** (1 July 2007 to 30 June 2010). Over this period Pike's three key decision-makers were risk seekers/takers, as they believed they had a robust reference narrative and were operating with known and resolvable uncertainties. As a consequence of that view, inherent risks were naturally assessed as low, so oversimplifications of complexity were consciously/unconsciously confidently made. Extreme optimism and confirmation bias led to the planning fallacy, resulting in unexpected problems causing serious cost and time delays which caused serious and persistent over promising and underdelivering. Pike's three key decision-makers were stuck in this zone because of the lack of any effective challenge to their way of thinking.
- **Factor 2: Pike's view - Time 2** (1 July 2010 to 19 November 2010), being the period of the desperate need for production. In this period Pike's three key decision-makers were extreme risk seekers/takers, as they were affected by the 'sunk cost' fallacy and were clearly in the fourth quadrant of prospect theory, with

the hope that 'hydro-mining' would dramatically improve production levels, despite all the evidence to the contrary. They were consciously/unconsciously taking a gamble against almost (but not quite) certain humiliation that the whole project was shown to be a 'house of cards'. This collapse would involve loss of deep emotional sunk costs such as personal and professional reputation in a small close-knit community, especially as they promised so much and delivered so little.

- **Factor 3: The actor-critics – Time 1 to 2** were consistently critical of Pike's three key decision-makers oversimplifying complexity, which resulted in significant uncertainty being unrecognised and understated. There was no successful challenge, at any level, to the reference narrative of Pike's three key decision-makers.
- **Factor 4: The hindsight bias** (When previous unknowns are now known) - Hedgehog cognitive thinkers, like Pike's three key decision-makers are masters of the known, as they value the known and certain, and this naturally makes them very poor at foresight (i.e., understanding the unknown). They are especially prone to hindsight bias (Tetlock, 2005), because once an unexpected event occurs or new information (i.e., unknowns) becomes available, and after a period of initial shock, these new facts are incorporated into their thinking since they are now part of the known and certain. This can make them unaware that the new thinking they now have suffers from unrecognised hindsight bias, and this reinforces their view that what is important are 'knowns' not 'unknowns'. Once they are in this position, they then view the new situation through a 'blame' lens, since someone else was at fault for not advising them correctly, rather than a learning lens, which accepts that no one, including the key decision-makers saw it coming. The three key decision-makers are not the only people to be affected by the hindsight bias, as it is reasonable to assume that many ex-post readers of the Royal Commission report will be prone to this same affect. They will be completely unaware of the hindsight bias and how, over time, what is known and certain, keeps changing.

These four factors are summarised in the Figure 5.2, as: over time, the Pike view continues to be influenced by increased cognitive biases, whereas the actor-critics remain fully aware that these biases are creating a disconnect with reality. The hindsight bias is included, since for Pike, this is how their mindset was corrected to reflect surprise events. Unfortunately, their mindset remained in the known and certain part of the uncertainty spectrum.

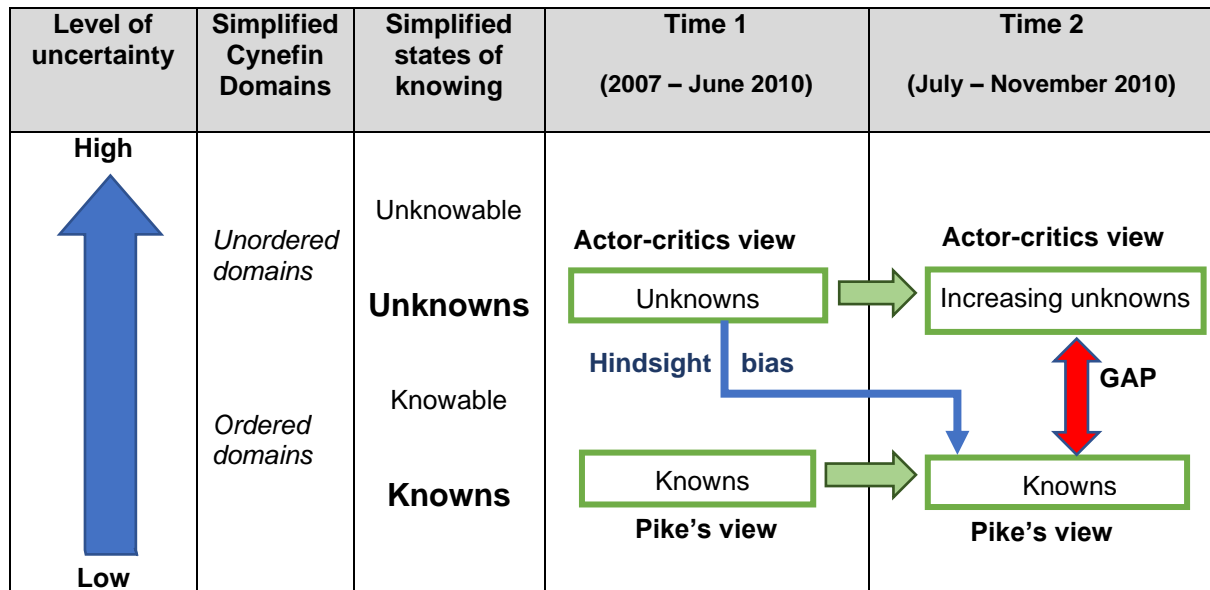


Figure 5.2: The uncertainty spectrum - blinded by induction and inductive cognitive biases

5.3 Pike's three key decision-makers were blinded by a single top-down reference narrative

The simple but compelling reference narrative of Pike's three key decision-makers was that there was 18 million tonnes of premium-quality coal, worth approximately \$4b, that was safe and commercially viable to mine. With ex-post evidence, this can be seen as a flawed and simplified reference narrative because it did not contain all the critical information that was available elsewhere in the organisation or with their consultants. This section looks at why Pike's three key decision-makers were 'deaf and blind' to information that differed from their reference narrative.

5.3.1 Pike's three key decision-makers constructed and defended a simple, compelling, top-down narrative

5.3.1.1 Pike's three key decision-makers had hedgehog cognitive thinking attitudes

Pike's three decision-makers assumed that they had a robust reference narrative based on the known and certain, and they used a number of approaches to defend it from criticism. What they failed to recognise was that the narrative failed to reach the requisite complexity needed for Pike to successfully address the internal/external challenges. Many things that Pike did were counter-productive to increasing the level of requisite complexity of response, as they are examples of hedgehog cognitive thinking (Gardner, 2011; Tetlock, 2005; Tetlock & Gardner, 2015). For example:

- Oversimplifying complexity by actively using the inside view/local rationality which let them construct a compelling top-down, single lens narrative that is neater and tidier than reality, as opposed to being empirical and relying on observations rather than just belief or opinion.
- Oversimplifying complexity by strongly favouring belief perseverance/confirmation bias, as opposed to being active Bayesian belief updaters. This led to being excessively closed minded and made them

especially prone to not learning from the new information/circumstance. New knowledge is used to refine the original model, rather than update it.

- Having a strong top-down management style, with no diversity or dissent. Outside thinking was avoided, as were other views on different tools, information and diverse perspectives. The tensions were managed by strength of personality, position and use of controlling management practices, such as micromanaging and overriding objections.
- An unwillingness to acknowledge other viewpoints or perspectives, their own mistakes or accept blame. This made them confident with the decisions they made, even if to others they were wrong. They never exposed and examined their ignorance or examined the assumptions made, or reflected on past failures and successes.

These points are developed in the following sections.

5.3.1.2 Pike's reference narrative relied on an undeveloped and 'passive trust' management information system

The Royal Commission wrote that, *'Throughout the commission's hearings, witnesses disavowed knowledge of methane spikes, ventilation problems and a host of other signs that suggested all was not well underground. A repeated refrain from witnesses was that no one drew this or that report or data to their attention. Pike's safety management system lacked an essential component – procedures that made specific people responsible for collecting, assessing and responding to safety information. Nor was there a functioning process for communicating information to everyone on a need-to-know basis'* (RCPRCMT, 2012, p. 176, Volume 2).

If there had been good management information systems a number of warning signs that pointed to the risk of an underground methane explosion would have been noticed. For example, for months before the explosion, the underground deputies and workers had reported incidents of excess methane (and many other health and

safety issues). Ex-post this was analysed. In the 48 days before the explosion there were 21 reports of methane levels reaching explosive volumes, and 27 reports of lesser, but potentially dangerous, volumes. The reports of excess methane continued up to the very morning of the tragedy. The warnings were not heeded or reported upwards, and as a consequence of this management blindness, serious harm notifications which are required to be reported to the DOL were not always done (RCPRCMT, 2012).

Pike's reference narrative relied on a management information system where for some key information there was only a relatively 'passive trust' collection/reporting upwards system. Dow believed that if management had a major issue, they would do the right thing and raise it with the board, and that it was not the board's job to check that all major issues were brought to the attention of the board. Dow believed that the board should stay out of the detail of management and so most external reports on a whole range of activities from insurance to production were not presented to the board, not even as summaries (RCPRCMT, 2012). Ex-post, it was found that management had not always raised important problem issues with the board. The board interpreted the silence on problem issues as evidence of no problems existing.

Whittall applied the same logic to his managers and said ex-post that he did not read or request any of the numerous reports being prepared by consultants/agencies on a range of matters such as gas drainage or second egress. These would go directly to the relevant operational department manager and if something was important that he should know about, he relied on them telling him. Managers were expected to be proactive and raise significant issues with Whittall. If none were raised, Whittall would assume that the issues were being resolved somehow, perhaps with other managers. Ex-post Whittall expressed surprise that many of the critical findings within these reports were not reported to him, especially as he knew most of the people who prepared them and talked to them casually. Whittall's response was that, *'Sometimes your officials let you down'* (RCPRCMT, 2011-2012 - Whittall).

5.3.1.3 Pike's three key decision-makers strongly favoured belief perseverance

Pike's three decision-makers were poor Bayesian learners who de facto defaulted to confirmation bias. They consistently refused to update any of the key targets or value propositions, even when presented with new evidence. Over the whole period under review, from the public listing on 1 July 2007 to the explosion on 19 November 2010 the three key decision-makers did not change any of their inherent reference narrative, despite significant evidence to the contrary. For example, there were no changes in the quality and quantity of coal reserves; despite never reaching the required purity in the first three coal shipments; or a loss of potential coal reserves when they hit the 200-metre rock graben which was meant to be coal; or updates of reserves once the in-seam drilling has occurred; or the methane risk was more than low/moderate. The three decision-makers stuck to their reference narrative.

Another area where there was little evidence of learning by Pike's three decision-makers is how they dealt with the various unexpected events that happened before the 'unexpected' methane explosion. In all these examples there is a commonality of issues such as insufficient geological knowledge, understatement of the costs and the blaming of others once things went wrong. Greater initial geological input was what was needed, but that did not happen. Pike went from one surprise event to the next.

There are two specific examples of Whittall not updating his reference narrative as conditions and information changed. One was when Pike's geotechnical advisers, URS, warned about the poor rock quality at the bottom half of the proposed shaft. Their advice was dismissed. The subsequent shaft collapse was a massive financial and production setback. The second example was Whittall's stubborn refusal to replace the expensive Waratah machinery that he had helped specify. It effectively never worked and had very poor productivity. It was only after NZO&G received the Behre Dolbear 2010 report in May 2010 that Whittall was forced to accept a leased ABM20 – a 100-tonne machine - that worked straight away. This shows extreme belief perseverance (and sunk cost fallacy) (Macfie, 2013).

5.3.1.4 Pike's three key decision-makers strongly favoured using only their own single lens

Overall, Pike's three key decision-makers believed they had a strong reference narrative and they saw no reason to search for new thinking or approaches. Their aim was to operationalise their reference narrative, not to rewrite it. As a consequence, there is evidence of avoiding diversity of thinking and approaches. For the entire period under review, Pike had a strong top-down management style, which acknowledged their own considerable experience, but seriously downplayed the experience of others, including shutting down any divergent views, internally or externally. Pike's three key decision-makers seemed to be cognitively aligned throughout the entire period. This may be because the three had different roles and adopted silo thinking, such as Ward looked after the money and reporting, whereas Whittall looked after the mine and Dow dealt with the Board and shareholders.

The Pike mine was run by Whittall and it was run his way. Whittall was seen by some as autocratic, dominating, bullying, micro-managing. It was his way or the highway and that was literally true for many of the 17 senior managers in four key positions (i.e., Technical, Statutory Mine Manager, Production and Engineering) who were joining and then leaving Pike in the last 25 months before the explosion. Whittall's confident views grated with many of his reporting managers. These managers would argue their case but he overruled them and over time they left Pike. This included Renk, Louw, Slonker, van Rooyen and consultants like Bell and Nishioka. Whittall used his high intelligence and position to micro-manage the things he was interested in or where he had to make decisions. What he was not interested in or unaware of, were not micromanaged. There was an unhealthy operating environment, which included a blame culture and the resultant silo thinking, as well as a culture of shouting at management meetings. Dissent was not encouraged (Macfie, 2013; RCPRCMT, 2011-2012, 2012).

Pike workers did not have an effective voice in such a dysfunctional working environment. This was due to multiple reasons, such as Pike's extreme focus on production, high turnover of middle management, the number of inexperienced staff, the large number of contractors, where contractors were managing other contractors,

the number of foreign workers, lack of supervision, poor morale, high absenteeism, lack of training at all levels and the lack of union involvement (RCPRCMT, 2012).

Ex-ante criticism from geological consultants like Dr Cave and Dr Newman, that Pike was simplifying the geological complexity in their models, were curtly rebuked by Pike with comments that they were speaking outside their scope of employment or it was not their role to tell Pike how to mine, or their comments were just ill-informed and inaccurate. (Refer section 4.2.3)

5.3.1.5 Pike's three key decision-makers fostered a blame culture, but accepted none themselves

Pike's three decision-makers believed they had a strong reference narrative, so when this was not being achieved, they became strong on the accountability of others for lack of performance (i.e., the outcome bias). This created a blame culture and silo thinking. Top management blamed staff, consultants or contractors for failures. For example, refer quotes in section 4.2.6 from senior managers such as White, Van Rooyen and Lambley, as well as consultants like Bell and contractors like McConnell Dowell and URS New Zealand. They were blamed by Pike key decision-makers for the 'unexpected' problems with the 2.3km access tunnel and ventilation shaft collapse (Macfie, 2013). Ex-post, both Dow and Whittall blamed management and staff for not telling them there were problems. When Rawiri suggested to Whittall that the mine machinery was the problem for the poor production, Whittall (who had helped design that machinery) took offence and blamed poor worker training, productivity and morale as the key factors. (Refer section 4.2.3) Unfortunately, the three key decision-makers only rarely applied this criticism to themselves.

Whittall thought he was just unlucky and thus not to blame for the methane explosion. For example, as in the five-cherry example in section 5.1. Whittall was clear that none of the mine managers who left prior to the explosion had ever raised concerns with him about unresolved safety issues prior to their departures (RCPRCMT, 2011-2012 - Whittall).

On the day of the explosion, none of the three key decision-makers had any doubts as to their actions, so it is not surprising that ex-post they also had no regrets about the design or construction of the mine. Others may have thought ex-ante and ex-post that there were significant flaws in the mine design and construction, but not the three key decision-makers. (Refer 4.3.2)

In complex organisations, like Pike, Dr Callaghan (University of Auckland) told the Royal Commission that it is important to have a just culture, not a blame culture. Good safety management is like a team sport, as decision-makers never know who's holding an important piece of the puzzle. Normally multiple people are holding different pieces of the puzzle that need to be put together. It is therefore essential to avoid punishing people inappropriately using derogatory language, blaming people, or failing to look at the reasons why behaviour is being undertaken, as they are the antithesis of good safety management. You want an open and honest environment so that teams/people can come forward with issues and the issues are dealt with constructively (RCPRCMT, 2011-2012 - Dr Callaghan).

5.3.1.6 The three key decision-makers told a compelling but flawed reference narrative

Macfie (2013, p. 181) sums up the problems at Pike, as: *'Pike promised the best geological knowledge, the best equipment and the most rigorous safety regime, but they had the worst of everything. They had a regulator that was submissive and unwilling to use the power at its disposal; a board that was incurious, bereft of knowledge and experience of underground coal mining, and unable to see the symptoms of failure; management that was unstable, ill-equipped for the environment, and incapable of pulling together all the pieces of its own frightening picture; and a union that was marginalised and irrelevant.'*

This ex-post assessment needs to be matched against the equally valid ex-ante local rationality position. For example, Macfie's assessment is affected by the outcome bias of knowing there was an explosion and having had the benefit of a Royal Commission to bring all the parts together. Based on Dow/Whittall's unrepentant

attitudes at the Royal Commission hearing, it is unlikely that Pike's three decision-makers would have accepted any of Macfie's comments after the first half of the first sentence. They would say they have successfully operated for at least three years in the current mode without any explosions or other serious problems. The Pike mine was still in the setup phase which had started three years earlier with the building of an entrance tunnel. Important parts to the mine were still being added. The three key decision-makers did not accept ex-ante (and sometimes, but not always, ex-post) that the Pike mine had poor air quality (they had a plan to build a second egress/entrance within a year); that Pike had poor geological information (they had a programme of in-seam drilling to collect more information); that Pike had poor gas monitoring (they had a plan to buy a tube-bundle system); and that Pike had poor equipment (they had just acquired the leased ABM20 mining machines). Pike's key decision-makers had no information that caused them any trouble other than the obvious lack of production. Both Dow and Whittall commented ex-post that people below them had not communicated important issues highlighted ex-post to them ex-ante. They were clear it was the fault of those who had failed to communicate that information to them. They believed that they were on top of the issues that were apparent to them.

It appears from the RCPRCMT findings that the problem for Pike's three key decision-makers was that they had oversimplified the complexity/uncertainty and, while they thought they were making good decisions based on the available information, the information that was available was seriously flawed. It was always going to be flawed because of all the different and incorrect hedgehog approaches they were applying.

5.3.1.7 Challenges to Pike reference narrative and Pike's response

There are two key factors (i.e., challenge and response) that relate to Pike's three key decision-makers being affected by a single top-down reference narrative. These are:

- **Factor 1: Pike's three key decision-makers strongly defended** their single top-down reference narrative. There were never any doubts ex-ante or ex-post. They believed they had a strong and robust reference narrative, with low uncertainty, which made them completely unaware and unconcerned that their management information system was seriously flawed. This made them unaware of the need to revise their thinking and, believing that their reference narrative was so robust, meant they did not seek or value different views or approaches. This made for a very top-down management style with a strong blame culture when performance was not achieved, and where dissent was not appreciated. Since Pike's reference narrative did not match reality, this created cognitive dissonance (Festinger, Riecken, & Schachter, 1956). Groupthink (Janis, 1972) kept the small ingroup together (And kept them blind!) and the conformity bias and organisational silence (Milliken & Morrison, 2003)/obedience (Milgram, 1974) kept the much larger outgroup quiet. This culture of silence/lack of power was helped by having a high number of inexperienced workers, a high number of foreign workers and a high number of contractors. There was a high turnover of staff and management throughout the entire period, which was put down to the mining boom occurring at that time.
- **Factor 2: The internal/external actor-critics** continuously, but unsuccessfully, challenged Pike's reference narrative. If these challenges had been successful, it would have increased the cognitive diversity inputting into Pike's reference narrative, as this would have resulted in some of Pike's assumptions having to change and therefore making the narrative more robust. But this was not to happen, as Pike stuck to its single lens, with no apparent desire for other input. Pike's three key decision-makers (plus their supporting ingroup) were confidently blind ex-ante.

These two trends are summarised in Figure 5.3, being the unsuccessful challenge by the actor-critics of Pike's reference narrative, and the strong defence of that narrative by the three key decision-makers and their supporting in-group. The key feature of Figure 5.3, is the ignoring and/or blocking of dissenting comments, as represented by the deflected arrows hitting a wall.

5.3.2 Pike's board and the NZO&G board were also captured by this narrative

5.3.2.1 Pike's board of directors saw no evidence of any serious problems, so they assumed there were no serious problems

Ex-post, there were numerous issues around the actions of Pike's board of directors. No director had underground coal mining experience. There was no systematic assessment of risk throughout the organisation. The corporate risk management policy required an overall risk management committee, but none was established. Pike did have a Health and Safety Committee, but that had not met for 13 months and was not scheduled to meet in 2011 (RCPRCMT, 2012).

The Pike board did review some health and safety data, such as personal injury rates and time lost in accidents, as they related directly/indirectly to production which was their prime focus. They did not receive or ask for information on high-potential incidents, such as near misses, or information on the effectiveness of gas monitoring and ventilation. The chair believed these matters were the responsibility of management (RCPRCMT, 2012).

Third party reviews of Pike were made for insurance and legislative compliance in 2010, but were not received by the board and they were not briefed on the results, as these were deemed management matters, not governance. The health and safety manager also did not see the reports. The board assumed that if management saw a problem, then they would brief the board. The board assumed that issues were under control, unless told otherwise. This was an unwise policy (RCPRCMT, 2012).

Pike's board of directors failed to deal with cognitive biases

Presenting a rosier situation than the facts allow can be construed as either a masterpiece of spin or is the result of judgement bias, or a lack of challenge affected by optimism and confidence bias (Moxey, 2019). Based on the fact that all the Pike directors and the key decision-makers were all surprised by the events, it is reasonable to assume that cognitive biases were at play. It is clear that Dow, Ward

and Whittall, who seemed to work well together, all suffered from optimism, overconfidence and misguided self-assurance. Optimistic judgements led to the annual reports presenting an over-optimistic picture.

Within the Pike board of directors there seemed to be no dissent. For most of the meetings, all three key decision-makers were present, but not all directors who should have been there were present, as the two Indian directors were often absent and Radford would only skype in from Australia. Noting that the three key decision-makers were all strong personalities in their different ways, once they agreed something, the Board followed, which could indicate groupthink, especially if other board members had a focus on fundraising activities.

Another bias that was evident was the confirmation bias, where decision-makers rejected (with little consideration) any information which challenged their position but relied on information which supported it. Confirmation bias with optimism and confidence bias, can be a toxic combination. Moxey (2019) believes it is the responsibility of the board as a whole to question whether cognitive bias is affecting them and ensure their decisions are unaffected. One approach is for the board to imagine scenarios where a crisis affects the company and then considers the root causes of failure. This is known as a premortem (Klein, 2007), and helps to remove bias.

Moxey (2018) believes that whether or not a company thrives or fails is down to the leadership of the board and particularly the chair and the CEO. CEOs are paid to be optimistic and take calculated risks. It is largely up to the board chair to ensure that this is in pursuit of long-term value creation and that the board sufficiently understands the risks being taken or faced, and provides proper checks and balances. In this regard, Pike's chair failed completely.

5.3.2.2 Can shareholders correctly interpret reality from exaggerated optimism and ‘spin’?

In many companies that experience a black swan event, such as a major financial collapse or, in this case, a mine explosion, there is always the question of how could this event have happened in what looked like a well governed company? After all, Pike gave the impression of being financially sound and claimed high standards of corporate governance, with rigorous risk management, and excellent health and safety policies and training. Pike’s Annual and Quarterly Reports strongly conveyed a picture of a well-governed progressive company, with a state-of-the-art mine that was a showcase for modern sustainable mining in New Zealand. This raises the problem that it is difficult to tell from public statements a well-governed healthy company from a company where the board misguidedly believes it is well governed and healthy (Moxey, 2019; RCPRCMT, 2011-2012).

When dealing with a company that has experienced a black swan event, there is a difference between active and passive major investors. For example, it was found in the 2018 British Carillion plc collapse that an active investor who had a programme of regular engagement with the company, had reduced its holding prior to the black swan event. It did not like what the company’s management told them in response to their questions on performance. That investor had sold all its shares before the bad news was announced. Another major investor relied purely on the optimistic public information from the company and they were completely surprised and lost heavily (Moxey, 2019). In Pike’s case, all investors were effectively passive until five months before the explosion when NZO&G was required to take a more active approach, including taking over a \$40 million loan, that Pike would otherwise default on. NZO&G now wanted to sell down their shares, but were waiting until after the November 2010 share issue to do so. Without direct access to the executives, it was not obvious ex-ante to most of the other 5,000 shareholders and stakeholders that there were serious problems, over and above those reported.

5.3.2.3 The first and only serious challenge to Pike's reference narrative

NZO&G had managed to put pressure on Pike to dismiss the CEO (Ward) in September 2010 because they were the largest shareholder and had the benefit of the Behre Dolbear report 2010, which outlined multiple fundamental problems. The Pike board then voted unanimously to appoint Whittall as CEO without considering any other internal/external applicants. NZO&G should have requested greater cognitive diversity and coal mining experience on the Pike Board to challenge the board chair and CEO. The Pike board consisted of only seven directors, of which two were already from NZO&G (i.e., Radford and Dr Meyer), two were the independent chair (Dow) and Pike's CEO, the two Indian coal company directors did not always attend and the last person was an independent director. It seemed a very passive board and there was little or no challenging of the 'inside' reference narrative. If we look ex-post, then one of the valuable results of the Royal Commission was to require codes of good practice for directors, management and for worker participation. In the future, if all the powers of the various stakeholders are increased, they can then apply more pressure on any future 'strong boss'.

Some blame can be apportioned to the Board of NZO&G who did not change/rotate their two directors on Pike, to provide more challenge at Pike's board meetings from mid-2010, when they realised Pike was in significant, financial and production difficulties. NZO&G were caught by a human blind spot with their own 'baby', as well as being caught in Pike's sunk cost fallacy as they were publicly backing Pike going out to shareholders for another \$70m at the time of the explosion. This money wasn't going to be used to solve any of the underlying problems, it was purely to pay the costs of continued 24-7 hydro-mining, i.e., more of the same – poor coal production, from poorly performing machinery, with high methane levels, the same inexperienced staff and the same key decision-makers (i.e., Dow and Whittall). The commercial assumption was that once Pike got significant coal income Pike could pay for all the missing parts in the overall system. Failing to address any of these significant issues, made what happened or something happening, more certain.

The two NZO&G directors on the Pike board, Radford and Dr Meyer, both had a long-term association with Pike, as the first chair of Pike (Radford) and as a director

from 2000 (Dr Meyer). They were the people who hired Ward from 1998 to develop the idea of mining coal at Pike River and to turn it into reality. While we do not have any information on what they thought about the explosion and its causes, it is reasonable to assume that they were actively part of developing Pike's 'inside view', and that some of Ward's subsequent views were shaped by his NZO&G/Pike bosses. NZO&G had a governance problem of needing to change the two long-time directors (being NZO&G's Chair/deputy) to more active directors, which if left to themselves, they would not have even considered, noting they would be judging themselves.

What we do know from Macfie's interview of Salisbury (Macfie, 2013) is that Radford and Dr Meyer had to act in the interests of each company. So when NZO&G discussed Pike, both directors refrained from passing on any knowledge they had of the mine's operational and management struggles to the NZO&G board. That meant the remainder of the board and executive were in the same situation as other investors – reliant on Pike's upbeat statements to the sharemarket for information on how the mine was progressing. At the time, in early 2010, Pike represented about one-third of NZO&G's market capitalisation.

Dr Meyer (aged 78 in 2010) had signalled in NZO&G's 2010 annual report, dated September 2010, that he intended to retire from the NZO&G Board at the 2010 AGM (NZO&G, 2010). He retired from the Pike board in December 2010. He had told Dow in mid-2010 that he wanted to retire (RCPRCMT, 2011-2012 December). Other directors retired from Pike in September 2011. Radford was 72 in 2010.

It seems that the key players in NZO&G and Pike, who the public shareholders relied on for good governance (i.e., making the tough decisions) were all captured by their collective inside view. The NZO&G/Pike actions were too measured, even if they did eventually dismiss the Pike CEO (Ward), who was one of their own and had developed the project from a concept to reality. This was all the Pike board and presumably the NZO&G board, considered necessary, based on the filtered information they received. This was a problem and only some sort of 'event' was going to change the status quo, since nothing else had. The unfortunate consequence of the two boards not wanting to rethink or kill the Pike dream (i.e.,

their ‘baby’), was the death of 29 miners. It wasn’t so much that the two boards made bad decisions on the information they had, what they had wasn’t all the information they needed and they seemed completely unaware and unconcerned about that.

A collectively agreed inside view is the exact opposite of having the desired (for good decision-making under uncertainty) cognitive diversity. Organisations often lack cognitive diversity and it is one cause for why organisations fail, for example, ex-post, Enron was noted for its lack of cognitive diversity (Dekker, 2011). Diversity of views can push decision-makers out of their comfort zones. In hindsight, the Pike board seemed to get on very well with each other and for the three years up to the explosion, they had operated in their collective comfort zone that was too cosy.

Dismissing Ward two months before the explosion was a start, but not sufficient for any real progress, with two of the three key decision-makers holding their pre-existing views and continuing to hold most of the collective decision-making power throughout the history of the project. The lack of diversity of thinking and approaches was metaphorically and literally fatal for Pike.

Commenting ex-post on Whittall’s promotion to CEO, Salisbury, the Managing Director of NZO&G, stated that he was surprised that Whittall was the replacement, as he considered Whittall as much the problem as Ward. This statement by Salisbury needs to be taken as a hindsight reflection of what he actually thought about Whittall, since it conflicts with what Dow and Whittall remember was said at the time. Further, it conflicts with how Pike’s two NZO&G directors (Radford and Dr Meyer) also acted at that time, as they voted unanimously to appoint Whittall as CEO. This act does not align with any loss of confidence in Whittall (RCPRCMT, 2011-2012 - Whittall). Ex-post, Salisbury was right that both Whittall and Ward should have both left Pike to allow for fresh thinking. Perhaps with even more foresight, all three key decision-makers should have gone, because the fresh thinking needed to start at the very top. It may be inferred that both boards of Pike and NZO&G were blinded by the same cognitive biases.

A consequent view might be that this is a case where if you cannot ‘change’ the key decision-makers (i.e., their belief system), you have to ‘change’ them (i.e., by

replacing them). If shareholder governance had proactive or activated, and both Dow (Independent chair) and the new CEO (Whittall) were either replaced or side-lined, change could have happened. That is an inherent governance choice, but only NZO&G had the power to do this ex-ante and this was unlikely noting the support for the Pike reference narrative.

The ex-post reaction to Pike's relentless single-minded focus and reference narrative for coal production at all costs (since production was so low), was that Pike needed to 'stop, rethink and correct'. This view was advocated ex-post at the Royal Commission of Inquiry by an experienced Australian mine manager and mine safety expert. He suggested that if he been Pike's mine manager, as a prudent manager he would effectively have said, "*Let's stop production. Let's sort out these matters of egress and of ventilation and of gas monitoring and of gas drainage before we go into production*" (RCPRCMT, 2011-2012 - Reece).

Unfortunately, it is unclear who in Pike ex-ante would have been able to do this, as it cut directly across the sunk cost fallacy views of Pike's three key decision-makers and the board. Ex-post it has been concluded that Pike had a weak senior management team, a weak regulator and a very weak union. After three years of big promises, and having spent more than \$300m, the three key decision-makers were unlikely to have admitted they were wrong, as the reputational damage for everyone, especially to them would have been too high.

5.3.2.4 Pike's board of directors failed to deal with the inherent complexity

There were three questions the board should have been asking in relation to the mine: Was there actually enough coal to be commercial? Was that coal extractable? Was it safe to do so? Based on the ex-post public evidence from actor-critics, there is doubt about the answers given to all three questions. Pike always had a strong focus on coal exploitation, and to have successfully achieved this meant that they should have spent a lot more time and effort on the 'explore' phase as early as possible. It is difficult to build a mine over three years and then start assessing the quantity, quality and safety of getting the coal out, when all the money has been

spent. At that point in the Pike operations, there was no spare money, no spare time and no mood for change at the board level (RCPRCMT, 2011-2012 - White).

The RCPRCMT report suggests that there were too many significant problems that Pike had not addressed. Moreover, they were living at the peak of a Chinese-created coal price bubble. In hindsight, it was only a matter of when they should have wound up. Within a year or so of the explosion the world coal price crashed and this would have ended Pike's mining dreams. The decision on whether to continue or not was made for Pike by the explosion of November 2010, when all mining ceased.

Tetlock and Gardner (2015) believe that when using counterfactual 'what-ifs', the most incisive alternative narratives/histories come from only tiny tweaks, which yield big changes. Close-call counterfactuals portray what happened as highly contingent, hence unforeseeable. This view is based on a belief that people's fate is a product of a string of extraordinary coincidences. This view is therefore the polar opposite of the hindsight bias which heavily affects hedgehogs thinkers, as that portrays what happened as, in retrospect, inevitable, hence something one should have foreseen (Tetlock, 2005). In Pike's case, instead of Pike's three key decision-makers being hedgehog-like cognitive thinkers, supported by their board, the 'what if' question is, would the accident have occurred if they had a mix of fox and hedgehog cognitive thinkers rather than what seemed to be all hedgehog-like cognitive thinkers? That is partly unknowable, but the journey and choices made would have been completely different. Tetlock suggests that foxes are better at dealing with complexity and uncertainty and that describes the situation operating at the Pike River mine. If more thorough and systematic scenario analysis had been undertaken consistently during the mine development phase, and the CEO and the Board had responded to the advice they received from 2007 onwards, then it is quite likely the disastrous accident may have been averted. It is noted that under that scenario production would have been greatly delayed, and given the subsequent international crash in price, may have involved closing the mine subsequently - but all this would have avoided a disastrous accident.

Whilst this subsection considered why the Pike and NZO&G boards seemed to be blind and deaf to the potential of a black swan event, the next section comes to a

conclusion, and puts all three cognitive blindnesses together to answer the research question.

6. Conclusions

The previous chapters have explored the management decision-making leading up to the explosion at the Pike River mine, through the lens and related perspectives of the uncertainty spectrum framework. This chapter brings the different threads together to answer the research questions, to reflect on research boundaries and research contribution, and to consider further research and subsequent use of the research findings and practice

6.1 The research questions

6.1.1 Linking the research question to the overall context of strategic drift

Pike River Coal Ltd's (Pike's) three key decision-makers were operating in a situation that aligned with the notion of strategic drift as defined by Sammut-Bonnici (2015). Strategic drift occurs when cognitive processes and management assumptions are unable to acknowledge or to shift with changes in the external environment. Drift is a reflection of a static outlook, which over time becomes more distant from the reality of shifting operating conditions. Strategic drift is a form of cognitive sloth reflecting the inability to update the original objectives of an organisation to meet the shifting reality. Symptoms include, homogeneous mind set at managerial and board levels; preservation of the status quo mind set; lack of focus on the external environment and decline in performance (Sammut-Bonnici, 2015). Pike suffered from all these symptoms and therefore failed to prevent the wearing out of an organisation's reference narrative, which included Pike's overall strategy and provide a constant check on the compatibility of internal strategy making and external variables. The solutions to the strategic-drift symptoms (Sammut-Bonnici, 2015), which Pike also failed to address, includes:

- **Encourage diverse perspectives**, such as diversity in managerial culture, skills, and perspectives to avoid the build-up of a homogeneous mind set.
- **Champion innovation**. Reward and incentivize initiatives that bring about positive change in the organisation's processes and discourage managerial behaviour that is intolerant of innovation.

- **Promote an external focus.** This can be done through a coordinated flow of information for decision-makers and influencers within the organisation.
- **Use industry benchmarking** to challenge prevailing assumptions.
- **Monitor performance.** Failure to meet objectives is a clear signal that the company is misaligned with external realities.

The research gap in relation to black swan events is not what happens when strategic drift connects with a black swan event, or the symptoms and solutions for strategic drift, but why do otherwise good boards and management teams get into this cognitive sloth that causes strategic drift that results in a black swan event. The research question asks why key decision-makers failed to foresee, listen to or act upon a black swan event? The answer lies in, but not exclusively to the three types of organisational bounded rationality which this research explored. All three forms of organisational bounded rationality actively work to make a fixed and time bound organisational reference narrative, which may lead to strategic drift and therefore the potential for a black swan event, being a surprising extreme event relative to the organisation's knowledge/beliefs.

6.1.2 Linking the research question to the other research constructs

The key research question was: ***Why did the key decision-makers in Pike River Coal Ltd fail to foresee, listen to or act upon the black swan event?***

Pike's three key decision-makers behaved in a manner described elsewhere by the philosopher Nietzsche, of having the courage of their convictions, but not the courage to challenge and change them (Kaufmann & Nehamas, 2013).

With the benefit of hindsight and a Royal Commission of Inquiry, we can determine that Pike's three key decision-makers believed that they were operating under the resolvable uncertainty of Cynefin's ordered domains, rather than the alternative of operating under the radical uncertainty of Cynefin's unordered domains. Their collective mindset of the world they were operating in, while to them was coherent, was flawed. This resulted in Pike consistently using inappropriate methods and

approaches in dealing with complex issues. Individually and collectively they displayed what Tetlock (2005) calls strong 'hedgehog' cognitive thinking, which predominantly focuses on the known and certain. This is a cognitive thinking style for decision-makers that can be highly inappropriate when dealing with high uncertainty and complexity. This cognitive style oversimplifies complexity and uncertainty without understanding that by doing so, it may overlook or under appreciate uncertainty and risk. Some of these cognitive simplifications involved inductive biases, such as the optimism bias, the planning fallacy, the sunk cost fallacy, confirmation bias and extreme risk taking of the fourth quadrant of Prospect theory.

Pike's collective decision-making resulted in a flawed reference narrative, that favoured 'exploit' approaches rather than 'explore' approaches; that favoured the inside view rather than the outside view; that favoured the top-down approach over any internal/external diversity of thinking, approaches or attitudes; and there was little evidence of organisational learning. The three key decision-makers held strong views that didn't change quickly, despite the contradictory evidence. They demonstrated over-confidence in this simplified, but flawed reference narrative or collective mindset. Ex-post, it is clear that they were the wrong people using the wrong cognitive and management approaches to the complexity of the Pike mine operations. Their hedgehog thinking contributed to them becoming almost 'wilfully blind'. This made them particularly vulnerable to surprise black swan events, such as the methane explosions at the Pike River coal mine in November 2010. Since it was hard trying to change their beliefs, all that could have been done was to replace them. Unfortunately for Pike, this was not able to happen before the explosion.

An alternative, and in hindsight, more appropriate approach would have been for Pike's key decision-makers to adapt, right from the start, a fox-like or a mix of fox/hedgehog cognitive thinking styles, to avoid oversimplifying complexity and uncertainty. Those embracing a fox cognitive thinking style can be less fixated in their opinions than hedgehog thinkers. They embrace diversity of thinking and approaches with a mindset that continually challenges the reference narrative, that uses for example, scenarios to keep options open. This makes foxes far more aware of black swan surprises (positive/negative).

Whilst both foxes/hedgehogs are capable of changing the existing reference narrative, it is likely that only foxes with higher awareness of uncertainty/complexity will consider a paradigm shift, where the reference narrative itself needs to be radically changed to align better with the emerging reality. While Pike was operating in a situation of high complexity and uncertainty, there was no one on the board or senior management who demonstrated fox-like cognitive thinking, and/or the necessary organisational authority to successfully challenge and overturn the collective thinking of the top team. The three key Pike decision-makers tried to stabilise the operational turbulence, adhering to their reference narrative, which would be appropriate in more certain situations. However, they should have intentionally increased the diversity of cognitive thinking to better address the emerging complexity and to ensure greater alignment with the emerging reality (i.e., avoid strategic drift). Like most organisations in a crisis, which for Pike was at least for the three years it was publicly listed, Pike focussed on constructing a single, perfect plan. They felt they did not have time for alternative options. Overwhelmed by complexity, it appears they shrank their options just when they needed their focus to go broad (Heffernan, 2020).

Overall, the chosen Pike coal mining proposal was a 'single big bet' in a complex environment, with high risk. It involved setting up a coal mining company for a single mine, rather than drawing on the resources of an established company or mine operator. The 2010 mine explosion was completely unexpected by the key decision-makers. It had tragic consequences for the 29 who died, and all those involved. It was an economic blow for Pike's shareholders, the local community and for New Zealand as a whole, and many wondered how this accident could occur in 2010 (i.e., modern times).

The second and consequential research question was: ***To develop a conceptual framework to assist key decision-makers and other stakeholders to better manage their organisation's avoidance of potential black swan events.***

In response, the study has evolved the development of the uncertainty spectrum and enhanced understanding the importance of the reference narrative. When operating under uncertainty, decision-making is not based on a calculation of probabilities, but

plausibility on weighing up the credibility and coherence of competing narratives. The key to managing risk is the identification of reference narratives which have the properties of robustness and resilience (Kay & King, 2020). Pike's three key decision-makers (with their supporting Pike/NZO&G boards) exhibited 'hedgehog' cognitive thinking style that produced a flawed reference narrative which was neither comprehensive, robust or resilient. Unfortunately, they acted to defend this narrative from internal or external challenge. Overall, the flaws included unrecognised uncertainties, unchallenged cognitive inductive biases as well as an unchallenged reference narrative. This limited Pike's collective intelligence to that of a small number of people at a time when the collective intelligence could have been expanded, to include for example, all staff and consultants. This is summarised below in Figure 6.1.

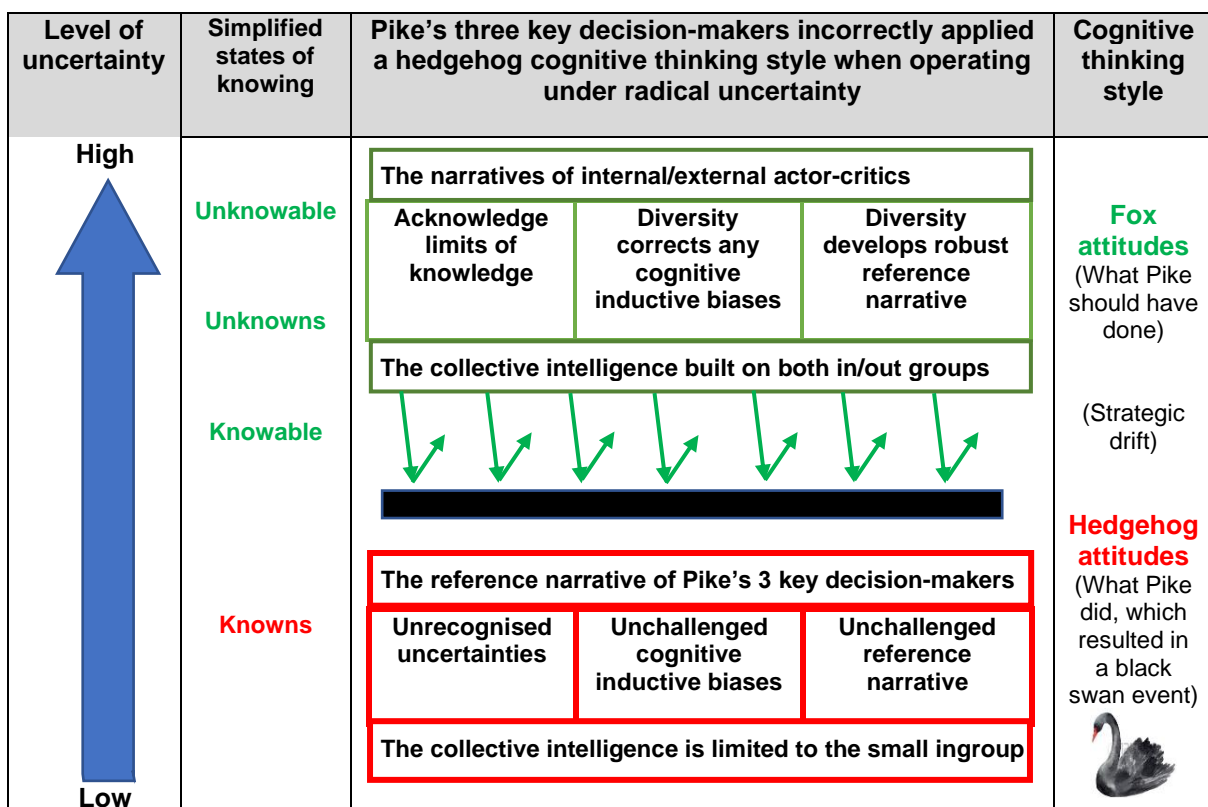


Figure 6.1: Pike's three key decision-makers were blinded by hedgehog cognitive blindesses

The three hedgehog cognitive blindesses (being forms of organisational bounded rationality) identified in this research, and summarised in Figure 6.1, provide an

important visual conceptual framework that can assist key decision-makers and other stakeholders, to better manage their organisations and avoid potential black swan events, being '*surprising extreme events relative to one's knowledge/beliefs*' (Aven, 2015).

There are a number of general observations about the need to challenge the collective reference narrative. These include:

- Since the reference narrative is inherently a collective one, within an organisation or group, there will be individuals within that group who are more visionary than the collective and will see well ahead of the majority of the need to update the collective mindset.
- Changing or challenging a dominant reference narrative takes courage and confidence, since challengers are rarely welcomed and the machinery of the organisation or government works against them. Examples of extreme whistle-blowers would be Dr Daniel Ellsberg (1971 Pentagon papers) or Dr David Kelly (2003 Advisor to the UK Prime Minister). Whilst history says they were correct in their message, it was not well received by the dominant narrative and they received considerable public criticism.
- Reference narratives exist where ever there is group decision-making, so strategic drift has wide potential applicability, especially across business, politics, religion and science. Black swan events are the natural consequence of getting too far away from reality and reality is always partly in the unknown domains.

6.2 Research boundaries

All research is constrained by one or more limitations/boundaries (O'Leary, 2014). This research has been constrained by a number of boundaries such as the time allowed for completing a PhD thesis; restricted scope, e.g., 'group' decision-making was not examined; a small sample size, being one complex exploratory case study; restricted access to Royal Commission records; and the inherent limitations of thematic analysis and emergent design. The research was undertaken with full awareness of the inherent problems of analysing past events, especially the need to address hindsight and outcome biases.

6.2.1 Limitations in access to information

The information used has been the publicly available primary documentation from Pike's quarterly/annual reporting to shareholders and from the Royal Commission website, that includes its final report and a complete set of hearing transcripts. It also includes secondary sources such as articles and books written about Pike. These sources also included primary data from numerous actor-critics interviewed either as part of the Royal Commission process or in a follow-up process, as part of writing a book. These sources provided the basis for understanding the positions taken by Pike's three key decision-makers and the actor-critics at different times. However, there are gaps, where some key actors were publicly silent. For example, Ward (former and long-serving CEO) and all Pike board members except for Dow (the Chair) and Whittall (the new CEO and former General Manager – Mines). Their ex-post views are not known or publicly available.

While the individual submissions to the Royal Commission were not made public, as they are embargoed for 100 years, they were available to the various counsel, including those working for the Royal Commission. During the Commission hearings, they quoted large extracts from different submissions, especially from the more detailed submissions of different corporate stakeholders. It is reasonable to assume, that those counsel had assessed the most important points for their cross-examinations and defence. The voluminous hearing transcripts, where they referred

to these submissions, were publicly available on the Royal Commission website. Noting that, not everything in the submissions were therefore made public, so there is an unknown gap in what may be publicly available key information.

6.2.2 Limitations of the research approach, i.e., the problem of induction

The research used thematic analysis to search through data to inductively identify interconnections and patterns. Patterns were then analysed and explored as potential themes (O'Leary, 2014). The researcher as bricoleur, using abductive reasoning, gathered disparate evidence to develop the best explanation or narrative account of this unique event. As themes coalesced, the next level of abstraction built the uncertainty spectrum framework. This was an emergent process.

A stated weakness associated with induction, as noted in section 2.3.3 of the framework construction section, is that the researcher may only see white swans, because they are the only swans present, and the researcher therefore assumes (based on that evidence) that all swans are white. What is 'absent' from the data may be very important, so research is only as good as the information currently available. New information could potentially change one or more assumptions/assertions. However, throughout the research, there have been some consistent and (from an evidence viewpoint) stable trends. For example, the risk assessments of the three key decision-makers were always lower than the actor-critics, who thought there was considerable complexity and uncertainty unaddressed. As such, the emergent pattern shows a cluster/swarm of factors with potential red flag warnings. (Refer Table 4.13: Summary of red flag warnings of high uncertainty of achieving objectives). We note that adding or subtracting any red flag factor will not change the overall pattern of high inherent uncertainty/complexity.

6.2.3 Limitations of the uncertainty spectrum framework

The uncertainty spectrum framework is a useful way of showing a number of constructs matched against the level of uncertainty, but it does not show these constructs matched against the level of uncertainty over time. The research therefore used Dekker's drift over time charts to show trends over time.

6.3 Research contribution

This research contributes to theoretical, methodological and applied aspects, for example, by:

- Developing a new theoretical perspective.
- An applied/practical contribution, by providing new insights into the Pike River coal mine disaster.
- An applied/methodological contribution, by providing a new framework for decision-makers to use ex-ante and ex-post, in analysing the consequences of their decisions.

6.3.1 Theoretical contribution

The research makes a unique theoretical contribution to the literature on decision-making under uncertainty. It does this by developing the uncertainty spectrum framework, which highlights diagrammatically the problem of hedgehog cognitive thinkers being surprised by black swan events, when they are operating in a complex and uncertain environment. It notes, by contrast that fox cognitive thinking approaches to highly certain situations can be wasteful of organisational resources.

The individual conceptual threads or lines of thinking used in this research have been developed and explored by others (refer section 1.1.4) and they come from a range of different literatures. What is unique in this study is that these different conceptual threads have been teased together into a flexible and visual conceptual framework. The resulting framework guided the researcher's interpretation and subsequent conclusions that may not have been possible by just using the different individual conceptual threads and perspectives.

The conceptual framework is both flexible to construct and is simple and understandability. It weaves together different, but related, conceptual threads in various ways. For example, it uses the uncertainty spectrum chart to describe and interpret the different uncertainty dimensions of the physical environment. This

process draws on some or all of: the Cynefin sensemaking framework (Snowden & Boone, 2007); the four states of knowing (Boschetti, 2011); types of cognitive thinking styles; and alternative approaches to probability. Sometimes a simplified Cynefin description (i.e., unordered, and ordered domains) or simplified states of knowing (i.e., knowns, knowables, unknowns and unknowable) is sufficient.

To guide interpretation, it also weaves the conceptual threads together is through the lens of the fox/hedgehog framework (Tetlock, 2005), as a means of understanding the two broad types of decision-makers. In using this framework, attitudes to uncertainty are highlighted and emphasised. It does this, by complementing the uncertainty spectrum framework, with a variety of different but interconnected concepts, such as: separating out fox versus hedgehog cognitive thinking (Tetlock, 2005); highlighting the challenge/response to the reference narrative (Kay & King, 2020); black swan events (Taleb, 2008a); the illusion of certainty (Gigerenzer, 2014); inductive cognitive biases (Kahneman, 2011); emphasising what is knowable and what is unknowable; and factoring in the dynamic of time, where time-related factors such as the hindsight bias can be noted.

Weaving the conceptual threads in this manner generates a conceptual framework that draws attention to the states of knowing (i.e., what we know and are aware of and what we do not know), overlaid temporarily onto other factors, such as retrospection/prospection, as well as the various concepts detailed above.

6.3.2 Applied contribution: to provide new insights into the Pike River coal mine disaster

In comparison to other mainly single lens examinations of the Pike River Mine disaster, this study used a multiplicity of lenses. This resulted in different observations, perspectives and conclusions being made about what happened at Pike River and insights about why key decision-makers failed to foresee the potential black swan event. A dominant view of what went wrong at Pike River is that management placed production over safety (RCPRCMT, 2012) and the implicit assumption taken by many analysts and observers is that 'someone' should have

said 'stop operations' before the explosion. There are a number of difficulties with this dominant view, not least, that it is the norm for business organisations to always put achievement of commercial/primary objectives first, before other important, but secondary matters, like health and safety, staff training and culture etc. in addition, this dominant view does not take into account the effects of staff obedience (Milgram, 1974), conformity and organisational silence (Milliken & Morrison, 2003), negative organisational responses to whistle-blowers (Lennane, 2012), and agency theory, or that as a corollary most organisations value staff who get on with the job, not those who publicly challenge senior management.

6.3.3 Applied contributions: by providing a new framework for decision-makers to use ex-post and ex-ante

An important high-level applied contribution was the actual approach to developing the conceptual framework. This theoretical contribution linked directly to an applied contribution, as theory and practice became highly interrelated. This set up a cycle of refinement of theory development which linked to the case study, which further refined both the case study and the theory, in an iterative fashion, throughout the period of research.

The conceptual framework developed in this research has a much wider practical contribution than considering the decision-making at Pike River, in as much as it provides an additional framework for both ex-post and ex-ante analysis of business and public policy decision-making under uncertainty. For example:

- Ex-post analysis of surprise events of consequence, especially where there is a need for a public inquiry. The framework would add to other approaches by considering the decision-makers and their reference narrative ex-ante; their attitude to new information and challenges to their reference narrative; and an awareness of cognitive thinking styles and biases (the hedgehog cognitive blindnesses) that impact judgement and decision-making. The framework provides a different and additional set of lenses for reviews of decision-making failures, including historical disasters such as the Fukushima Tsunami and

Nuclear Accident 2011, 911, and the failure of the U.S. Space Shuttle *Columbia* in 2003. The framework is not limited to physical disasters, as it could equally apply to ex-post analysis of decision-making under uncertainty in major political decisions. For example, going to war in Iraq/Afghanistan, where at face value, the uncertainty/complexity was misjudged by American decision-makers, there were strong cognitive biases applied (i.e., optimism, planning fallacy and sunk cost fallacy), and a confident, consistent but flawed reference narrative existed. The 'surprises' that followed meant that extra time, money and resources were needed above initial estimates. This framework sheds light on why the key decision-makers failed to foresee the subsequent surprises.

- Boards/management should include both fox/hedgehog cognitive thinkers, when there is the possibility of uncertainty/complexity. Both types of thinkers can add value, but since boards need, among other things, a future focus, with awareness of high-cost, low-probability events, having one or more fox-like cognitive thinkers is critical.
- Highlighting the importance of ex-ante decision-making under high uncertainty/complexity, and the need to amend the reference narrative as required. In this situation the decision-makers should be doing more than monitoring their reference narrative. New information and new interpretations of that information will mean that the decision-makers will need to actively revise their reference narrative. At some stage, if the complexity/uncertainty is high, then decision-makers must be prepared for a paradigm shift in thinking and a complete revision of their reference narrative. Despite the popular view in business/government, which uses phrases such as 'thinking outside the box' and 'seeking a paradigm shift', there is no evidence in business, public policy or science that people actually like disruptive change that comes from a paradigm change. The actor-critic proposing the paradigm shift has to be confident in dealing with active hostility from all parties. Paradigm shifts in science also result in considerable emotional turbulence, as evident in the lives of great scientists, e.g., Darwin, Einstein etc. They had to endure considerable hostility from those who believed the existing reference narrative and were unhappy with the

proposed paradigm shift. The Pike case study was an example of how the necessary 'paradigm' shift was suppressed, which lead directly to a significant surprise event occurring.

- The package of lenses used in this research could be applied to past or future Commissions of Inquiry that involve disasters. This is especially so, if there is evidence available to the Inquiry of a strong actor-critic involvement ex-ante, to establish if strategic drift had occurred and that the relevant board/management had a relatively static reference narrative inducing a blindness that was a contributing cause to the black swan event.

6.4 Next steps

Normally most qualitative research, particularly exploratory and inductive qualitative research based on a single case study, has the challenge of understanding the generalisability and transferability of the findings. This is not perceived as a problem for this thesis, as outlined above. The research has relevance for all business and public policy decision-making under high uncertainty and complexity, where there is a high risk of unexpected events occurring. It can be used as a means of assessing the utility and transferability of the uncertainty spectrum framework to other contexts and other decision-makers, in both ex-ante and ex-post setting, the next step would be to apply the uncertainty spectrum framework to another completely different application.

The conceptual framework developed in this thesis naturally draws itself to the current worldwide challenges of COVID-19. The current COVID-19 pandemic is a major disruptor or black swan event, with grounded planes, and effectively the short-term cessation of international tourism and foreign students. There is great uncertainty across a range of areas, for example: there are unclear but emerging medical effects of 'long COVID', various supply chain problems of the volatility of oil/gas supplies/prices, labour constraints, lack of availability of silicon chips, vaccination concerns around new and more aggressive COVID-19 variants and problems with all 'just-in-time' inventories.

The framework developed in this thesis provides for fox-like cognitive thinking to be used by decision-makers in complex and uncertain situations. The alternative hedgehog cognitive thinking style, if used predominantly by key decision-makers, increases the potential for some form of surprise negative black swan event, to occur 'unannounced' and to be harmful as was the case in the 2010 Pike River coal mine disaster.

Whilst the PhD thesis is a one-off study, it potentially provides a consequential cornerstone for a rich future research agenda.

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