THE IMPACT OF VISUALIZATIONS IN PROMOTING INFORMED NATURAL RESOURCE DECESIONS

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ABSTRACT

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The research in this dissertation was conducted in order to understand the ways in which scientific visualizations can influence the decision process of non-scientists. A wide variety of classical and novel methods were used in order to capture and analyze the decision process. Data were collected from non-scientists through role-play interviews on an interactive whiteboard, as well as a desktop eye-tracking device. These interviews were analyzed through qualitative content analysis, cognitive mapping decision analysis, and computerized network analysis. In the natural resource scenario given to these participants, these numerous techniques show that map style images promote the most complex, informed, and efficient decision strategies when compared to other visualizations or plain text.

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Dissertation Introduction

The aim of this study was to assess the differences in human reasoning caused by differences in the mode of display of relevant information during the decision process. The water resource allocation scenario in which research participants were asked to reason through is highly relevant for the earth sciences. The findings herein provide insight into best practices for geoscientists wishing to disseminate their research with non-scientists. In particular, this study compares the effectiveness of different visual representations at promoting informed policy decisions on environmental issues.

Two populations were studied in this research. The first three chapters describe the findings from role-play interviews of 42 non-scientists recruited from the public. Participants were asked to assume the role of a decision-maker and choose whether or not they will accept a water resource trade. All participants were given the same scenario and the same economic and water resource data. However, participants were broken into one of four experimental groups. One group was presented the information on a geographic map, another in a cross-sectional profile, another on a box-and-arrow schematic, and the other given the information in plain text. While participants utilized the displayed information to make their decision, they were instructed to think aloud their thoughts as they come to mind. This produced rich verbal data to be analyzed.

Chapter 1: This chapter thoroughly outlines the interview methodology and the study population. The verbal data collected from think aloud interviews was transcribed and qualitatively coded through content analysis. This chapter highlights these coded themes. While most themes came directly from information presented in the scenario, there were a number of emergent themes that were not directly stated in the task. Nonetheless, these themes influenced

the final decision made by participants. These themes include humanitarian goodwill, environmental concern, appreciation of aquatic culture, importance of agriculture, wariness of increasing greed, and water conservation or recycling. The most significant finding in relation to the visual representations was that those viewing the Map Image gave the most thorough explanations for their decisions.

Chapter 2: This chapter utilizes a classic decision analysis technique to formally visualize the decision process of each participant for comparison. Using Cognitive Mapping theory, each participant's verbal data were coded into a series of cause and effect relationships. The cause-effect statements were then "mapped" into decision trees as described in cognitive mapping theory. Comparison of these cognitive maps showed that those viewing the Map Image had the most interconnected thoughts during their decision process.

Chapter 3: This chapter describes the development of a new technique for visualizing the decision process. Instead of the laborious and sometimes ambiguous coding required in cognitive mapping or other classical decision analysis techniques, this chapter shows that new social network analysis techniques used in computer science and many other fields can be used to model the decision process. Using the simple content analysis in Chapter 1, each theme can be represented as interconnected nodes. Social network analytics provide a wealth of quantitative statistics for use in comparison of each participant's reasoning process. While the findings of this chapter mimic those in Chapter 2, the process is much simpler and provides more commonly used metrics. The major finding in this chapter is that the networks created from viewers of the Map image are the most complex and most efficient decision processes.

Chapter 4: This chapter utilizes a second study population in an eye tracking experiment to provide validation and further insight into the findings of the first three chapters. Over 40 non-

science major undergraduates participated in this study. Each participant was given a simplified version of the same scenario and then presented with one of the three visual representations (the text control was not used) used in the previous study. Eye-tracking and follow-up questionnaires showed that those viewing the map image spent significantly less time viewing textual labels. However, the overall understanding of the presented information was much higher in this group. This suggests that the Map Image is much more efficient at communicating the information to non-scientists. Analysis also showed that the understanding of the information significantly influenced the final decision of those viewing the Map Image. This was not the case for those viewing the other images.

Conclusions: These four chapters combined show that thorough analysis of the decision process can be used to distinguish visual representations used during the decision process. Across two populations and multiple techniques, the Map Image stood out as different. This difference is that these participants made more informed, more complex decisions in the most efficient manner. This is encouraging for scientists wishing to communicate their findings with non-scientists in a way that promotes informed decision-making. The use of geographic information systems (GIS) is growing in many sub-disciplines of earth and environmental science, as well as in urban planning and the social sciences. The use of GIS is creating spatial datasets that are already represented in map form. The methods presented in this dissertation can be used on real-world datasets to determine the most effective way these maps can be used to communicate with their target audience.

Chapter 1

Internal and external influences on water resource decision-making

As scarcity of water intensifies due to population growth and climatic changes, the public will become increasingly aware of the ramifications and need for solutions to water shortages. To sustain further human development, water resources will need to be conserved and traded through changes in public policy. Such policies will undoubtedly involve scientific experts but also laypersons who may have little understanding of water science. This article investigates the factors that influence the decision-making processes of non-scientists when making natural resource decisions. Public participant were given a water resource decision in which they had to choose between two possible solutions. The only variable that changed between participant groups was the visual style in which information was presented. Verbal protocols were analyzed to extract the cognitive factors that influenced their decision. In addition to differences based on visual style, personal values such as appreciation for aquatic culture, environment, and agriculture emerged.

1.1 Introduction

Increasing water demands throughout the world are putting greater and greater pressure on water users and governance structures (Varela-Ortega 1998). As the most fundamental resource for human civilization: public participation, directly or indirectly, will be unavoidable. Understanding how the public interacts with natural resource decision-making is essential for predicting and avoiding public backlash to new policies and key to "winning the sympathies of a few influential citizens" where there is strong opposition to environmental regulations (Irvin &

Stansbury, 2004, p. 58). Areas with seemingly bountiful water resources such as the Great Lakes region of the United States continue to be under the scrutiny of more arid regions hoping to access the water resource. These "Water Wars" debates have been contentious. When New Mexico governor Bill Richardson proposed a national dialogue toward policies of interstate water resource trade agreements, Michigan governor Jennifer Granholm responded starkly with "Hell no," and later with "I'm sure I would be joined by 10 million Michigan citizens who would stand in the way of anyone coming to put a pipe in or haul out our water," (Fox, 2007). While Michiganders and other Great Lakes citizens may feel protective of their water resources, what specific factors would influence their decision-making if such a proposal were put on the TABLE? This research looks at how to best communicate such a resource proposal and how different forms of visual communication may influence the decision process within individuals.

In his seminal work on information-utilization in decision-making, Payne (1976, p. 386), concluded that "the procedure of presenting subjects with a decision task where they would have to search for information, along with the collection of verbal protocols from subjects while actually performing the decision task, has proved valuable in illuminating the effects of … task variables on a decision maker's processing strategies." This methodological framework, enhanced with the past three decades of decision-making research, serves as the foundation for this study. The findings presented herein are also part of a larger study on how differing visualizations of the same scenario impact participant decision strategies. Highlighted in this article are the emergent concepts arising from verbal protocols of participants. These influences on decision-making range from economic to environmental and cultural concerns, both supporting previous decision research as well as illuminating new ideas.

1.2 Using Visualizations in Decision-Making

The goal of this research is to determine how static visual media can be used as an effective mode of communicating the environmental information necessary for a non-scientist to make an informed decision. As such, the research methodology focuses on different styles of visualizations as communicators of information. Visualizations are ubiquitous in the environmental sciences due to the ability of an image to convey interconnected parts of a system more efficiently than text. This is the idea of a "picture worth a thousand words" (Mayer and Sims, 1994) in that visualizations are cognitively economic (Larkin and Simon, 1987). In fact, extensive research shows that people extract more information from images than they do from text when scientific concepts and complex systems are being represented (Cromley, 2010; Lewalter, 2003; Moore and Scevak, 1997). Furthermore, a diagram is not simply a way to depict a situation, but a means by which people can generate new ideas (Cheng, 2001). Zhang (1997) defines a diagram as a map of internal and external rules within the structure of the problem space. Each visual, then, should have its own set of rules for how information is conveyed and related to other information. Through these rules, people are able to create mental models of the features being depicted. Without rules, an image would not convey anything meaningful, nor be useful in facilitating understanding. Examples of these rules include the distance scale on a map, or directionality shown by arrows on a flow diagram. Environmental issues are generally related to complex natural and human systems, and therefore visualizations in this research are heavily dependent on arrows. The conventional arrow symbol is used to represent transfer of material, energy or other constructs, and appears to be sufficient in representing dynamic processes to viewers. Arrows are a special symbol used on maps, schematics, and other diagrams that allow people to infer the organizations between features (Heiser and Tversky, 2006) without the need

for animated imagery. The research presented herein involves these sorts of visualizations and their influence on decision-making.

Considering the elements and structure an intended by the image's author (ex. arrows) is only one half of understanding the use of that image. The other half is understanding how the viewer utilizes the image. In order to use a visualization in decision making, humans must read the information embedded in the diagram, which is an external object, and then abstract it into something cognitively (internally) useable (Larkin, 1989). Connections are made between the elements that make up a diagram, both spatially and in a temporal sequence (Norman, 1993, Vera and Simon, 1993). As a consequence, any cognitive process stemming from a diagram, such as decision-making, can be sequentially broken down into a series of steps. These individual cognitive steps are the data points analyzed in this article. Explained in the next sections are the methods used to extract these steps from decision makers.

1.2.1 External Influences on Decision-Making

Decision-making is a complex phenomenon that is controlled by many different variables. The images presented to a decision-maker might not be the only source of information upon which a participant utilizes. Although previous scientific knowledge has tremendous impact on a decision (Lowe, 1993; Butcher, 2006; Koedinger and Anderson, 1990), this variablecan be controlled for by recruitment screening. Extensive literature suggests individual differences in decision-making behavior may arise from past experiences and personal values (Connor and Becker, 1979; Homer and Kahle, 1988). Additionally, Brief (1991) suggests that when faced with an ethical dilemma, values are the most predictive variable in a person's decision. Broadly, values are usually categorized into either *Smithian* or *humanitarian* (McCoy, 1985), or otherwise thought of as *self-enhancement* vs *altruistic* (Schwartz, 2000). Some suggest

that most people favor a humanitarian value system when making decisions that impact others (Brief, 1991). For the above reasons, this study would not be able to fully investigate the decision process without describing the role of these values in addition to the role of the images presented.

1.3 Using Role-play to Extract the Decision Process

A role-play methodology was used in order to ascertain which features of an image as well as which external variables an individual used to make their decision. A role-play in which participants must explain their position on an important issue with perceived consequence, compared to a simple yes/no question, is much more likely elicit a systematic, verbalized reasoning process instead of jumping to a quick conclusion based on heuristics or gut-instinct (Brooks et al., 1991; Rips, 1990; Chaiken, Liberman and Eagly, 1989; Chaiken, Wood and Eagly.1996). In a think-aloud role-play, participants are actors in a constructed scenario. They are asked to verbalize any thoughts that come to mind and speak directly to other actors in the scenario, whether these actors exist or not. This verbalized process is necessary for adequate analysis to tease apart differences between participants.

1.4 Methodology

This study was conducted in a lab equipped with an interactive whiteboard and audio recording equipment. Results derive from transcribed interviews collected from 43 participants recruited through online advertisements on Craig's List (http://www.craigslist.org). During the summer of 2011, over 200 members of the public responded to the advertisement by completing

an online survey that collected demographic information, knowledge of water resources, level of science education, and familiarity with different types of images.

The online survey was used to pre-screen the population and assure an equal number of males and females, equivalent knowledge levels, and a representative range of ages. Only participants with less than two college science courses were chosen to participate in order to control for scientific knowledge. Approximately 100 people were invited to participate and of these, 43 were scheduled and participated one at a time over a 3-week period. The average participant age was 33.7 years, ranging between 18 and 63. Fifty percent of the 43 participants had no education beyond high school and those with college experience had majored and were employed outside of science disciplines. Occupations were widely varied, ranging from elementary teachers, construction workers, retail clerks, baby sitters, as well as the unemployed. Interviews took between 30 minutes to just over an hour. All participants were compensated with a $25 stipend.

In order to promote thoughtful, verbalized, decision-making in participants, a role-play style interview (Shubik, 1975) was utilized in the experiment. For the role-play to be effective, a story needs to be told in which participants will take on the role of a key stakeholder in a problem scenario. The scenario for the present study is loosely based on potential real world solutions to water supply issues. Many regions in the American Southwest and High Plains are over-pumping their groundwater supplies and for decades have been looking to other regions of the country with abundant sources of freshwater, such as the Great Lakes. In fact, the US Army Corp of Engineers assessed the possibility of long-distance transport of Great Lakes water to resupply the areas reliant on the depleting Ogallala aquifer (High Plains Study Council, 1982). Although the ultimate finding was that the benefits did not justify the environmental and

economic costs, this idea is still fresh in the mind of many (Bouzane, 2009). The scenario used in this research was a simplified, fabricated version of such a water resource trade between a dry region and a wet one. The names and geography are purely fantasy to eliminate the potential for illicit personal biases. The other advantage of this scenario is that it can easily be represented in numerous types of visualizations.

Participants were asked to assume the role of a government official (mayor) that is called upon to make a final decision and explain to their constituents why their decision is the best for the community in which they govern. The decision must be made whether or not a pipeline should be built in order to transfer water between the regions. The pipeline, if built, will provide economic benefit for the participant's region but will lead to water withdrawal rates higher than that of the natural recharge. Each participant was presented with the same set of instructions and the same scenario. On the interactive whiteboard, the participants were randomly given one of the three informationally-equivalent images (Palmer, 1977) of the scenario described below or given the equivalent information in text. Each image was used by 11 different participants, but technical issues caused data to be lost for one participant viewing the map visual (FIGURE 1.1). Ten participants were also in a control group that viewed the information as text on the interactive whiteboard. The only non-textual elements for this control were the monetary and water resource symbols that matched those used in the three images.

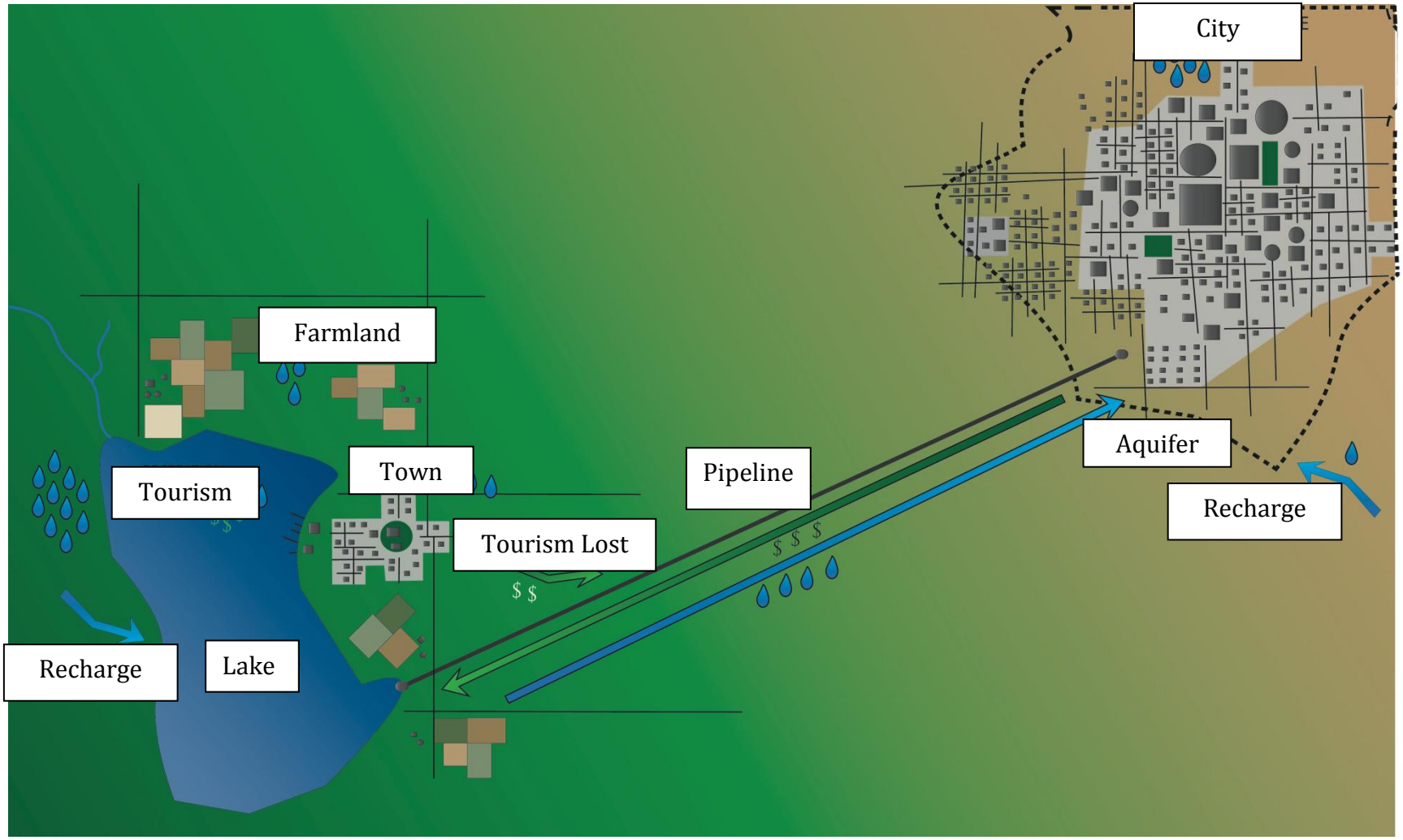


FIGURE 1.1 Map image. Characterized by top-down vantage point of surficial features. Features are closest to realistic scale. Augmented by arrows, labels, and informational data. Contact author for original image. *For interpretation of the references to color in this and all other FIGUREs, the reader is referred to the electronic version of this dissertation.*

Participants were shown the image and handed an electronic stylus as soon as the participant confirmed that they understood the scenario. The researcher left the room at this point. Participants took between 10 and 45 minutes to complete the role-play. Participants were required to make a yes or no decision by the end of the task on whether or not the pipeline should be built. The interview laboratory recorded both the think aloud audio and marks on the interactive whiteboard. For this paper, only results and analysis from the audio portion is being reported. The participant audio data were then transcribed for further analysis. The transcripts were then broken up into small phrases in order to isolate "a series of unambiguous 'measurements' of what information the subject had at particular times," (Newell and Simon, 1972, p. 166).

1.4.1 Types of Images used in role-play

The first type of visualization in which this scenario can be represented is that of a map (FIGURE 1.1). This diagram is the least abstract and most realistic in terms of scale and imagery. Realistic imagery may not always be beneficial to the viewer in terms of the information retrieved compared with more abstract images, (Butcher, 2006) yet it is a common visualization seen in textbooks and popular media. Information related to the water cycle and economic features is presented next to the structures they explain. Colors, labels, and the key are meant to closely mimic those seen on a true map. Maps commonly occur in someone's everyday environment whether looking up directions online, on a classroom wall, or on the televised local weather. This commonality does not necessarily imply that a person can successively utilize a map to make an informed decision (Lowe, 1993). The common use of maps makes this style of visualization a point of interest for this study.

The second type of visualization created for this study is a profile image (FIGURE 1.2). Although features in this image are similar to those present on the Map diagram, the scale on this profile image is greatly distorted in order to highlight important characteristics and present them from a human's viewpoint. This style of visualization is very common in scientific textbooks, geological or biological related news articles, or scientific TV programs. There is some literature on student understanding of these diagrams, but limited research about the layperson's ability to utilize these common scientific portrayals of natural phenomena exists (Dove, 1997; Eves & Davis, 1988).

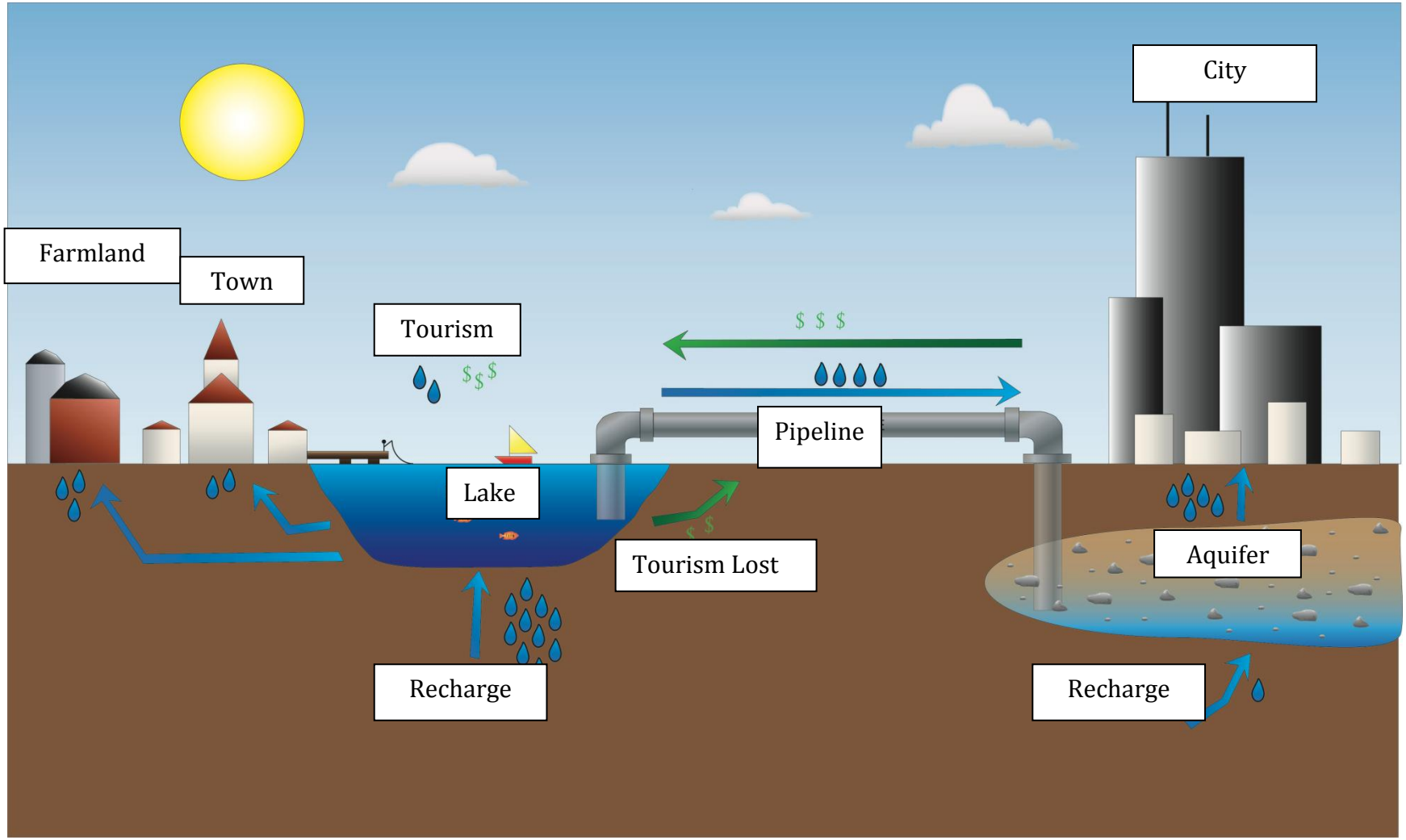


FIGURE 1.2 Profile image. Characterized by cross-sectional vantage point and highly exaggerated scale. Features are more cartoon-like. Also augmented by arrows, labels, and informational data. This is a common depiction in science textbooks of water systems because it can illustrate subterranean features. Contact author for original image.

The last style of visualization used is a schematic drawing (FIGURE 1.3). This third diagram removes the context and physical relationships between features and only displays relevant links between features through box-and-arrows (Clark et al. 2009). These Schematic diagrams are commonly used in textbooks and in industry as a way to convey structures between features (Sibley et al. 2007). This style of diagram relies heavily on arrows in order to portray functional relationships between spatial structures (Heiser and Tversky, 2006). The water resource and monetary information were represented identically in all three images. In these images, resource quantity was presented as droplets or dollar signs to prevent numeracy bias (Apter et al., 2008; Nelson et al., 2008).

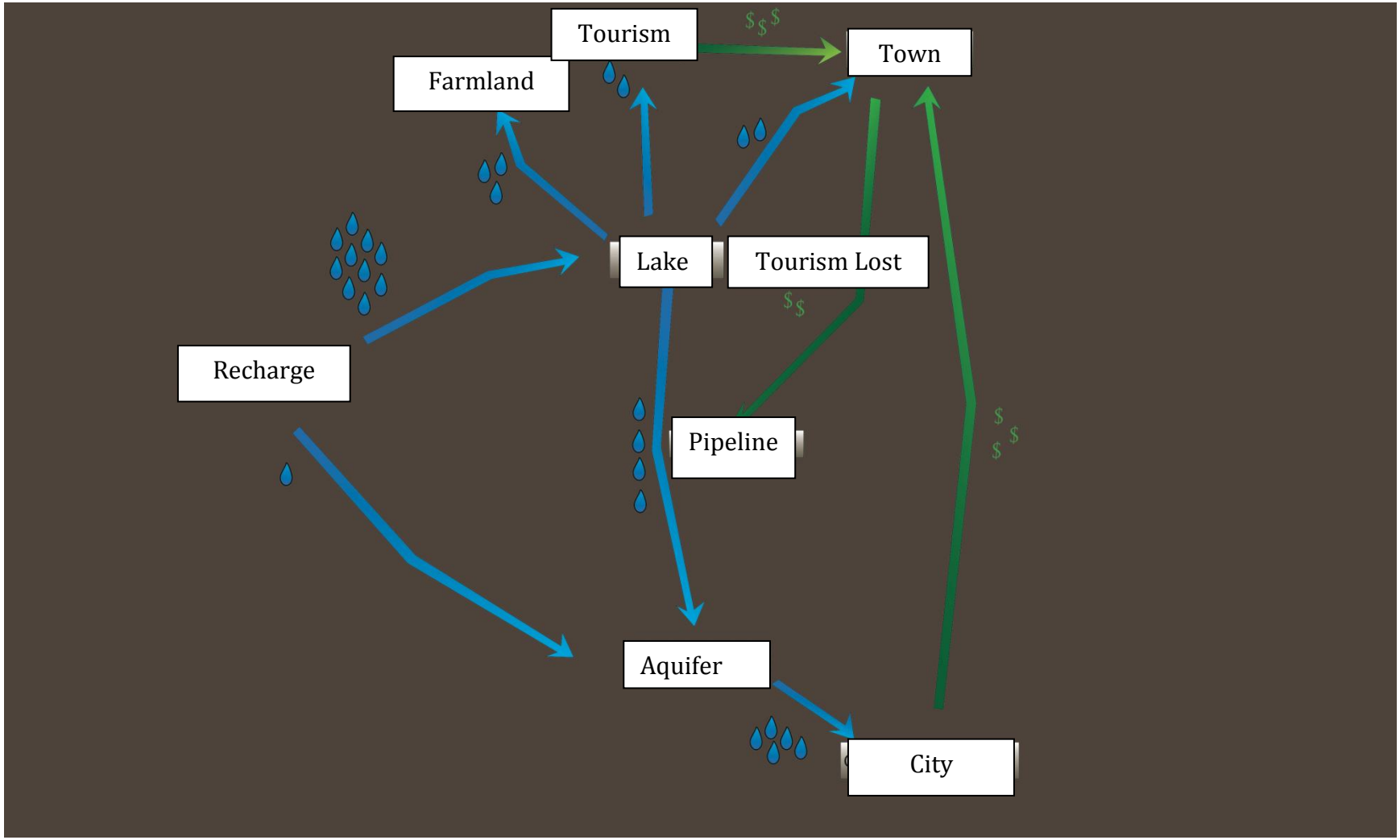


FIGURE 1.3 Schematic image. Features are completely described by labels and no visual context given. A common mode of depiction for illustrating the water cycle. Contact author for original image.

1.4.2 Content Analysis of Interviews

Content analysis of the interview transcripts began with separation of two main categories of concepts: those concepts where participants were utilizing information internal to the images, and those where participants pulled from their own cognition (external to image). Coding of the from-image concepts provided two levels of detail. In the course grain level for themes from the image, each phrase was simply coded as related to *water usage, natural recharge,* or *revenue.* Within these categories were nested themes, comprising the second level of detail. For example, statements such as "The farmland of course relies on our water as well," or "our farmland requires three units of water," were coded generally as *water usage,* and specifically as *water usage: farmland*. The other *water usages* come from either of the two cities involved, recreation and tourism, or the proposed amount to be transferred through the pipeline. These codes can be found in TABLE 1.1. The unforeseen external themes emerging from the interview transcripts were all coded as *external variables* at the first level and nested more specifically as themes agreed upon by researchers (TABLE 1.2).

TABLE 1.1 Two levels of codes from participant transcripts. Themes with image as source of information

Course-grained Coded Themes	Nested Fine-grained Themes
Water Usage	*Farmland,* *Recreation and Tourism,* *Participant's town* *Town with water shortage* *Proposed Pipeline*
Natural Recharge	*Of the Lake* *Of the Aquifer*
Revenue	*Recreation and Tourism,* *Proposed Pipeline*

TABLE 1.2 Emerging themes from individuals, not stated in scenario or on images.

Emerging theme	Description from Coding Rubric
Humanitarian good-will	Participant gives a reason for helping neighbor involving necessity of doing good, or helping other people.
Appreciation of aquatic culture	Participant comments about the importance of a water source for the economy and culture of towns that use freshwater for sports, fishing, etc.
Importance of agriculture	Participant considers agriculture an important resource that must be protected.
Environmental concern	When participant makes comments dealing with concern over the environmental impacts of building the pipeline.
Wariness of increasing greed	When participant makes comments dealing with concern that neighbors will eventually want more water than in original agreement.
Water conservation or recycling	When participant describes ideas that could help conserve water such as recycling or more conscious household uses.

Also coded were the phrases indicating when participants were confused or wanted more information. The rubric was encoded into text analysis software and a colleague with previous interview content analysis experience independently coded an overlapping 10% of the interviews, producing over 300 coded phrases. The inter-rater agreement index (Miles & Huberman, 1994) was .85 on the first run with minimal training. The discrepancies came from grammatically misunderstandings of the rubric. After discussion and further rubric training, inter-rater agreement index was over .95.

1.5 Findings

Highlighted in this article are the expected and emergent themes coded from the interview transcripts, along with example participant quotes. The number of times each code was represented varied greatly, as well as differences between codes found on particular images.

1.5.1 Decision factors from the images

For most participants, the majority of the discussion was focused on features contained within the presented image or text. As seen in TABLE 1.1, these features were coded into three overarching categories of *water usage*, *natural recharge*, and *revenue*. On average, participants in all four study groups focused on *revenue* and *natural recharge* in equal proportion, while the discussion of *water usage* was more variable. Those viewing the Map image spent most of the discussion focused on *water usage* while those viewing the Schematic image focused the least on water usage. The proposed amount of water to be traded through the pipeline was the most commonly mentioned water usage theme among all participants. The second broad category of themes deriving from the scenario itself was *natural recharge*. This was only separated into the *recharge of the lake* and the *recharge of the aquifer*. Some participants compared the relative amounts in the two systems "They have obviously a lot more supply coming from the lake". The recharge of the lake was much more commonly mentioned than that of the aquifer. Overall, *natural recharge* was mentioned much less than *revenue* and *water usage*. Although much less of the "ink" on the images (Tufte, 2001) was dedicated to describing *revenue* as compared with *water usage*, this economic variable was mentioned nearly the same extent was the water resource. The main categories within *revenue* are the amount currently coming in from recreation and tourism, the amount in the proposed trade, and the amount that would be lost were the pipeline built (TABLE 1.1). The proposed amount of revenue gained by building the pipeline was the most common specific theme across the whole study population. Examples range from relatively positive "They are willing to pay us a lot of money," to somewhat negative connotations "the income that we are going to derive from it is, is minimal."

1.5.2 Decision factors from the individual

Over half the participants spoke of themes that did not come directly from the image. These emerging themes were grouped into six categories (TABLE 1.2). The two most common were the *importance of humanitarian good-will* and the *appreciation of aquatic culture*. Interestingly, neither of these themes emerged in the participants viewing the Profile image. Overall, those viewing the Profile image were less likely to mention factors not from the image while the average number of mentions for the other two images and text group were relatively the same. Typical responses considered humanitarian in nature include "that would be the neighborly thing to do" or "because we want to help our fellow citizens." These responses were usually the most tied to a sense of moral responsibility or justice such as in one participant's response:

> I don't know how else I could convince you that this is the right way to go outside of the fact that, people helping people is what it is all about. I'm sure if the situation was reversed, and we were in need of water, I'm sure they would extend us the same courtesy and let us build the pipeline from their lake to our town.

Responses of humanitarian nature were some of the most verbose and strongly worded of the themes. The other most common theme, appreciation and respect of the cultural aspects of living near water bodies, usually included discussion of uses not stated directly on the images such as "I personally enjoy jet skiing and boating on the lake. My favorite place to fish is right here. Maybe that area would be depleted." Others worried about the aesthetic deterioration of the area: "with the eyesore of the pipeline if it be above ground…our city would ultimately lose recreation

and tourism." Some of these participants role-played a deep connection to the way of life for those on a lake. One participant, for example, stated:

> I have spent time in other towns where the economy and the whole lifestyle and atmosphere benefit a lot from having the water sports and recreation and tourism. It creates traffic, but it also creates sort of a carefree type of life, which we loved for all these years, despite our economic difficulties.

The next most common theme that emerged was the *importance of agriculture* and their determination to not see this industry harmed. These responses usually made firm statements such as "The farmland is very important obviously", or "obviously we don't want to shoot ourselves in the foot and effect the farmlands". When imagining the impacts if the lake were depleted, some participants weighed the option of "not let the farmers have water, which is a bad idea."

On par with agricultural concern was *environmental concern*. The participants with this concern (emerging from participants viewing all media except the Profile image) usually stated their worry for the impact on the ecosystem, which was not mentioned in the task or any image. For example, a common response of this type was worded "How long can the plants and animals and ecosystem survive with this type of decline due to usage and natural recharge?" Environmental concern did not always correlate with saying no to the pipeline. Some participants may want to protect the environment, but may have other aspects they want to protect more (such as agriculture or economic stability). An example of a participant with this dilemma is

highlighted in a statement made on the conditions of building the pipeline: “Without destroying the environment. [pause] Without destroying unnecessarily.”

While these first four themes generally relate to a will to protect features with personal value, another factor in participant decisions was more cynical. A small number of participants were worried that by sharing some of their water, the other city will eventually want more than they can supply. This *wariness of increasing greed* is highlighted in statements such as “They would be asking for more and more as they went” or “So in time they will probably need more water than that.” Some participants took this further by offering a possible solution outside the requirements of the task. Although the least common theme, these interesting solutions are suggestions of *better water conservation or recycling*. Some participants chose not to build the pipeline and offer the other town their solutions of “I think that there would be ways to reduce their water, “ or “So I would like to see them use less water.” Others, however, did decide to build the pipeline but under conditions: “I think we vote yes on the condition that our neighbor use water-saving, water-conscious building techniques while working on their ineviTABLE new growth.”

1.5.3 Confusion and want of more information

In addition to themes coming from the image and those coming from the participant’s own cognition, thorough coding of the interviews also highlighted other aspects that may impact decision making. These include *confusion* and *desire for more information.* Although confusion occurred in all four participant groups (three images and text control), those participants viewing the profile image were the only ones to never ask for more information. It should be noted, however, that less than 10% of the entire study population asked for more information. The most common responses that were coded as confusion were math errors or misdirection of resources

such as adding usage to the reservoirs instead of removing. For example, one participant thought recreation and tourism added water to the lake. A small minority of participants had contextual confusion with the scenario in the relationship between natural recharge and usage. These misunderstandings sometimes led to the desire of more information, but usually this desire stemmed from participants who understood the scenario well enough, but thought the images did not give them enough to make a good decision. The most common signs of this were simple statements such as "I look at this and I would want more information. You always want more information, right?" or "we have a lot of unanswered questions here." Within this theme of wanting more information, a few participants were specifically concerned with not knowing the long-term sustainability. An example of these questions includes: "And what are the long term effects of that? And is this need for now, or is it for the next 10 years, or for the next 100 years, or how long is that need for?" Two participants also inquired into the legal aspects of future issues: "Who is going to take care of any sort of liability?" and "Say if it broke right here, would they be in charge or would we?" Only one participant, who had successfully understood the scenario and done the math, asked, "It would also be nice to know if this is enough extra revenue. Is this enough to increase the quality of life in our town?"

Overall, 25 of 42 participants made the decision to build the pipeline, while the remaining 17 chose not to build the pipeline. Only those viewing the Map image were more likely to decide not to build the pipeline, while the majority of participants for each other image and text decided to build the pipeline.

1.6 Discussion

In this study, members of the public were presented with a natural resource issue on which they were to make a decision. The only variable that changed between the four study groups was how the information was presented. Analysis of each participant's explanation and self-reported thought process revealed not only how they used information presented on the image, but also highlighted a number of influences coming from their own backgrounds and experiences. These emerging themes should be of interest to those hoping to inform, or possibly influence, the decision making process of non-scientists on environmental issues.

As expected, much of the discourse for each participant was focused on the information presented within the visualization. More specifically, the most referred to pieces of information were the amount of water being proposed and the amount of revenue that would be exchanged for that water. This fits well within a standard decision making framework given by Payne (1976) stating that when faced with two alternatives, people will search for the same amount of information from each alternative. This also explains why economic factors were mentioned disproportionately greater than the amount of monetary information displayed on the images. Interestingly, this framework of "information searching" may also explain the relative lack of value statements from those viewing the Profile image. This image was the only one to depict people fishing or boating on the lake. However, some participants viewing the Map, the Schematic, and even reading text all mentioned these activities while none viewing the profile did. One explanation might be that when the information is value laden by representation in the image that the participant assumes the context but when this information is missing, they have to use their imagination to add this value. For example, on the Schematic image "Recreation and Tourism" is merely a box with text and arrows and the participant imagines and then explains

that this may be activities like boating and fishing. In the Profile image, however, these things are represented and the participant feels no need to further explain. Future research could include eye-tracking analysis of a similar decision in order to tease apart the information used by participants that is not reported aloud (Sanchez and Wiley, 2006). In terms of differences in the final decision, this analysis provides no definitive explanation of why those viewing the Map image tended to decide against the trade agreement. However, the number of internal and external themes emerging does suggest that those participants viewing the Map image tended to have a more complete conceptual model of the scenario than those viewing other images or text. Further work is being done to understand the completeness and complexity of each participant's thought process, which may reveal the causes of these differences.

The statements made by participants that do not stem from the images are also revealing. These personal values were not entirely unexpected for two reasons: 1.) When faced with a complex task, people tend to use heuristics in order to conserve cognitive load (Payne, 1976) and 2.) There was no clear "right" answer to the problem as this study was interested more in their decision process and less in their decision. To make a decision, the participant had to choose whether a resource trade for economic gain was worth a diminished supply of that resource. Such a dilemma goes beyond the scope of the scenario and information presented. The most common themes emerging also reflect this conflict between two valid alternatives. The humanitarian theme that was commonly mentioned adds support to Fritzche and Oz (2007) findings that people prefer altruistic intentions to those of self-enhancement as well as those who critique economists for equating personal gain with public interest (deLeon and Denhard, 2000). While humanitarianism may be a global value, the other most common theme may be geographically specific and derive from personal experiences. The many references to water culture and lake

activities seem to reflect participants accustomed to living near lakes as depicted in the scenario. This Great Lakes bias may also explain the next most common theme of the importance of agriculture. This is an important influence to consider since across the world, even small fractions of agricultural water use far outweigh urban and residential use (Varela-Ortega, 1998). Would these two themes emerge if the study population were from dryer regions with less farmland or surface water? Those living in different regions perceive the activities and environment that lead to a good "quality of life" differently (Svart, 1976). This study backs up the importance of considering environmental and demographic differences between regions when public participation is involved in environmental policies. Consideration of the geographic scale and scope of environmental problems and the relation to environmental justice was explored by Baden et al. (2007) who were able to explain some of the inconsistency in the environmental literature through geographic differences in spatial analysis. Also reaffirmed in these interviews was Hinchman's (2004) suggestion that humanism and environmentalism do not necessarily have to be at odds with one another. Although some participants in this study may have seen public good at opposition with environmental protection, the discourse on conservation and protection of natural resources was generally treated as what was best for the community. This may be linked to those participants who see enjoyment of their natural resources as a way of life, financially and recreationally. The influence of confusion and desire for more information should also be carefully considered as uncertainty can lead to perceived risk and strongly influence a person's decision-making process (Scholz, 1983). However, this uncertainty may also be the explanation for some of the responses as one of the major ways someone will attempt to reduce uncertainty is by drawing on their past experiences (Cox and Rich, 1964).

The goal of this article was to highlight the considerations one should take when utilizing visualizations to explain complex environmental issues for use in decision support. Irvin and Stansbury (2004) show that one of the major contributing factors to how costly and effective citizen participation in decision-making is the technical knowledge of the public. Better-designed visualizations can be a large factor in promoting public understanding, therefore improving effectiveness and decreasing costs of such a solution. This research has shown that small differences in the way we communicate environmental problems can have significant impacts on the information people use to develop solutions. In addition, no matter how well constrained and thought out our visualizations may be, they will still elicit value judgments and draw out past experiences from the viewer. One of the most encouraging aspects of this study is that everyday citizens were willing and able to place themselves in a situation for which they had no training or experience, but still produce detailed, thought-out explanations and decisions while weighing a large number of environmental, humanitarian, and economic factors.

Chapter 2

The effect of visual representations on environmental decision-making: A cognitive mapping study

Visual representations play a vital role in facilitating decision-making while communicating scientific information to non-scientists. This article presents a qualitative decision analysis of a controlled laboratory experiment in which members of the Michigan public were asked to role-play through a water resource management decision. A common scenario and data set were presented to participants. Participants were divided into three cohorts, with each viewing the data on a different type of visual representation. Cognitive mapping theory was used to compare the mental models of experimental groups viewing different representations. This analysis showed that image type impacts not only the process of reaching a decision, but the final decision as well.

2.1 Introduction and Research Questions

Today's decision makers face high stakes, complicated decisions in which solutions must be justified and no single expert grasps the entire problem space (Keeney, 1982). This is especially true of environmental and natural resource decisions (Pielke, 2007) where many interconnected pieces of information must be carefully considered in order to engage in effective decision making. Scientific information plays a crucial role in this process, but equally crucial is the channel through which that information is passed from scientist to decision maker. While scientists collect more data and improve their understanding, it is also important they provide the best quality means to communicate their findings. In complex scenarios, visual representations

are sometimes the most efficient way to communicate this information (Heiser and Tversky, 2006). Science communicators now focus on how this visual information impacts decision-making. While much of the research on decision analysis has been conducted in controlled laboratory settings using very simplistic problems, these studies may not provide as fruitful or generalizable findings that apply to real-world decisions (Hogarth et al., 1980). However, retroactive analysis of complex real-world decisions does not allow for enough control to test certain hypotheses. The aim of this research is to determine what types of representations are most effective at assisting the decision-making process for those with limited scientific knowledge. In this study, a formal decision analysis technique is used in combination with a role-play methodology involving naïve participants in order to simulate a quasi-realistic decision where one communication variable, visualization style, is changed.

2.1.1 Assisting decision-making

In order to improve the communication of scientific information important for informed decision-making, the first step is to understand how a decision is made. Collins (1989) reviewed a large number of interviews where subjects explained their reasoning and highlighted several fundamental principles that emerged: 1) any question could be answered through multiple patterns of inference, 2) similar patterns of inference reoccur in different answers, 3) a decision-maker's final conclusion is based on different weights assigned to different lines of evidence, 4) the decision-maker's confidence in their solution is based on the comparison of these inference patterns and whether or not they lead to the same solution. The combination of these principles provides support that the decision-making process can be represented by dynamic hierarchies. Using a formalized analysis scheme, the decision process of multiple decision-makers in different experimental groups can be compared and contrasted. This framework of formally

representing the decision process is the foundation for decision analysis contained within this article.

2.1.2 Evaluating a decision

Many researchers have investigated the reasoning processes that underlie effective decision-making. This body of work has identified a number of ways in which to visual represent these processes. Keeney (1982) outlines the basics of any experiment evaluating reasoning processes by highlighting the sequential steps during a decision. The first step is to structure the decision problem, or simply to FIGURE out the constraints or boundaries of the decision. This is something the researcher can do for the participants by carefully explaining the task and the limits to the experiment space. Any problem will have multiple solutions (even if it is a simple "act or not act" binary choice) and so the next step is for the decision-maker to assess the possible impacts of each alternative. This is also something the researcher can assist with, by laying out the possible solutions and providing relevant information for the decision-maker to utilize. With this information, the decision-maker must determine their preferences or values. This is generally beyond the control of the researcher but has been explored and documented in Turner (in review) for this particular study. Once the decision-maker has determined their preferences, they will evaluate each alternative to see which solution meets the greatest number of valued outcomes.

This step-by-step evaluation of alternative solutions has also been described as an explanation or story model (Pennington & Hastie, 1992; 1993). In evaluating alternatives, decision-makers summarize causal relationships between events given each alternative. By doing this, they create multiple "stories" and then judge which story fits the evidence. For example, a juror deciding a verdict will imagine the evidence in a scenario where the defendant is guilty and

the same evidence in a scenario where he or she is innocent. The verdict will be decided by which scenario the juror feels is more plausible (Hastie & Pennington, 2000). This is a good model for retroactively determining how someone made a particular decision. However, in order to then compare one person's decision to another, or to compare the decisions of one experimental group to those in another, a formal representation is needed. As mentioned above, this syntactic process used by decision-makers lends itself well to such formal representation. In his seminal book "Structure of a Decision", Axelrod (1976) provided a foundation for visually representing the mental model of a decision-maker as they evaluate the causes and effects of alternatives. The FIGUREs produced by this analysis are named cognitive maps.

2.1.3 Cognitive maps

The evidence used and the inferences made by a decision-maker can be systematically pulled from an interview and represented by nodes and connections (Collins 1989, Axelrod 1976). Each node of a cognitive map represents either a cause concept or an effect concept (note that some concepts can be both a cause and an effect). The connections between these nodes can be described as having either a positive or negative parameter, indicating whether the cause increases or decreases the value of the effect concept. Hogarth et al. (1980) showed the effectiveness of cognitive mapping at differentiating decision-makers in urban planning. Through coding of face-to-face interviews into cognitive maps, they were able to show differences in complexity of the mental models for different decision-makers. They were able to link these differences with the technical backgrounds of the decision-makers and the stake each had in the outcome. Klein & Cooper (1982) also demonstrate the usefulness of cognitive mapping for differentiating populations in the study of wargames. They show that the cognitive

mapping approach is a combination of political and psychological decision analysis techniques and works in the "world of the subjective decision-maker".

2.1.4 Research Question

Images are widely used in the communication of scientific concepts, especially in complex problems such as coupled human–natural systems. Natural resource decisions include not only complex natural systems such as the water cycle, but also require information on the economic and other human factors involved (Pielke, 2007). Presentation of these multiple data sets in text and TABLEs would not only be difficult to process by an individual, but the linearity hinders appreciation of the dynamic system. For these reasons, a "picture is worth a thousand words" when it comes to supporting environmental decision-making. At the same time, visualizations of scientific data are highly variable in scale and realism. Some research suggests that realism may be less useful to users than more abstract images (Butcher, 2006). In addition, familiarity may play a role in usability of an image (Lowe, 1993). Other factors such frame of reference or color schemes make the question of "best image" for decision support ambiguous. This study attempts to elucidate some of this ambiguity and compare three types of the most common depictions in a controlled experiment. The research question is as follows:

> Do visually different, informationally-equivalent images generate different inference patterns in decision-makers?

As a null hypothesis this could be written as: *The type of visual representation will have no effect on the cognitive maps of decision-makers.* This hypothesis was tested using the methods presented in the next section.

2.2 Methods

The data for this study were collected through a role-play interview using think-aloud methodology. This type of interview is useful for eliciting thought out verbalized explanations of a participant's reasoning process. (Shubik, 1975). For a more in-depth breakdown of the role-play methodology in this research, see Turner (in review). Participants were given the role of mayor and asked to utilize information on an interactive whiteboard to make a decision and give a presentation to their constituents to why their decision is the better option. The resulting verbal data were transcribed, coded, and analyzed.

This paper specifically focuses on the cognitive maps of the decision maker. These cognitive maps are graphical representations of the links between causal chains as described by each participant. By discerning the similarities and differences between these cognitive maps, the impact of experimental variables on the decision process can be determined. Description and interpretation of these cognitive maps are detailed in the following sections.

2.2.1 Context of study

Decision-making on many environmental issues, especially those involving local natural resources, often include participation by a public without formal science training. Additionally, authorities or lawmakers making these decisions may not have a scientific background above that of the general populace. This study, therefore, is focused on decision-makers without formal scientific training. To achieve this, 42 participants were recruited from the public through online recruitment methods and screened to control gender, age, and education (Turner, in review). All participants were recruited from central Michigan, near the research institution. Half of the participants had no education beyond high school and those with college experience had taken less than two total science courses.

The scenario in which participants must make a decision is that of a water resource trade. Participants were given the role of mayor in a town with a large fresh water source that serves as the foundation agriculture and tourism that supports the struggling local economy. The participants are told of another city that is working to maintain adequate fresh water supplies as that city's own aquifer dwindles. This city proposes to buy lake water from the participant's town. It is the role of the participant to decide whether or not to agree to a proposal of building a pipeline that would permit this trade. Since this study is interested in how people make their decisions, participants were asked to think aloud and explain to their constituents why they have made their decision. They were given economic and natural resource information via an interactive whiteboard on which they were able to take notes and highlight features with the use of an electronic stylus. Audio of their explanation was recorded and serves as the base data for this study.

2.2.2 Protocol and Measures

Participants were recruited through an online survey advertised on a classifieds website. Each participant met with the researcher in the interview room equipped with audio and video recording devices, as well as the interactive whiteboard used in this study. Before beginning the experiment, the researcher led the participant through a calibration exercise to insure the recording equipment was functioning properly and to allow the participant to practice the think-aloud method in conjunction with an electronic stylus for writing on the interactive whiteboard. To ensure well thought out responses, the researcher read all directions and the scenario aloud as well as verify after each instruction that the participant understood both the scenario and task. Once the participant was ready, the task began and recording started.

The participant was presented with one of four possible displays on the interactive whiteboard. The equivalent information was presented on each display but the differing styles of representation are based on common images found in scientific material. As a control, one experimental group received all of the information as text on the interactive whiteboard. Another group viewed the information in the form of a schematic, or box-and-arrow diagram (FIGURE 1.3). The *schematic diagram* presents all sources and sinks of monetary or water resources in boxes, connected by arrows. In the second image (FIGURE 1.2), the *profile diagram*, these features are represented as not-to-scale, stylized cartoons in a cross-sectional view, connected by arrows. In the final image (FIGURE 1.1), *the map diagram*, features are represented from a top-down view with a more realistic scale similar to what is seen on actual maps. In addition to the arrows to show transfer, all three images utilize symbols to represent relative amounts of monetary and water resources being transferred. Each participants spent between 25 and 60 minutes interacting with the image and completing the task.

The verbal data for each participant was transcribed to text. Cognitive mapping theory requires the coding of cause concepts, effect concepts, and the positive or negative relationship between the two. For example, a participant's statement of, "The pipeline will take water from the lake and give it to our neighbor" contains two such relationships. Under cognitive mapping theory, "The pipeline will take water from the lake and give it to our neighbor," could be coded as seen in TABLE 2.1.

TABLE 2.1 Two cause-effect relationships coded from the phrase: *The pipeline will take water from the lake and give it to our neighbor.*

Cause Concept	Effect Concept	Relationship
Building the Pipeline	Lake Water Amount	Negative (-)
Building the Pipeline	Water for Neighbor	Positive (+)

Symbolically these two relationships can be represented with arrows going from the cause concept to the effect concept. If an effect has multiple causes or a cause has multiple effects, it can be represented with multiple connections as demonstrated in FIGURE 2.1.

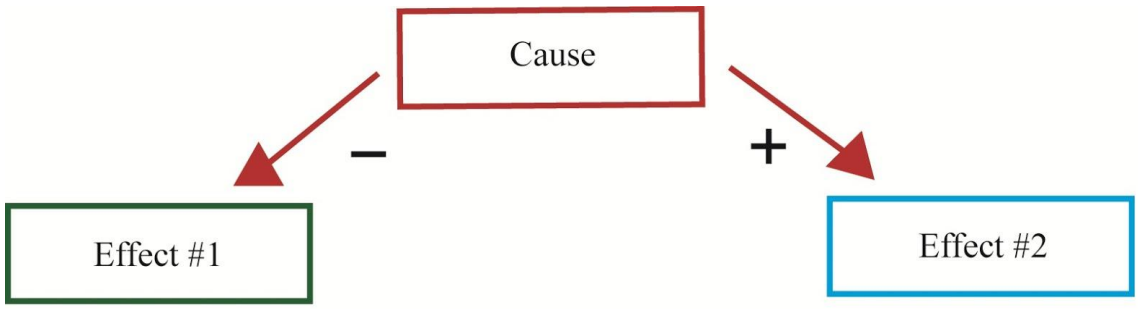


FIGURE 2.1 Basic cognitive map. The cause concept has two linked effect concepts. The cause has a negative impact on the value of effect #1 and a positive impact on effect #2.

A cognitive map is the complete assemblage of these cause-effect relationships. These maps were constructed for each individual and represent their mental model of the scenario in which they were asked to make a decision. The results of this analysis are described below.

2.3 Results of Role Play Interview

This section describes the emergent concepts and their relationships to each other represented as cognitive maps. First explained are the varying concepts used by participants and

the frequency of use. However, it is the interconnections of these concepts that are key to this study. Rather than sorting through 42 individual cognitive maps, some of the cognitive maps are represented below as amalgamations of cognitive maps. On these combined maps, the ratio of each causal link to the total number of participants in that group is displayed as a percentage. It is through comparison of these groups that the role of the different images can be discerned.

2.3.1 General Observations from the Roleplay Interviews

The transcribed interviews ranged from 89 to 1321 total words with those viewing the *map image* giving the longest answers, on average. Out of the 42 participants, 25 came to the final solution of building the pipeline while 17 decided against the proposal. Those viewing the *map image* were more likely to decide against (7 of 10) while more people decided for the proposal than against in the other experimental groups. There were no significant differences based on demographic information collected. The most significant differences came out of the coded cause and effect concepts and their relationships, the focus of this article.

Coding of the transcripts yielded eight recurring cause concepts and ten effect concepts. Some concepts were coded as both a cause and effect. For example, *Revenue from Recreation and Tourism* is affected by *Building the Pipeline*, but it also effects the *Revenue for the Town*. These codes are listed in TABLE 2.2. In total, there were 12 unique concepts and 22 unique cause-effect relationships stated across the participants. While many of these concepts derive directly from the images and were expected, some were not implicitly stated in the scenario or on the image and came from the participants' own inferences. These include the concepts of *Water Culture for Town* and *Environmental Health*. The concept of water culture was usually expressed as the innate value of the lifestyles of the residents such as recreational fishing or skiing and was readily distinguishable from tourism revenue. In addition to these emergent concepts, there were

also numerous connections made that were not implicated stated in the task material. For example, *Building the Pipeline* is only shown to decrease *Water in Lake*, but some participants saw a direct negative impact of *Building the Pipeline* to *Water for Agriculture.* The significance of these concepts for this study is discussed in later sections.

TABLE 2.2 List of cause and effect concepts coded from 42 transcribed interviews.

Cause Concepts	Effect Concepts
Building the Pipeline	Aquifer Water Amount
Water for Agriculture	Lake Water Amount
Water for Recreation and Tourism	Revenue of Town
Revenue from Recreation and Tourism	Water for Agriculture
Water for Town	Water for Recreation and Tourism
Natural Recharge	Revenue from Recreation and Tourism
Water for Neighbor	Water for Town
Water Culture of Town	Water for Neighbor
	Environmental Health
	Water Culture of Town

FIGURE 2.2 represents the "ideal cognitive map" were a participant to completely understand the scenario and only use concepts and connections directly stated in the scenario or presented by the images. This was created to provide a standard on which to compare participant responses. FIGURE 2.3, on the other hand, shows an amalgamation of all connections made across the entire study population. The most common cause-effect chain was that *Building the*

Pipeline would have a positive effect on the *Revenue of the Town*. As evident from FIGURE 2.2, *Building the Pipeline* was the most common cause concept. It was the starting point in nearly half (10 of 21) of the unique relationships in the participants' cognitive maps. The Lake Water Amount was the most common effect concept. The degree to which these two concepts are given (FIGURE 2.3) is in proportion to the number of links for each in the ideal map (FIGURE 2.2). One significant deviation from the ideal is the number of cause concepts that participants connected with the *Revenue of the Town* for which they are mayor.

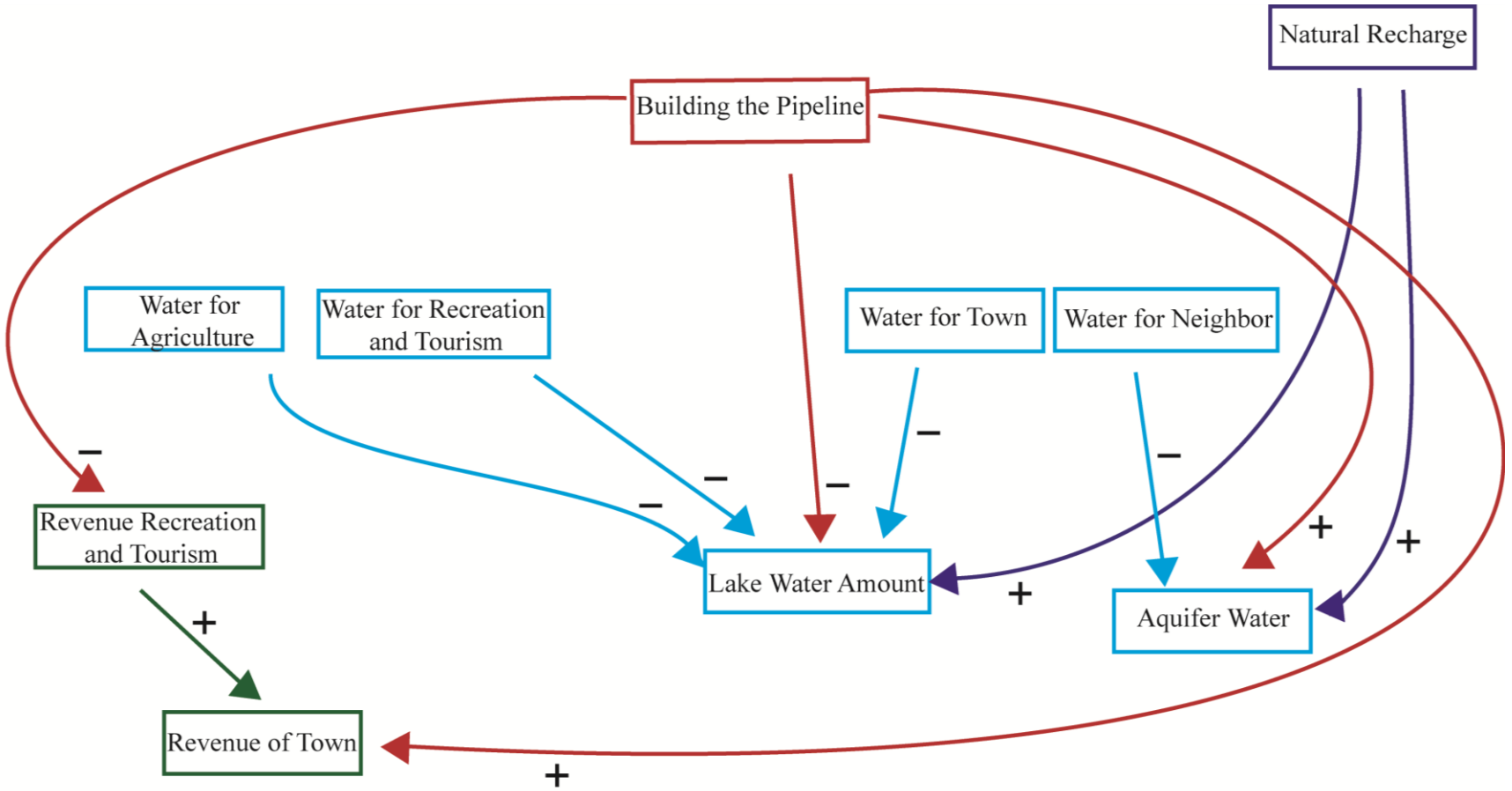


FIGURE 2.2 Ideal "cognitive map" for scenario presented in this study. This was not created through the typical coding scheme laid out by Axelrod (1973), but rather the connections are those stated directly in the task instructions and the images. This provides a baseline for comparing individual cognitive maps.

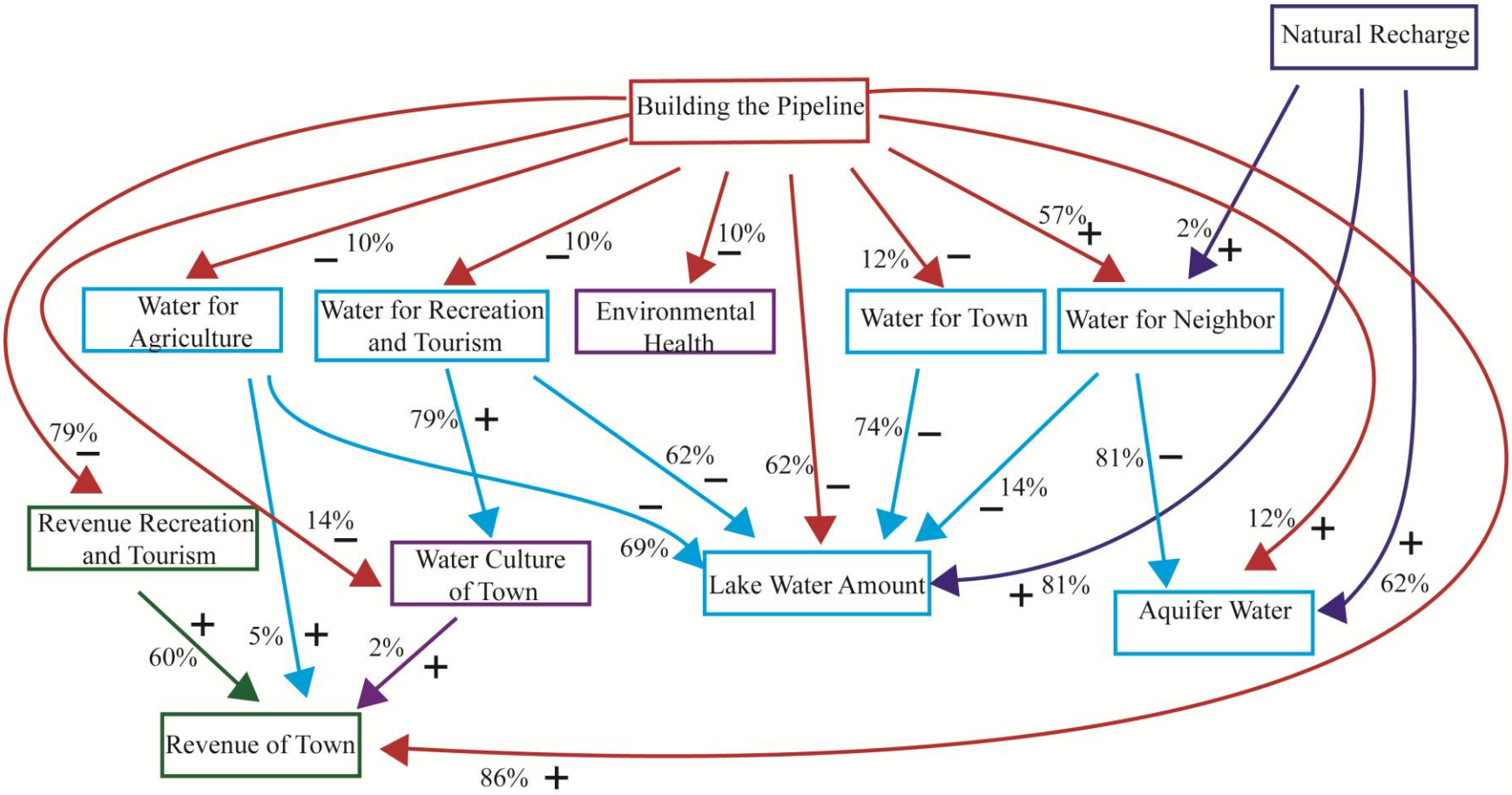


FIGURE 2.3 A cognitive map representing all the cause-effect relationships stated by participants (N=42). The percentages represent the ratio of total participants that stated the given relationship.

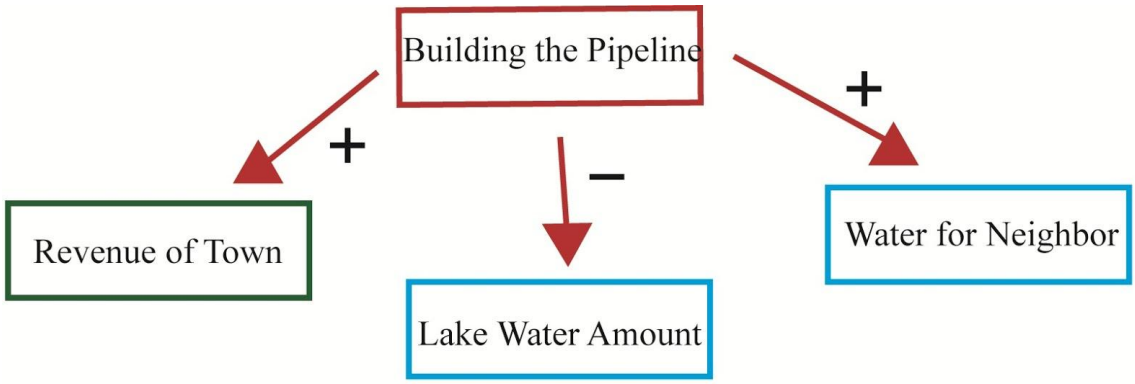


FIGURE 2.4 Some cognitive maps were very simplistic. As seen in this FIGURE, these simple cognitive maps generally entail only the proposed solution (Building the Pipeline) as a cause and list some of the effects. The participant represented in this FIGURE saw two positive (not inherently beneficial, but most likely in this case) effects and one negative effect.

There was a fair amount of variance in the number of nodes used and connections made. FIGURE 2.4 is an example of one of the more simplistic cognitive maps while FIGURE 2.5 is representative of a more complicated map. Building the Pipeline plays a central role in both of these cognitive maps. These cognitive maps are formal representations of the decision-maker's inference pattern and can be thought of as their mental model. In the simplistic cognitive map shown in FIGURE 2.4, the participant only evaluated the impacts of the proposal they were given. This participant reflected that building the pipeline would increase the amount of water going to the other city, increase his own town's revenue, but decrease the amount of water in the lake. Based on this mental model, the participant decided that the pipeline should be built. FIGURE 2.5, on the other hand, represents the mental model of a participant who decided against the proposal. Their model was also more complete. This participant evaluated a number of effects caused by the proposed building of the pipeline, but also looked at a number of other factors impact the amount of water in the lake. This participant's cognitive map looks very similar to the ideal map given in FIGURE 2.2, meaning their explanation included much of the

information presented in the task. However, they made some connections that were not directly stated in the task such as a connection between water needed for agriculture and the total revenue of their town.

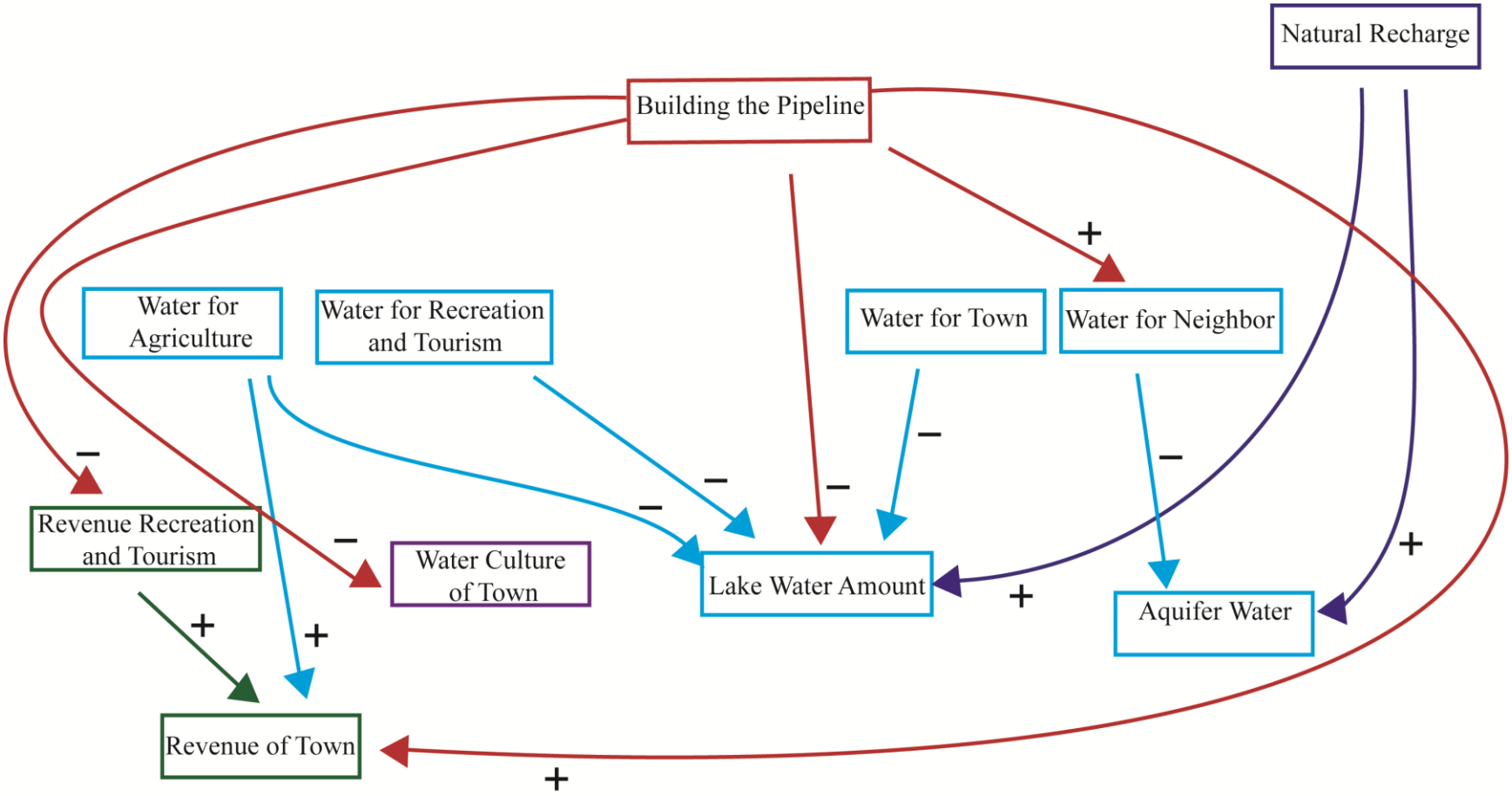
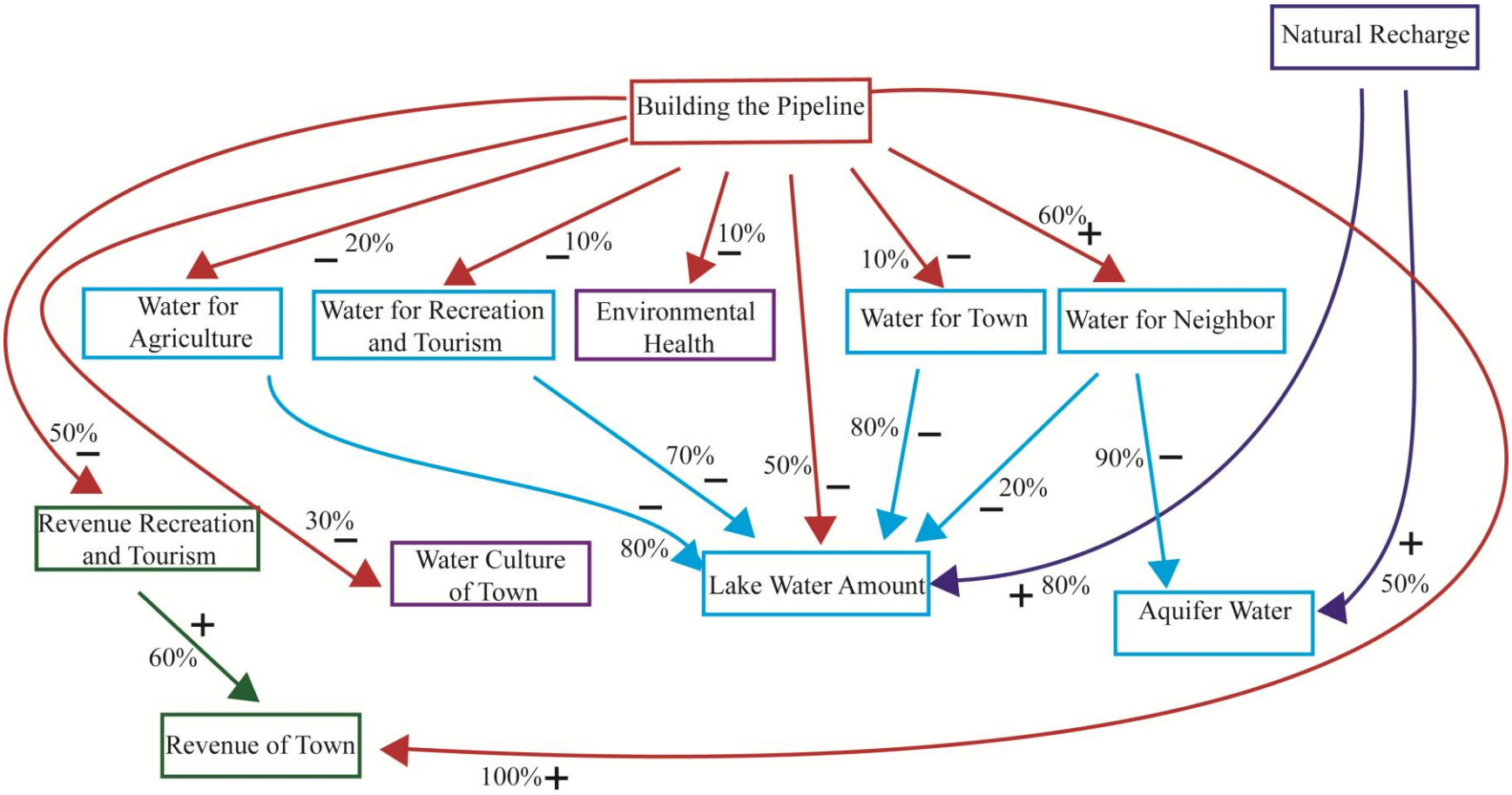


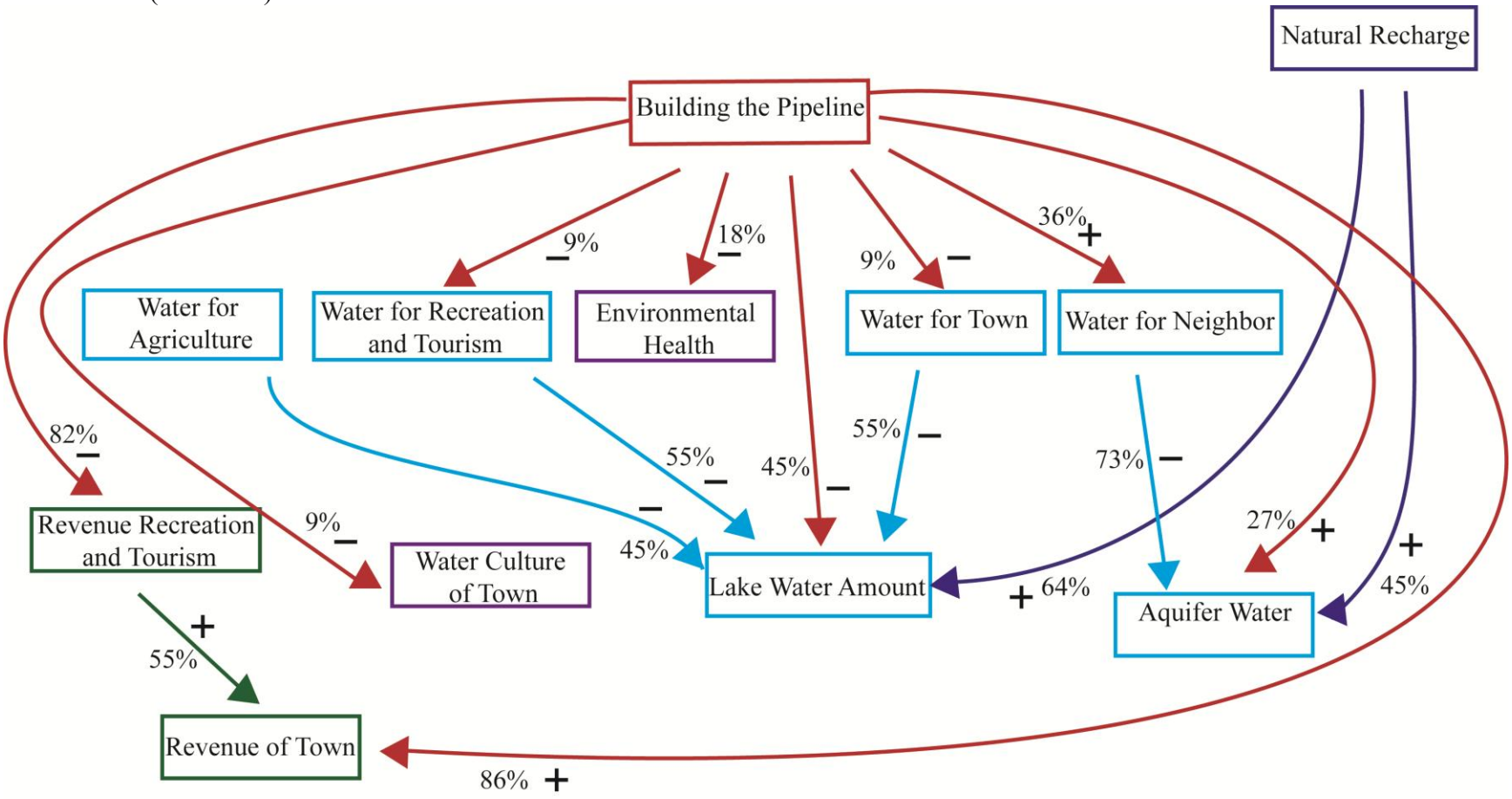
FIGURE 2.5 Other cognitive maps were much more complicated. As seen in this FIGURE, the complex cognitive maps often evaluate a more complete evaluation of the scenario.



"A"

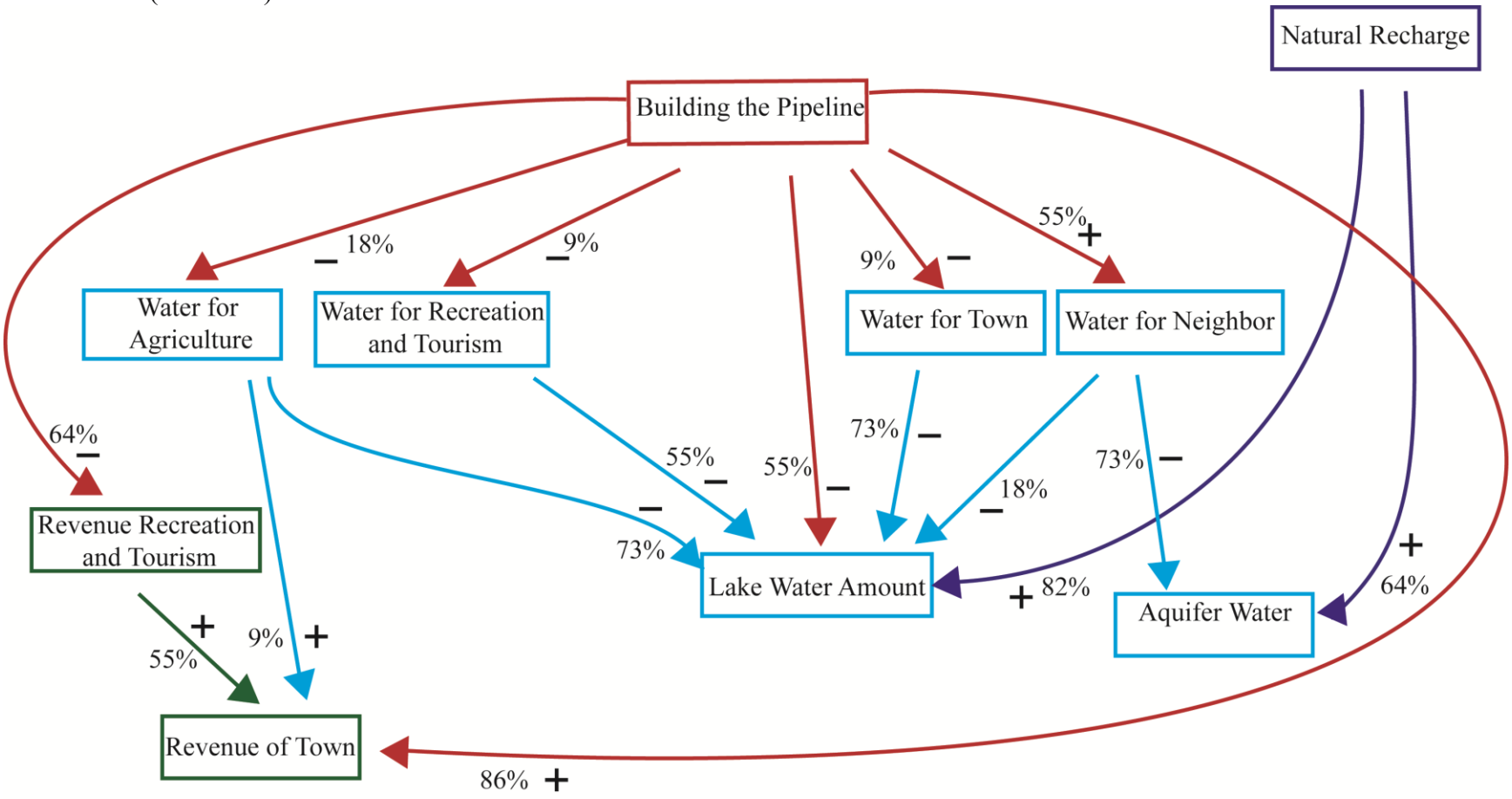
FIGURE 2.6 Amalgamated cognitive maps of the four experimental groups. Percentages represent ratio of participant transcripts in that group that were coded with that cause-effect link. "A" is a combined cognitive map of TEXT viewers (N = 10). "B" is the combined cognitive map of SCHEMATIC viewers (N = 11). "C" is the combined cognitive map of PROFILE viewers (N = 11). "D" is the combined cognitive map of MAP viewers (N = 10).

FIGURE 2.6 (CONT'D)



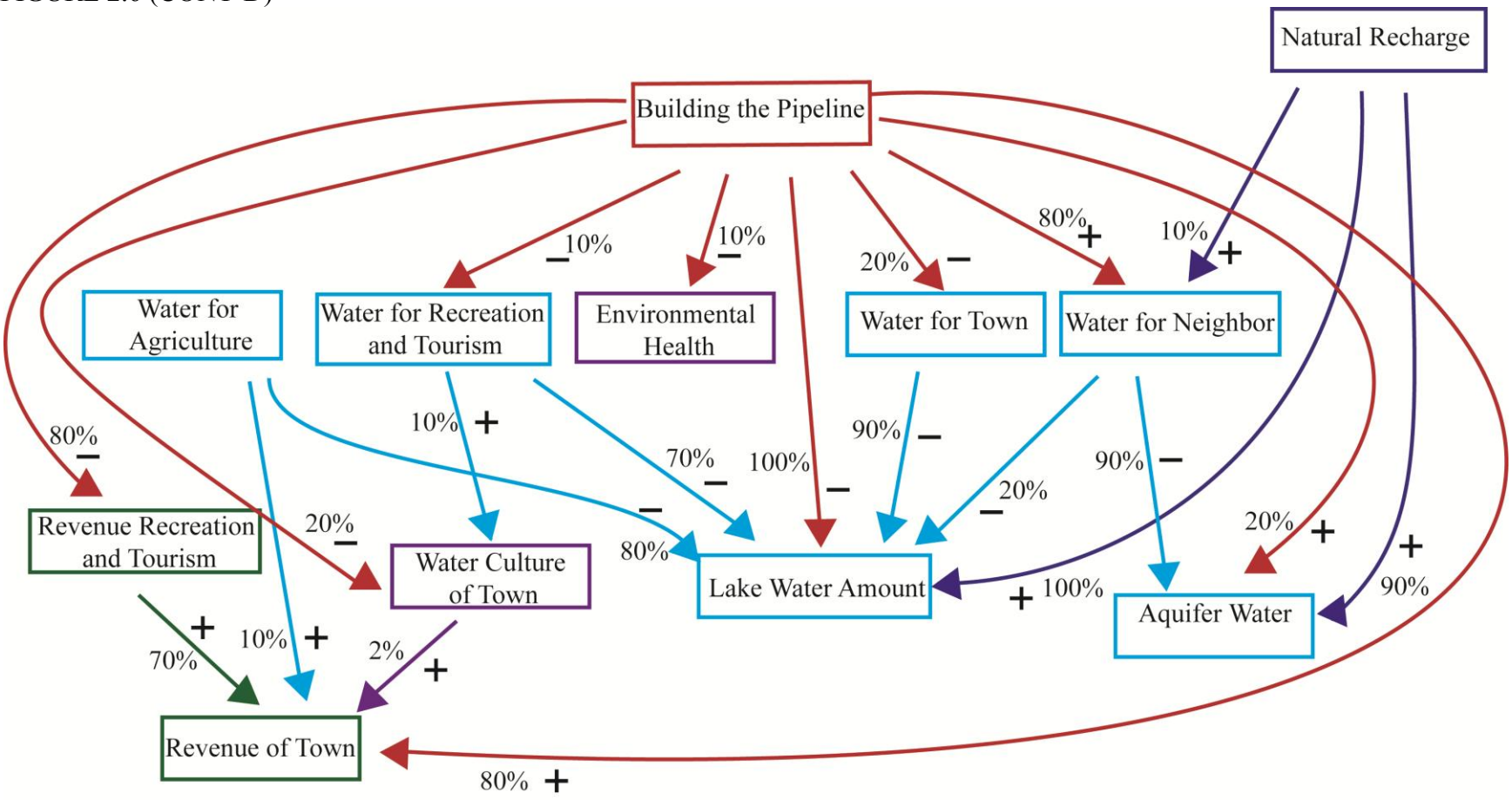
"B"

FIGURE 2.6 (CONT'D)



"C"

FIGURE 2.6 (CONT'D)



"D"

2.3.2 Differences in Cognitive Maps

Overall differences in cognitive maps seemed mostly tied to the visual representation type viewed by the paticipant. Ten transcripts were coded from participants who were given the information in plain text on the interactive whiteboard. The most consistent cause-effect relationships stated by this group involves revenue (FIGURE 2.6). All 10 participants viewing the text explained that building the pipeline would increase the revenue for the town, and 9 of 10 described a loss to revenue from tourism. The 11 participants given information as a *schematic image* have cognitive maps similar to those viewing the text, with a relative consistency of focus on revenue changes. Overall the groups viewing the *profile* and *schematic images* had less internal consistency in terms of coded cause-effect links. The most significant outlier in terms of overall pattern is found in the *map image* group. Ten of 10 participants in this group were coded as stating that building the pipeline would have a negative impact on the amount of water in the lake. On the other hand, only around half of the participants viewing the other images made this connection. Ten of 10 viewing the *map image* also noted the positive impact of natural recharge on the lake; 9 of 10 described the withdrawal of their own town on the lake, and 8 of 10 described the withdrawal of lake water for agriculture. Participants viewing the map image were more consistently focused on water resources than in the other groups.

In addition to just looking at which inferences were or were not involved in decision making for individuals, one can look at the characteristics of the cognitive map itself. Klein&Cooper (1982) calculate the map density of individual cognitive maps in order to differentiate decision makers. The function for map density (D) is given as:

Equation 2.1. Map Density

$$D = L/(N(N - 1))$$

L = number of links (relationships)

N = number of nodes (concepts)

After calculating this for each individual (see TABLE 2.3), a number of differences between groups appear. One obvious distinction between experimental groups is the smaller range in concepts and links seen in the *map image* group. Both the number of concepts and links are toward the higher end for this group meaning that their explanations were generally more thorough in terms of features pulled from the image or their own background and also that their cognitive maps were more interconnected. In this study, these two factors have a negative correlation with map density. This is due to the fact that many of the cognitive maps in the schematic and profile image groups are very small and therefore have high density. The cognitive maps of those in the *map image* and *text* group had more peripheral concepts and therefore any one concept has less chance of influencing another concept (Klein & Cooper, 1982). Note that the ideal cognitive map shown in FIGURE 2.2 has 10 concepts, 11 links, and a map density of 0.123. This makes the cognitive maps of those in the *map image* group the most similar on average to the cognitive map needed to fully understand the scenario.

TABLE 2.3 Average number of links, concepts, and map density for each image group.

Experimental Group	Number of concepts *Range (average)*	Number of links *Range (average)*	Map Density *Range (average)*
Text (n= 10)	7 – 12 (9.3)	5 – 14 (9.1)	0.08 – 0.14 (0.119)
Schematic (n = 11)	3 – 10 (7.0)	2 – 13 (7.1)	0.10 – 0.34 (0.189)
Profile (n = 11)	4 – 10 (8.4)	3 – 13 (7.9)	0.08 – 0.24 (0.134)
Map (n = 10)	8 – 11 (9.6)	8 – 14 (10.7)	0.10 – 0.17 (0.130)

The differences between these cognitive map characteristics for those participants who were for the pipeline and those against the pipeline is also discernible as seen in TABLE 2.4. Those with more concepts and more connections were more likely to be against the proposal.

TABLE 2.4 Concepts, links, and cognitive map density grouped by final decision.

Decision	Number of concepts *Range (average)*	Number of links *Range (average)*	Map Density *Range (average)*
Yes to pipeline (n = 25)	3 – 11 (7.9)	2 – 14 (7.8)	0.08 – 0.34 (0.155)
No to pipeline (n = 17)	7 – 12 (9.4)	6 – 13 (9.9)	0.10 – 0.17 (0.126)

2.4 Conclusions and Discussion

In this study, the hypothesis that different types of visual representations promote differences in a person's decision process was tested using one approach of qualitative decision analysis known as cognitive mapping. The differences in individual cognitive maps between control groups support this assertion. As in past work on many real-world and simulated decision

experiments, cognitive mapping has proved to be a valuable tool in visualizing the decision process. While cognitive mapping may not represent the actual structure of thought in the brain, it is a reliable analogy for exploring the mental models of decision-makers (Klein & Cooper, 1982). While surveys or more structured interviews may have made cognitive maps easier to obtain and given possible greater reliability, the role-play scenario and think-aloud mythology provided a more authentic look at the decision-process of non-scientist members of the public. Although this study may be considered "messy" by the standards in some fields of psychology and decision-analysis, there was enough experimental control to successfully test the hypothesis. Keeney (1982, p. 803) summarizes how one makes an environmental decision where multiple objectives may be in consideration:

> "in evaluating routes for proposed pipelines, one wishes simultaneously to minimize environmental impact, minimize health and safety hazards, maximize economic benefits, maximize positive social impact, and please all groups of interested citizens. All of this cannot be done with a single alternative, its is important to appraise the degree to which each objective is achieved by the competing alternatives"

Coding of cognitive maps done in this study show that Keeney's example was genuinely accurate. These cognitive maps demonstrate how participants weighed numerous objectives while deciding between building the pipeline or not. The two obvious objectives were bringing more income for their town and protecting their water resource. However, numerous participants also brought up new objectives such as protecting agriculture, their social culture, or the environment. The most common cause concept of the present study scenario, *building the pipeline*, fits in with Pennington & Hastie's (1992) story model where decision-makers look to

line up evidence and build competing stories. Instead of a guilty-innocent choice of a juror, the participants in this study were deciding between a story where the pipeline is built and one where it is not. Whichever story met the most of their objectives, or met their most valued objectives, was the solution they chose.

While this strategy is just one method of determining an image's influence on decision-making, this study along with Turner (in review) show that the *map image* uniquely promote more informed, more complex, longer, and more verbose self-reported explanations of the decision strategy. These details suggest that displaying scientific information on a top-down, to-scale map of the problem space may be most effective visualization when non-scientists must find solutions to complex problems. The image type also impacted the solution so even though the other images may have helped decision-makers filter out presented information to a few key economic factors, this lead to a lessened regard for other information such as water resources. There was purposefully no "right" or "wrong" answer on this task, but it is interesting that participants with more informed and complex explanations were more likely to decide against the proposal while those with simpler explanations were for the proposed pipeline.

Unanswered questions remain and there is room for more quantitative assessments of the role images can have on decision-making. While this cognitive mapping analysis was done following the strict guidelines outlined in Axelrod (1976, see Appendix 1 by M. T. Wrightson) to ensure the most valid and reliable results, there will always be a subjective nature to pulling a participant's mental model from an interview transcript. In addition, cognitive maps do not account for concepts that cannot be coded into a cause-effect chain. Since cognitive maps are meant to represent a mental model behind the decision-maker's explanation, the number of times a concept is mentioned or the order in which these relationships are mentioned is also

unaccounted for. It is possible these missing variables could be used with a difference decision analysis methodology in order to tease apart participant differences with finer resolution. However, cognitive maps provide a tried and true methodology and were able to reliably test the hypothesis presented.

If further studies show similar usefulness of map-style images, we must ask ourselves "why?" It is possible that people are more familiar with maps in their day-to-day lives and know what they are looking at. It may be that the public is experiences an expert effect on their decision making if they have this familiarity with the representation type (Chi et al., 1981) These findings are encouraging for those focused on using geographic information systems or programs such as Google Earth as a means to communicate natural and human systems with non-scientists (National Academies Press, 2006; Sheppard and Cizek, 2009). Further studies of this type could help generalize these findings to wider audiences in wider domains and provide definitive support for the use of particular images when communicating scientific concepts.

Chapter 3

Using network analysis to evaluate reasoning during a water resource allocation scenario

Reasoning, such as that during the decision-making process, has been formally expressed in many fields as a series of interconnected thoughts. This model of reasoning lends itself well to social network analysis. By representing each thought as a single node, and each connection as a path between nodes, network analysis can provide numerous statistics for comparing different reasoning processes. In this work, the decision process of participants viewing different visual representations was analyzed. The resulting networks of reasoning show how different visualizations of the same data can significantly alter the decision process itself.

3.1. Introduction

Diagrams are exceptionally important for portraying complex systems (Heiser and Tversky, 2006) that operate on Earth. The water cycle, for example, plays an integral role in human society. Earth systems both impact and are impacted by decisions made at all levels of government. Further, such decisions are often made by those with little scientific background. Cognitive scientists have long been interested in how humans extract information from diagrams (Larkin and Simon, 1987; Narayanan and Hegarty, 1998; Novick, 2001; Stenning and Oberlander, 1995; Tversky, 2001). Diagrams may be able to convey particularly relevant information in a way most useful for non-scientists, but exactly how these diagrams should be constructed and what people find most useful is not fully understood (Mayer et al., 2005). Cheng et al., (2001) and Larkin and Simon (1987) propose that diagrams may be compared using the Cognitive Information Processing approach. This approach considers the brain as an information

processor, similar to a computer, that handles information through a series of logical rules and algorithms. More specifically, this research utilizes an adaptation of the Heuristic-Systematic Persuasion Model (Chaiken, 1987; Chaiken, et al., 1989; Chaiken, et al., 1996) to model the decision-making process. Unlike other models of reasoning, this model describes processes that can be used to come to a decision, rather than explain or define the decision made. Heuristic reasoning or what is commonly referred to as gut-instinct, is not useful for analysis if the image objective is to facilitate a well-informed, complex decision. This study attempts to elucidate the alternative style of reasoning, a systematic or rule-based approach. Fodor and Pylyshyn (1988) show how systematic, rule-based reasoning is generated by language of thought that has syntax and semantics. Such syntax and semantics can be extracted from interviews and modeled for comparison between participants viewing different images. Decision analysts have invented a number of ways to formally represent the structured reasoning scheme of a decision maker. The purpose of this article is to introduce a new template for representing and analyzing a rule-based decision process through the use of social networking techniques.

3.2. Models of Reasoning

3.2.1 Cause and effect models

Decision analysis research is rich with varying techniques for formally representing the reasoning processes involved with decision-making. The simplest way to model reasoning is through a series of cause and effect statements. In his seminal book, Structure of a Decision, Axelrod (1975) introduces Cognitive Mapping as a reliable approach to turn a transcript of the decision process into a formally represented network of cause concepts and effect concepts. In this model, the researcher must look for statements that directly or indirectly imply causation and

in such statement, at least one cause concept and one effect concept will be found. These concepts can be visually represented as two nodes with the connecting line or paths representing the causal relationship. In Cognitive Mapping, these causations are directional and drawn as arrows. In addition, whether the cause has a negative or positive impact on the effect concept is represented with a plus (+) or minus (-) symbol. The cognitive map is formed when a cause has multiple effects or when a cause concept is also the effect concept of a different relationship. By continuing these connections, a "map" is created (FIGURE 3.1). This technique provides an easy-to-understand descriptive visual that represents the decision-maker's mental model.

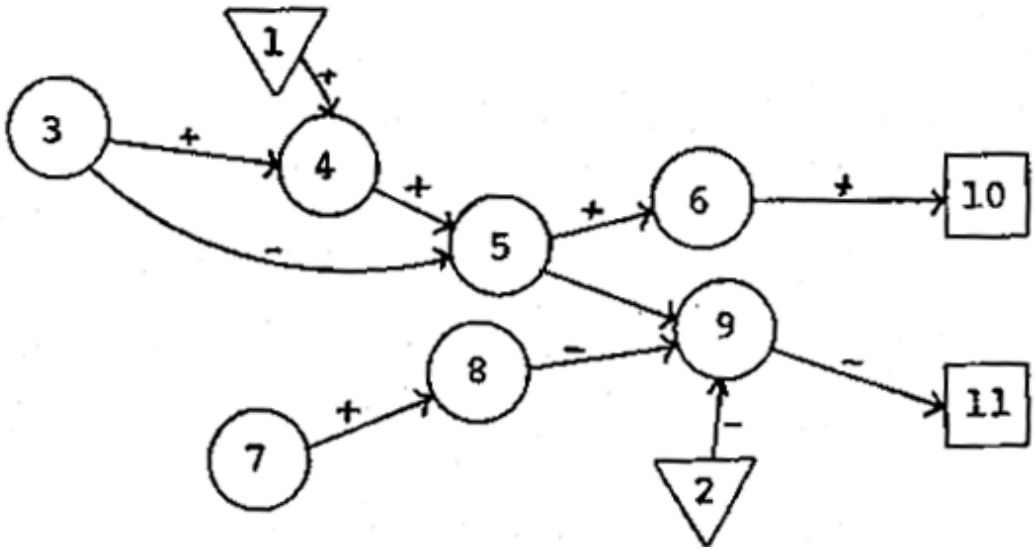


FIGURE 3.1 Example cognitive map. Positive (+) and negative (-) signs describe the impact of the cause on the effect while the arrow indicates the directionality of the causal link. For example, concept 2 decreases the value of concept 9 while 9 in turn has a negative impact on concept 11.

Others have taken similar approaches to representing decisions such as in Pennington & Hastie's (1992; 1993) Story Model of reasoning. Instead of requiring a subjective coding of cause and effect statements, the Story Model is used as a template to express a decision-maker's links between lines of evidence and explanations for that evidence. In a Story Model, each node

represents a line of evidence and each piece of evidence is connected to others through the decision-maker's inference. This particular model has been used extensively for mapping the decision of a juror. In which case the juror begins by using the evidence to create a unique story for each possible verdict. The story that best fits the evidence in the mind of the juror will represent the chosen verdict. Under this framework, the defense and prosecuting attorneys are trying to influence the juror's story model so that evidence nodes are most logically connected to their desired verdict. In such a representation (FIGURE 3.2) directionality and impact are less important than in cognitive map theory.

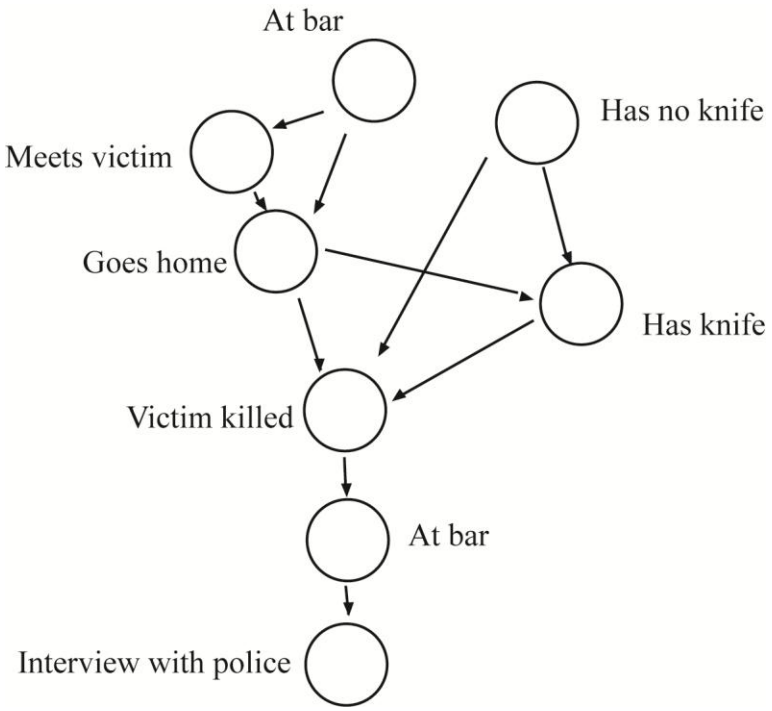


FIGURE 3.2 Example of constructed Story Model. Created from interview from juror in a civil suit (adapted from Pennington & Hastie, 1993).

Story models, cognitive maps, and similar representations of the reasoning process are useful in their ability to transform interview text into a graphical representation of a mental model. However, these techniques are inherently subjective and descriptive, not allowing for statistical comparisons to be made between two individual decision-makers. While some have attempted to use linear algebra to find the distance within components of cognitive maps (Langfield, 1992), these methods are cumbersome and require simplistic cause and effect concepts. For such a study, surveys are used that ask very specific questions of the participants about the concepts to determine direction, impact, and weight in the overall conceptual map. This inhibits the ability to test the naturally emergent reasoning chains structured by decision-

makers themselves. Other decision analysts have taken a much more objective approach to understanding reasoning.

3.2.2 Mathematical models

In order to move beyond descriptive models of reasoning, many decision analysts have taken a more objective economic approach to understanding the decision-making processes and the decision patterns of individuals. One of the earliest forms of objective decision modeling is Rational Decision Theory (von Neumann and Morgenstern 1947). This is now more commonly known as Expected Utility Theory (EUT) and describes how to determine the most rational choice for a decision with given probabilities. Utility theorists use a graphical representation of the decision space to do x, y, z (FIGURE 3.3). For example, if the decision maker chooses action "p", then there are three possible outcomes with given probabilities. For action "q" there are only two expected outcomes with different probabilities. Each outcome also has a numerical weight. By multiplying the probabilities by the outcomes, one can determine the most rational action that produces the highest probability of reward. For example, this could model the decision between two lottery tickets. One ticket may give you a high chance of winning, but the profits are low; while another ticket has a low probability of winning, with high payouts. One could multiply the probability of outcomes by the payout and determine which ticket is the most rational choice.

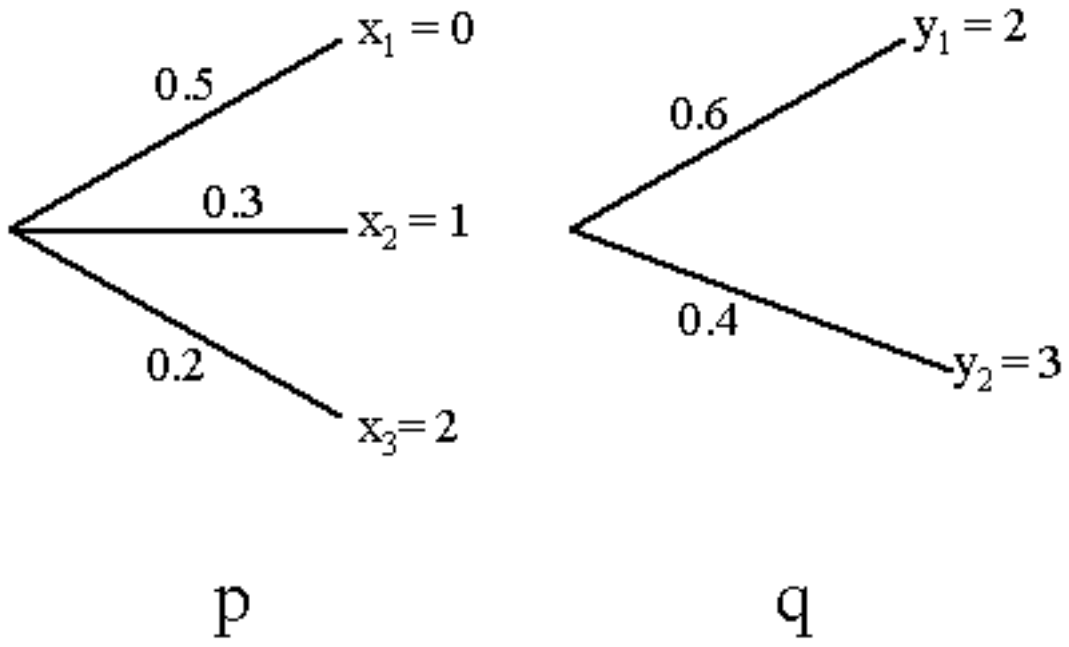


FIGURE 3.3 Example of expected utility theory. Each branch represents a possible outcome for a particular action. The weights are the probability that each outcome will occur.

Much research in human behavior has shown that EUT is a poor description of what people actually decide. This "cold" and rational approach assumes that people are aware of all probabilities at any given time and that decisions are entirely based on maximizing profit, without consideration fo risk (March, 1978).

In order to account for the differences between the expected utility and actual human behavior, Tversky and Kahneman (1992) developed Prospect Theory. This approach recognizes cognitive processes of the human mind and measures these processes as illusions. Illusions, as described in Prospect Theory, are the difference between the rational choice and the actual choice. Through use of surveys Tversky and Kahneman found common patterns in human decision making such as risk aversion and disregard for base-rates, thus confirming the prevalence of the gambler's fallacy. This is still essentially utility theory, however, in terms of

representing the structure of a decision for comparison. A more comprehensive and cognitively-valid model is needed to assess the effectiveness of communication on a decision-maker.

Currently, one of the most commonly used decision models is the Lens Model, based on a framework set by Egon Brunswik (Hammon & Stewart, 2001, Brunswik, 1956). This conceptual template represents the decision process as an interface between the decision maker and the world in which the decision is being made. The most basic version of the model is shown in FIGURE 3.4 where the decision-maker is on the right and the external world (called ecology) in on the left. Similar to the concepts of Cognitive Mapping or the evidence nodes of Story Models, there are a set of "cues" that represent each piece of information that goes into a decision (Cooksey, 1996). In the Lens Model, studies of decision analysis, the researcher's goal is to identify these cues and then determine the weights, called ecological and utilization validities. The ecological validities are the actual correlations between the cues and the criterion while the utilization validities are the perceived judgments of the decision maker for each cue. For example, when buying a new car, a decision maker is using gas mileage as one cue toward the value of the car. They may have a judged utilization validity based on the size and shape of the car to be a "high mileage" or "low mileage" vehicle. Meanwhile, there is an actual mile per gallon measurement that has been experimentally determined; this represents the ecological validity. If decision analysts map out such validity weights using the Lens Model framework, then they can then use linear regressions to model the accuracy of different decision makers and predict future decisions when similar weights are used (Hammon & Stewart, 2001; Cooksey, 1996)

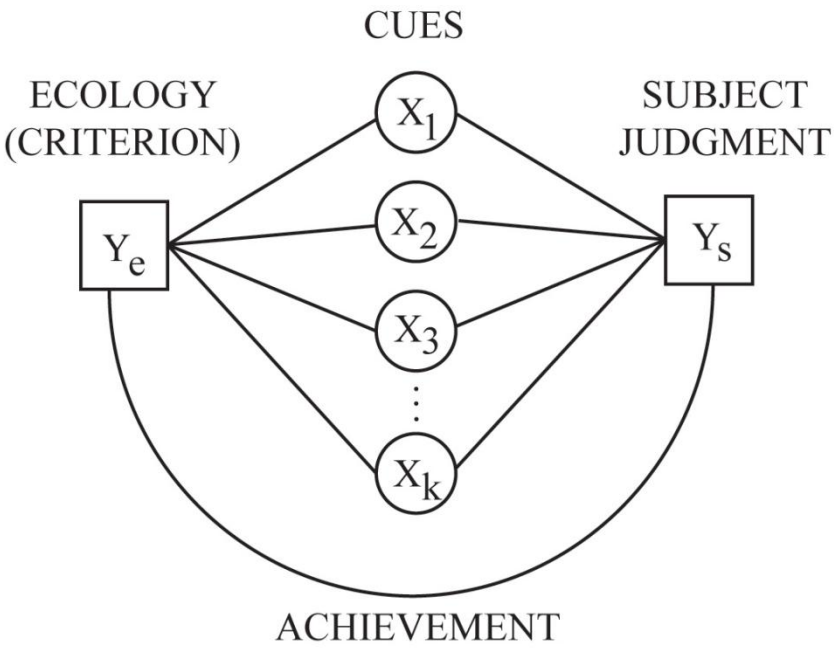


FIGURE 3.4 Template of Brunswick's Lens Model. The decision-maker's own judgment is represented on the right, while the real world criteria are represented on the left. The cues listed vertically down the center are the lines of evidence that have weights in both the real world and the decision-maker's cognition.

While the methods grounded in Prospect Theory and the Lens Model have been used to great success in determining why people have made particular decisions despite what Bayesian statistics would predict is the most rational approach, they are not as useful in comparing decision-makers in a controlled experiment. To determine how changing one variable (the image style in which information is being presented), can impact a decision, a method must be constructed that can differentiate the decision patterns of one participant from another and provide statistical measures of that difference. In such a controlled experiment, the utilization of real world measures is also irrelevant.

A common theme in all of these models of human reasoning is the representation of perceived information as nodes connected to other pieces of information through inferred or constructed linkages. This sort of structure mimics that which is seen in social network analysis.

As a well developed-and continually growing field, social network analysis provides a useful set of tools that may be used by decision analysts to trace and compare reasoning models.

3.3. Network Analysis

Social network analysis has a wide variety of applications including economics, geography, political science, and biology (Mizruchi and Schwartz, 1987; Wellman and Berkowitz, 1988). The fundamental structure of social networks is broken into two concepts: *attribute* data and *relational* data (Scott, 1987). Although now commonly associated with computer modeling and modern "social networking" websites, scientific study of social networks can be traced to Moreno (1934) where surveys of friendship were used to create easy to understand graphical representations of relationships, called "sociograms". Researchers then represented these networks as adjacency matrices in order to quantitatively compare these networks, and thus began social network analysis (Festinger, 1949; Meek and Bradley, 1986). These complicated linear algebra (matrix) techniques were replaced by computer analysis which both sped up analyses and provided a much richer set of comparative data. Today, numerous software packages exist to address the wide variety of applications for network analysis. The formal mathematics among these packages used as the common language of analysis for such networks is known as graph theory (Scott, 1987). Graph theory can be node-centric or graph-centric (also socio-centric, Barnes, 1974). While statistical measurements of an individual node, for the node-centric or anchored approach) , can be revealing about the "popularity" of an individual, it says little about the complexity of the system in which that node operates (Mitchell, 1969). Measures of the network's path length, diameter, or density, however, can reveal details about the whole system in ways that can be compared with other systems. Socio-centric studies

have revealed interesting insights into the similarities of seemingly isolated systems. Watts and Strogatz (1998) identified a particular graph centric theory characteristic held in common by many complex systems. Mathematically described as:

Equation 3.1:

$$L \propto \log N$$

Watts named any network with this mathematical phenomenon a Small-world Network, where L is the distance between two random nodes and N is the total number of nodes in the system. Since then, natural and manmade systems such as power grids, social networks, neuronal networks, and chemical polymers have been found to possess this attribute (Amarral, 2000). Latora and Marchiori (2001) showed that Small-world Networks are the most effective systems for quickly passing information from one node to another. Not only does graph theory and social network analysis provide a rigorous framework in which to model decision processes and compare decision makers, but it also allows such decisions to be compared with other complex systems in which these decisions occur.

3.4. Methods

The study population was mostly recruited through online classified ads. Over 200 people responded by filling out the online pre-screen survey. Only 42 were eligible, invited, and eventually participated. Less than 50% of the participants had any education beyond high school. Of those with college experience, none were in scientific professions and none had taken more than two college science courses. This was done in order to control for previous content knowledge. Professions were varied, including: elementary school teachers, construction workers, managers, retail clerks, babysitters, and some declared only unemployment. Ages

ranged from 18 to 63 years with an average of 33.7 years. The study was split among genders with 20 females, 21 males, and 1 transgendered participant. Participants were compensated with $25 for their time (approximately 30 minutes to 1 hour).

In order to encourage the use of rule-based reasoning over associative inferences in the participants, the task must be one that requires careful, complex thought, needs to be explained to an audience, and must be seen as of importance (Chaiken, Liberman and Eagly (1989), Chaiken, Wood and Eagly (1996). All of these components were met by creating a scenario and role-play experience for participants. In the role-play scenario, participants take the role of a city mayor faced with an important decision. Their own city is struggling economically but has a large source of freshwater. Meanwhile, another city is facing a water shortage and is looking to buy water from the participant's city. The role-play interview task was for the participant to decide weather or not to accept this water resource trade.

Each participant was given the same scenario and instructions on a paper memo and the interactive whiteboard. The participants were randomly assigned into one of three experimental image groups or one control group that viewed text (at least 10 participants for each image and 10 for the control). The water resource and monetary information were mimicked exactly in all three images and text. The images themselves were a Map Image, a Profile Image, and a Schematic Image. These align with Lohse's (1994) visual classifications of Maps, Structure/Process Diagrams, and Network Representations, respectively. Once all interviews had been collected as audio-video on the interactive whiteboard, the participant's speech was transcribed to text for further analysis. The first step in analysis was to code all interviews using a content analysis rubric designed to pull out individual thought processes (the semantics) in terms of information being used.

3.5. Results

3.5.1 Content Analysis

Most information came directly form the images and was coded as such. Other reasoning processes may have been emergent from the mathematical nature of the issue, these include addition and subtraction of different resource information. Some important steps in participant reasoning processes were brought from their own cognition. These external features include value judgments or wanting more information. Also coded were the points in which they came to their final conclusion and times they were confused. Confusion includes mathematical errors or misunderstanding of the scenario. All of these codes were nested into general categories allowing for course-grain and fine-grain analysis (TABLE 3.1).

TABLE 3.1 Codes from content analysis used as nodes in network analysis

Course-grain codes	Examples of some fine-grain nested codes	Description
Water Usage	Of Farmland, Of Portstown, Of Townsville, Of the Pipeline, Of Tourism and Recreation, etc.	Amount of water being taken from Lake Voda or Nero Aquifer for a particular usage.
Revenue	From the pipeline, From Recreation and Tourism	Monetary calculations of gain for Portstown
Recharge	Lake Voda, etc.	
External Variable	Environmental concerns, Humanitarian priorities, Agricultural priorities, etc.	When participant makes comments that are not related to data presented on image.
Confusion	--	Participant makes a mistake reading the image or understanding the Memo.
Conclusion	Build the pipeline, Do not build the pipeline	The participant's final decision.

3.5.2 Reasoning networks

Pulling out and aligning each coded feature sequentially from a participant's interview will create a reasoning "chain" with each "link" being a thought process (FIGURE 3.5). This matches the predicted step-by-step process described in Cognitive Information Processing models. However, for many participants, there are many times they circle back to previous thoughts (as should be expected for a complex decision). It would be more accurate, therefore, to not think of the decision process as a linear chain but an interconnected network where each node is a step in the reasoning. In order to model this reasoning network, binary adjacency matrices were created for each participant. If a coded reasoning feature followed or preceded another feature, it was recorded as adjacent. See TABLE 3.2 for an example. Using BioGrapher 4.4, these data matrices were modeled as networks (FIGURE 3.6). For this research, undirected networks were used. Nodes were spaced out based on a spring model. In networking, a spring model simulates a spring being placed between each node. The springs are stretched or compressed relative to the total connections of the nodes involved (Kamada and Kawai, 1989). The end result of a spring model is a network where the more connected nodes are more tightly packed and the less connected nodes are at the end of longer links. Although a directed network may better represent the reasoning process visually, it does not allow for rigorous connectivity tests in order to asses the complexity of the participant's reasoning.

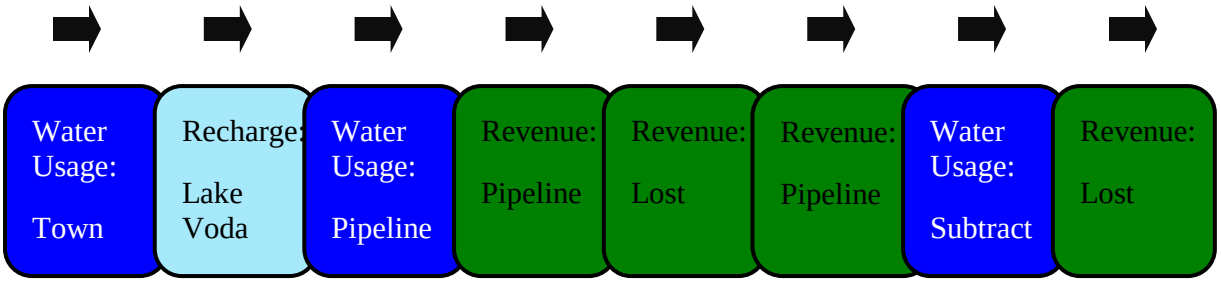


FIGURE 3.5 Example of a participant reasoning chain. This represents the step-by-step process as predicted by rule-based reasoning theory. Note the repeated steps or "links" in this chain.

TABLE 3.2 Adjacency matrix created from reasoning chain in FIGURE 5. Nodes are considered adjacent bidirectionaly, and only counted once.

	Water:Pip	Water:Tow	Water:Sub	Rev:Pipe	Rev:Lost	Rchg:Lake
Water:Pipe		0	0	1	0	1
Water:Tow	0		0	0	0	1
Water: Sub	0	0		1	1	0
Rev: Pipe	1	0	1		1	0
Rev: Lost	0	0	1	1		0
Rchg: Lake	1	1	0	0	0	

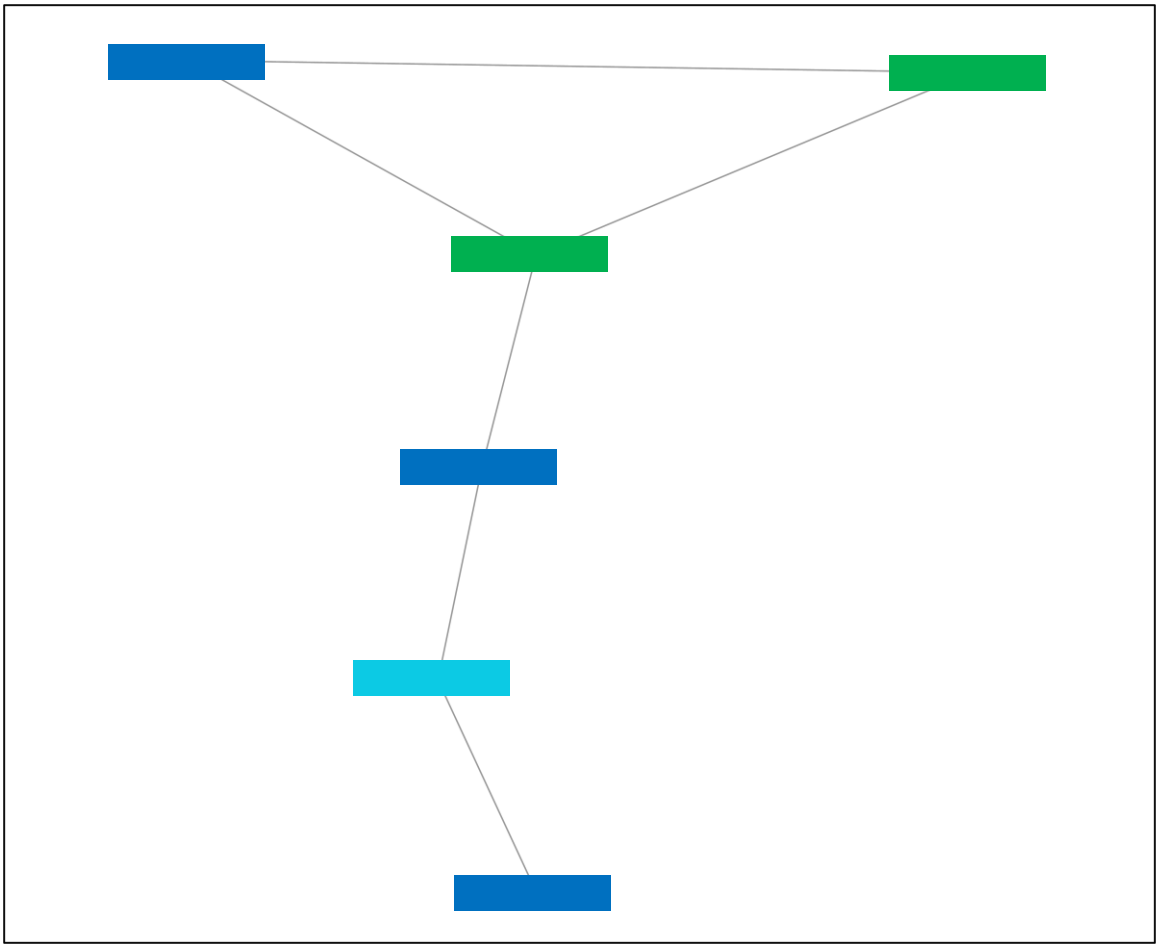


FIGURE 3.6 Example of an undirected network of the participant reasoning chain and adjacency matrix FIGURE 3.5 and TABLE 3.2. Repeated connections between nodes have been filtered out. Network was created using a Spring Model that optimizes arc placement based on number of connections for each node.

The first assessment of image effectiveness can be to see how "informed" participant decision were. This can easily be done by looking at the minimum number of features present in the scenario. To fully understand the scenario would require at least 10 pieces of information. Any more would come from calculations, confusion, or external variables. On average, those who viewed the profile and schematic images mentioned less than 10 pieces of information, using as low as three. Inversely, those viewing the map image averaged 14 pieces of information, and all discussed greater than the 10 minimum features.

3.5.3 Network analysis

Once in a network form, BioGrapher can then calculate clustering coefficient as defined by Watts (1999). The average clustering coefficient for the network is calculated using the following equation:

Equation 3.2

$$\bar{C} = \frac{1}{n}\sum_{i=1}^{n} C_i.$$

The global clustering coefficient gives a zero to one scale of how interconnected a graph is. A clustering coefficient of one means every node is connected to every other node, whereas a zero represents a linear or disconnected graph. When comparing reasoning networks, the participants that viewed the map image all exhibit non-zero clustering coefficients. Nearly half of those viewing the profile and schematic image produced reasoning networks with clustering coefficients of zero.

3.5.4 Small-world analysis

In order to form a base-line for comparison, one can look to the network literature. More and more researchers are finding characteristics of "small-world" networks in complex systems. Small-worlds were first described by Watts and Strogatz, (1998). In general, the Small-world property seems to be a characteristic of complex, developed systems. FIGURE 3.7 shows how this Small-world connectivity can be calculated for each participant reasoning network. The Small-world connectivity (coefficient of determination from these log-log plots) can then be used to compare images the participants viewed. When excluding those networks with clustering coefficients of zero, only viewing the map image significantly predicted for increases in small-world connectivity (15% of variance, significance of 0.080).

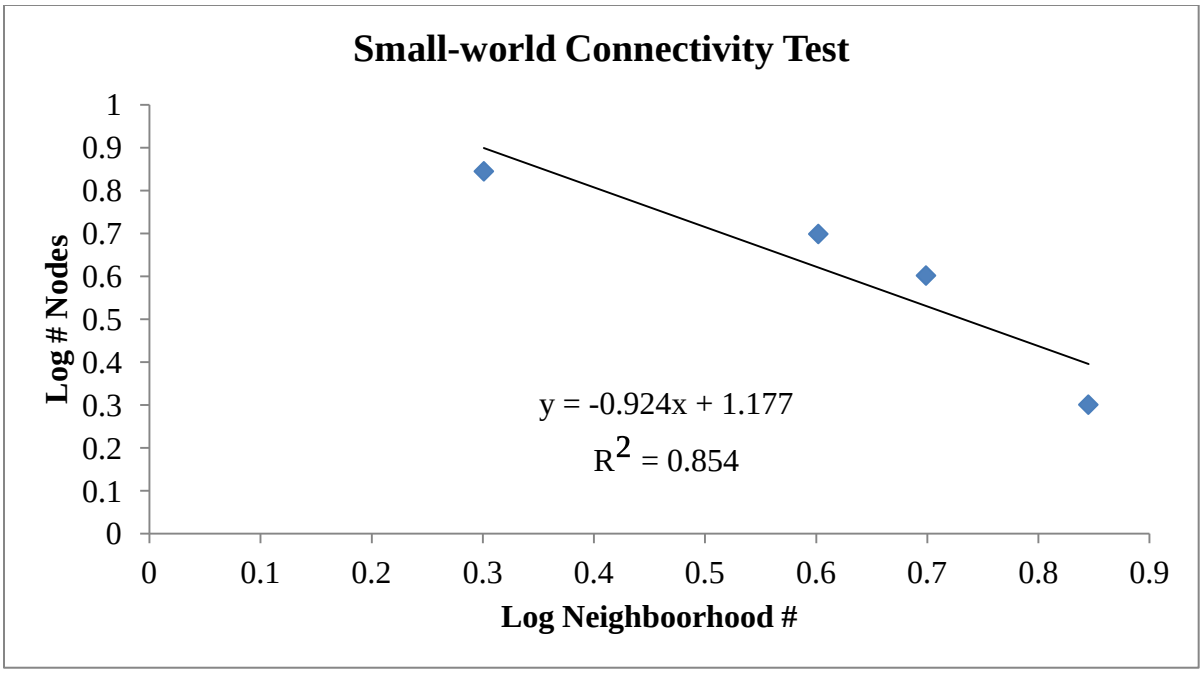


FIGURE 3.7 Example Log-Log plot of number of nodes in a given neighborhood vs the neighborhood number. The R^2 of the fitted line gives a 0 – 1 ratio of Small-world connectivity, 1 being a network that displays small-world characteristics. Only networks with non-zero clustering coefficients were used.

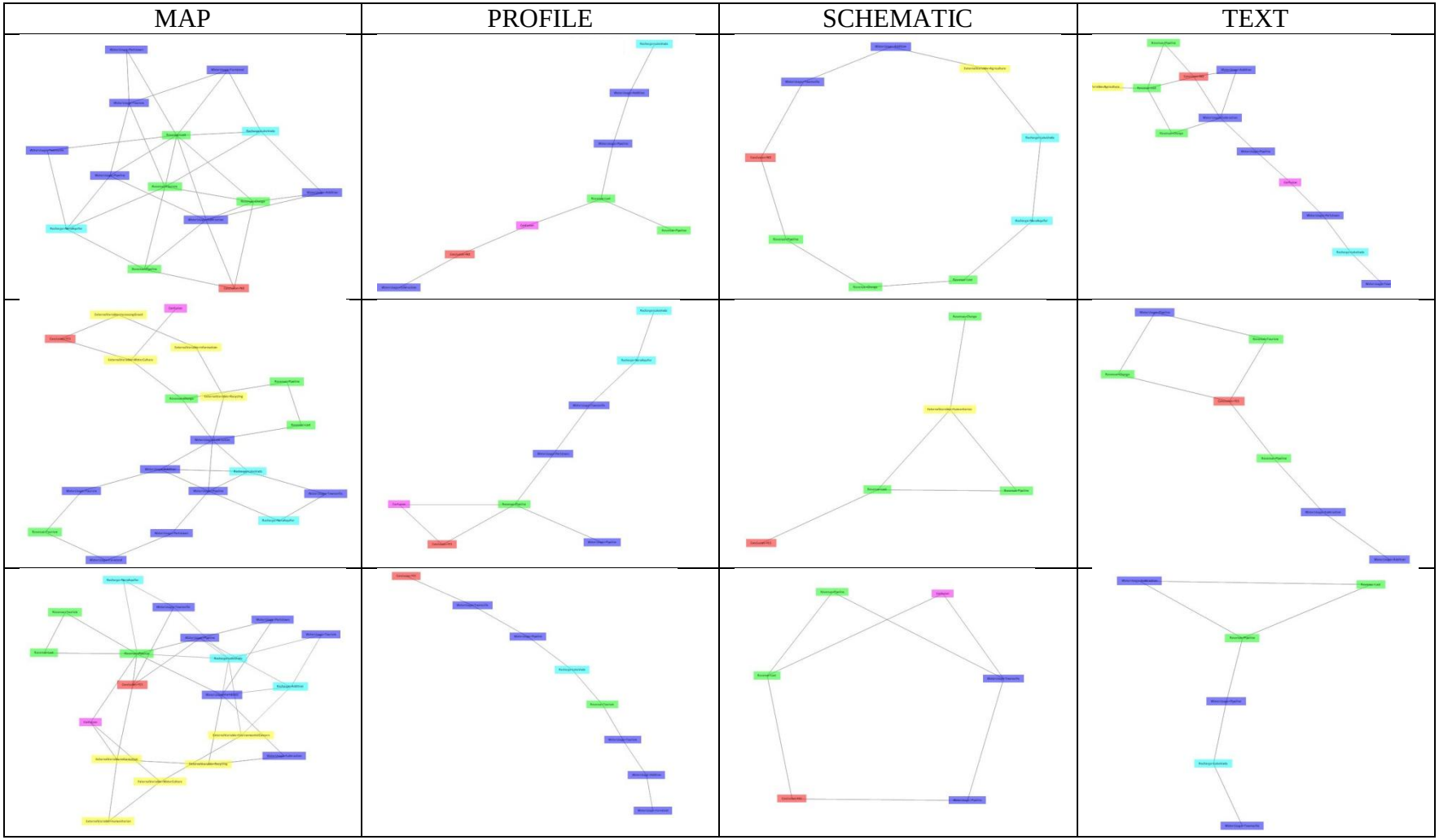


FIGURE 3.8 Example of participant reasoning networks organized by image viewed. Participants viewing the profile image and text control had very simplistic, linear reasoning. Those that viewed the schematic also had generally linear thought processes but finished where they started. Those viewing the map had the most thorough and interconnected reasoning chains.

3.6. Conclusions

Three metrics evaluated in this study identify maps as diagrams that promote the most informed decision-making process for participants in this study. The participants viewing the map utilized the most information from the diagrams and gave the most thorough responses. The network analysis shows that those viewing the map had the most complex, interconnected reasoning processes (FIGURE 3.8). The Small-world test that shows those viewing the map have reasoning chains that more closely resemble small-world networks. Latora and Marchiori (2001) show that networks exhibiting Small-world characteristics are both globally and locally most efficient at passing information between nodes. More psychological research may be needed on the significance of this finding for decision-making theories, but for this study it at least shows that these participants had much more developed reasoning processes that mimic the complexity of real world issues they may have to solve.

One possible explanation for the success of the map image is that the general public has a high level of familiarity with maps. Familiarity can be a key factor in how users interact with visual representations and make decisions (Lowe, 1993; Chi et al., 1981). In their daily lives, people utilizing maps to navigate roads, either in paper form or on their GPS. One of the most common places scientific information is displayed for the general public is during hourly weather forecasts on the television. This is nearly always in the form of maps. Although, it would seem a profile would be better for depicted subsurface features such as an aquifer, only those laypersons looking at textbooks or online sources of environmental systems would come across similar images.

Lastly, this study has shown the effectiveness of social networking analysis to be used for visualizing and comparing cognitive decision processes. Unlike techniques such as cognitive

mapping, this methodology does not require ambiguous coding of cause-effect statements. Instead, simple content analysis can be used to extract the stated information line by line. In addition, this type of network analysis does not require real world weights to assess the accuracy of the decision maker. While mathematical decision models can use this accuracy to compare the outcome of individual decisions, the methods presented in this paper can directly compare the decision processes themselves. Assessing decisions in the format of a social network also aligns future decision analysis with the same techniques and vocabulary used by many fields relevant to decisions such as those presented in this research. These include including sociology, urban planning, neuroscience, and environmental systems sciences.

Chapter 4

Assessing the effectiveness of different visual representations of a water resource scenario via eye tacking

Eye tracking methodologies are used to assess the effectiveness of three different visual representations in portraying a natural resource scenario. The results of this study are the captured eye-movements of participants viewing these images to assist them in a decision-process. The goal of the study is to determine which of these representations are most useful for participants and what specific graphic elements make them useful. Results show that the amount of time spent attending to different graphic elements is significantly different for one of the representations. In addition, those participants viewing this particular representation are basing their final decision on the information presented (as opposed to external factors) more so than those viewing the other two representations.

4.1. Introduction

Eye tracking is becoming a popular methodology to not only probe basic human psychology (Bojko, 2005: Poole and Ball, 2005; Trafton et al., 2002) but also assess the usability or effectiveness of visual representations in a variety of disciplines (Duchowski, 2002). This increase in poplarity can most likely be attributed to accurate, user-friendly technological advances in eye tracking methodologies (Yusuf et al., 2007). This relatively cost effective and easy-to-use systems allow researchers to capture the eye movements of participants in a low-stress, unobtrusive settings. Many studies of visual representation usability focus on the accuracy of follow-up responses. These studies treat the cognitive processes between the input (the visual representation) and the output (the participant response) as a "black box" (Huang, 2007). Eye

tracking methodologies show researchers where that cognitive time is spent and how the individual aspects of the visual representation impact response accuracy.

Visual representations such as those used in this study are commonly used to represent natural and human-constructed environmental systems (Dove, 2007; Eves and Davis, 1989). While a number of studies have focused on the processes by which experts and novices extract information from scientific visual representations (Trafton et al., 2002; Bertin, 1967; Kosslyn, 1989), less focus has been placed on the usability and effectiveness of one visual representation of an environmental system compared to another. Fortunately, the methods for such comparative assessments have been developed in other content areas (Hughes et al., 1996). Even so, these have generally relied on interview and questionnaire responses. The limitation of such methodologies is the difficulty in validating the alignment between what a user reports and what they actually attended to when viewing a visual representation (Yusuf et al., 2007). Especially during a difficult and lengthy task, the participant may only recall those visual features deemed important to their task, forgetting the other cues or distractions that may or may not have influenced their response.

This eye tracking study provides such alignment validation for a larger study on visual representation effectiveness. In the previous Chapters, content and decision analysis of think-aloud interview data shows that participants viewing one style of visual representation produce more complex, more well informed reasoning processes than those viewing other styles of representation. The study presented here takes a different approach to assessing the use of each visual representation. Here, eye tracking equipment is used to directly capture the participant's perceptual activity during the decision process. Variables collected include the number and duration of eye fixations within different visual elements (called Areas of Interest or AOIs). The

visual representations used in this eye tracking study are reproduced from these earlier studies (Chapters 1, 2, and 3).

Presented herein are the results of a study conducted to better understand how people perceive and use three types of visual representations commonly used in environmental systems science. In particular, this paper tries to answer the following questions:

Which visual representation is the most efficient in allowing users to extract information?

Do representations impact the decision made by participants using the visual to inform their decision?

Are particular features of these visual representations more or less engaging?

What are people really looking at and how does this compare to their responses?

How do people visually navigate different visual representations?

In the following sections, this paper presents: a background on the eye tracking methods used, a description of the visual representations used and the task performed by participants, the results and analysis of this study, and finally a comparison with the previous interview studies using these same visuals.

4.2. Eye tracking

The basic principle of eye tracking is that the location of the pupil of the human eye can be used to triangulate the point at which the person is visually focused. Modern eye tracking technologies use cameras to track the movement of the pupil. In this study, a Tobii T60 desktop eye tracker was used to capture the gaze patterns of participants. This setup utilizes two infrared cameras built into the 17-inch flat screen display. No extra restraint equipment found in older technologies (Yusuf et al., 2007) is required as this system is built to allow for a relatively large amount of head movement. The research participants see and operate the equipment in the same

way they would a normal desktop computer. The Tobii T60 desktop eye tracker sampling rate is 60MHZ, orders of magnitude higher than the minimum standards required for both usability and reading research (Poole and Ball, 2005). The XY coordinates of eye gazes, as well as the analysis tools are provided with the Tobii system.

The most important and widely discussed eye movements in eye tracking studies are fixations and saccades. Fixations are stabilizations of eye focus on particular objects while saccades are fast eye movements between fixations (Yusuf et al., 2007). For this study, only fixations are analyzed because it is generally agreed upon that cognitive processing of the visual representations only occurs during fixation (Yusuf et al., 2007; Jacob, 1990). A scanpath can be formed that represents the step-by-step movements from one fixation to the next. These fixations and saccades are captured as XY data that can be used to analyze where participants are looking at any given time

4.3. Effectiveness Study

The overarching goal is to determine if participant decisions are impacted by the style of visual representation in which the necessary information is presented. The general design of the study is as follows: 1.) all participants were given the same specific scenario in which they were to make a yes or no decision, 2.) each participant was given only one of the three possible visual representations, 3.) an eye-tracker was used to capture their fixations and saccades, 4.) a follow-up questionnaire collected their final decision as well as questions probing their understanding of the scenario based on the information presented in the visual. Detailed descriptions of each of these steps are in the following subsections.

4.3.1 Three Visual Representations

The three visual representations used in this study are described in detail in Turner (in review). They were created in Adobe Illustrator to represent three common layouts in which environmental systems are represented (Dove, 2007; Eves and Davis, 1989). FIGUREs 1.1, 1.2, and 1.3 shows these three images, respectively, from now on referred to as the Map Image, the Profile Image, and the Schematic Image. Closely aligning with Lohse's (1994) classification of visual representations, the Map Image shares qualities with other maps in that it is a symbolic representation of physical geopgraphy. The Profile Image is both a structure and process diagram, showing both the spatial distribution of objects as well as the interrelationships between those objects. The Schematic Image is a network representation, showing only the relationships between components with no regard for physical distribution. Another way to classify these visual representations is by their level of abstraction, with the map being the most similar to reality in terms of scale (least abstract). The Profile Image is more abstract, with vastly

exaggerated scaling. Finally, the schematic is the most abstract with no visual cues to the physical systems represented.

4.3.2 The Decision Task

The task was the same for all participants except for the visual representation they were presented. Upon beginning the task, the participant is first given the scenario on a series of slides on the desktop eye tracker screen. The scenario is a water resource trade in which one city has an abundance of water but is economically poor while other city is short on water but economically wealthy. The managers of the wealthier city propose to build a pipeline to transfer water between the two cities. The participant was instructed to think about the scenario from the point of view of the poorer city and make their decision based on this perspective. See Turner (in review) for a detailed description of why this scenario was chosen to elicit thoughtful decisions. Each participant was then shown one of three visual representations previously described. The amount of water and money moving through the system is provided on the visual. Prior to completing the task, participants were instructed to take as long as they need to look at the image to understand all of the relevant information. When they felt they had viewed the image adequately, they were prompted to move onto a follow-up questionnaire. The first question asks them to make the decision of whether or not the pipeline should be built. Next they are asked two true/false questions to see if they fully understood the scenario based on the information provided in the image:

1. True or False: If the pipeline were built, Lake Voda would eventually run out of water.
2. True or False: If the pipeline were built, Portstown would lose more money than they would gain.

Given the information they are provided on the visual, the answer to the first question is True and the answer to the second is False. Participants were also asked if they felt the visual representation helped them make their decision.

4.3.3 The Participants

Participants were recruited from undergraduate courses in psychology. Forty participants eventually were run through this study protocol, split into the three experimental groups. Ages ranged from 18 to 25 years, and predominately identified as female (31 out of 40). All participants had little to no training in earth or environmental science that may influence their viewing of the presented images.

4.3.4 Study Protocol

This study consisted of participants reading the instructions, viewing the image, and answering the questionnaire all on the desktop eye tracking system. The study was completed over a two-week period. Only one participant performed the study task at a time. Upon arriving in the research laboratory, the participant was instructed on the basic workings of the eye tracking system and what information would be recorded. While audio was recorded for parts of the task, it is not analyzed in this study. Once the participant felt they were sufficiently informed, they were asked to read and sign a consent form. They were placed approximately 2 feet in front of the eye tracker depending on their height in order to place their eye level in the center of the eye tracker's range. For each participant, an iterative calibration process was performed to assure accurate data collection. This calibration takes only a few minutes. Once the proctor verified the calibration, the task began and was generally completed in 5-8 minutes. Participants then received cash compensation but no course credit (as is sometimes common in such studies).

4.4. Analysis and Results

The captured gaze patterns and questionnaire data were analyzed to determine differences between experimental groups. These findings provide insight into the effectiveness of different visual representations for communicating information.

4.4.1 Decisions and Understanding

The first results analyzed were the follow-up questionnaire in order to look for overall differences in the participants' decisions and levels of understanding in the scenario. A Mann-Whitney test indicated that water understanding was greater for those viewing the Map Image than those viewing the Profile Image, $U = 58$, $p = .025$, $r = .42$. It was also greater for those viewing the Map Image than those viewing the Schematic Image, $U = 49.5$, $p = .016$, $r = .47$. Meanwhile there was no significant difference between the water understanding for participants viewing the Profile and Schematic Images. There was no significant difference in economic understanding between participants viewing different visual representations.

Moreover, the final decision made (yes or no to building the pipeline) was significantly correlated with both understanding measures. There is a significant positive correlation with the economic understanding variable, $r(38) = .59$, $p < .001$. This means that those who understood the positive economic impact of building the pipeline chose to build the pipeline more often. However, there was also a significant negative correlation with the water understanding variable, $r(38) = -.41$, $p < .01$, meaning those who understood the negative impact of the pipeline chose not to build the pipeline more often. The interface of visual representation style and scenario understanding can be seen in statistical modeling. Linear regression shows that both the Economic and Water understanding variables predict the final decision for those viewing the Map image (TABLE 4.1). For those viewing the Profile image, only Economic understanding

predicted the variance in the final decision made. For those viewing the Schematic image, neither understanding of Economics nor Water predicted the decision to build the pipeline. One hundred percent of participants said that the visual representation helped them make their decision.

TABLE 4.1 ANOVA impact of understanding variables on decision made

	B	SE B	β	*p*
Map Image R^2 = .751, p < .001				
Water Understanding	-.789	.177	-.671	.001
Economic Understanding	.386	.151	.386	.025
Profile Image R^2 = .594, p <.05				
Water Understanding	-.276	.202	-.276	.201
Economic Understanding	.793	.218	.734	.005
Schematic Image R^2 = .169, p = NS				
Water Understanding	-.050	.333	-.052	.884
Economic Understanding	.417	.379	.383	.300

4.4.2 Fixations and Scanpaths

The focus of the eye tracking analysis is to understand what participant eye movements can tell us about:

Visual navigation: How participants search the visual representation for information relevant to their decision.

Visual attention: How long participants spent looking at particular Areas of Interest (AOIs) or types of visual information.

Representation differences: How these gaze patterns and fixation durations differ across experimental groups

Scanpaths give the order and duration of fixations as well as saccades and were used in this analysis. These show that, overall:

Participants viewing the Map Image were much more focused in fixations. They fixated on fewer areas of the visual representation. This is especially true if only looking at the first 5 seconds of view. Qualitatively this focus is less on the textual labels for those viewing the Map Image.

Those viewing the Map image show a back and forth pattern between the two sides of the image. Those viewing the Profile image normally had a similar pattern to those viewing the Map, but focused on one side then the other with less back and forth. Those viewing the Schematic image usually viewed the image in a circular pattern, starting at one features and then moving clockwise or counterclockwise.

A more quantitative method for understanding what participants were focused on is through analysis of AOIs. These AOIs can be defined by the researcher or emerge naturally from the data. For the purposes of this study, they were pre-defined as features of each visual representation that were important information for use in the participant's decision. The AOIs used in this study are:

1. Water Information: Represented as water droplets
2. Economic Information: Represented as dollar signs
3. Text: The labels of each feature.
4. Distractors: Everything not in one of the above three AOIs.

The first three AOIs are equivalent on all three visual representations. While the visual content of the distractors may vary by visual representation, the total area remains the same. The duration of fixations within each of these AOIs proved to be useful for differentiation the experimental groups (TABLE 4.2). While there is no significant difference in the fixation durations for Water Information, Economic Information, and Distractors between the participants

viewing different images, the time spent looking at Text was distinct. A Mann-Whitney test indicates that those viewing the Map image spent less time on text than those viewing the Profile image, $U = 40$, $p = .008$, $r = .50$, and less time than those viewing the Schematic image, $U = 37$, $p = .010$, $r = .50$. There was no significant different in fixation duration on Text features between those viewing the Profile image and the Schematic image. Linear regressions show no significant predictions of the fixation durations on the final decision on whether or not to build the pipeline.

TABLE 4.2 Fixation data for three visual representations

Image		Economic		Water		Text		Total	
		Fixations	Duration(s)	Fixations	Duration(s)	Fixations	Duration(s)	Fixations	Duration(s)
Map	Mean	29.86	10.73	41.26	17.75	35.9	12.96	292.5	88.8
N = 15	Range	3 – 68	.65 – 27.4	19 – 92	4.5 – 58.9	9 – 77	2.6 – 39.6	133 – 699	47.6 – 196.5
Profile	Mean	30.38	11.83	59.15	20.89	66.69	25.20	330.5	104.8
N = 13	Range	3 – 71	.65 – 29.2	14 – 125	3.55 – 50.4	20 – 125	5.68 – 52.59	158 – 598	45.8 – 197.5
Schematic	Mean	25.08	9.43	56	15.69	90.66	33.02	340.75	111.1
N = 12	Range	2 – 67	.30 – 28.9	13 – 123	2.9 – 53	26 – 180	4.48 – 57.29	114 – 592	25.2 – 215

4.5. Discussion

While these findings were somewhat unexpected, previous eye tracking studies and research on visual representations may explain the results presented in this article. In addition, the previous work done by the author on these same visual representations (Chapters 1, 2, and 3) mimic the differentiation of the Map Image from the others. Combined, these studies explain why this particular representation stands out and hint at best practices for communicating systems such as the one in this research scenario.

4.5.1 Explanation of Findings

The eye tracking literature provides a solid basis on which to interpret the eye movements found in this study. While the difference in overall number of fixations was not statistically significant between experimental groups, those viewing the Map Image were lower on average. In general eye tracking studies, more overall fixations are interpreted as less efficient search patterns (Goldberg & Kotval, 1999; Poole and Ball, 2005). So even if the statistics on this metric cannot confirm that the Map Image promoted the most efficient searches, it can be stated that it did not promote *less* efficient visual searches. This is important to note, as confusion could have been one interpretation of the back and forth scanpaths of those viewing the Map Image. However, a more likely explanation reflects what is found in studies of graphs (Carpenter and Shah, 1998; Trafton et al., 2002). These studies find that experts, or those graphs that promote expert-like understanding, result in very specific reading patterns. Whether described in an interview, or captured in an eye track experiment, the general pattern is back and forth between the relevant information. On a typical graph with X and Y axes, pattern is between the data point and the two corresponding points on the axis. The back and forth pattern shown from participants

viewing the Map Image in this study can easily be interpreted as the participant comparing parallel informational features from the two sides of the scenario.

Analysis of the AOIs showed that the average fixations were lower in the Map Image group, but the significant difference was on Textual Information. Poole el al., (2004) describe how the number of fixations in an AOI is proportional to the importance or attention grabbing characteristics of the AOI. The text on these visual representations is only used as labels. Since the participants viewing the Map Image spent significantly less time on this text, we can assume they found it unnecessary (remember that the overall understanding of the scenario was higher for these participants). The spatial distribution of fixations for each experimental group in this study also shows the effectiveness of the Map Image. It is commonly excepted in eye tracking research that smaller, more focuses areas of fixations represent efficient search patterns whereas more spatially spread out fixations are from participants whoa are visually "lost" (Cowen et al., 2002). Overall, this eye tracking study showed a difference in eye movements between the different visual representations. Just as in Convertino (2003), a difference in these eye movements led to different levels of understanding and ability to answer questions about the viewed representation correctly.

4.5.2 Within Context of Previous Work

There was no right or wrong decision in this scenario. As mentioned above, participants who fully obtained and understood the information presented on the visual representation had to use personal preference, choosing between economic or water security. While eye tracking does not directly capture these preferences, previous work has illustrated some of the external factors that go into interpreting these visual representations. Chapter 1 and 2 analyzed think-aloud interviews of participants using these visuals to make a decision. It was found that a number of

personal values such as *environmental concern*, *humanitarian good-will*, or *appreciation of aquatic culture* that went into the decision process. As in other studies such as Trafton and Trickett (2001), these Turner findings show that different visual representations can illicit different concepts not directly stated or completely external to the information presented.

One of the most interesting parallel findings between this study population and those in the previous Chapters is the focus on water information for those viewing the Map Image. Trough cognitive mapping of the decision process, Chapter 2 showed that 100% of participants viewing the Map Image noted the negative impact the pipeline would have on water levels. In this eye tracking study, those viewing the Map Image were the only experimental group to consistently answer that probe correctly. While total fixations on the Water Information AOI does not directly address why this may be the case, the tight spatial distribution of fixations situated on the water features does. It seems that those viewing the other visual representations are focusing just as much on labels and nearby distractors as the water information features. Assuming the participants in this eye tracking study used similar search patterns to those in the interview studies, this might explain why the transcripts from those viewing the Map Image mentioned more discrete information and gave more thorough explanations of their decision. Comparatively, those viewing the other visual representations were lost in both their visual search and their mental models.

Lastly, Chapter 3 showed quantitatively that the decision process of those viewing the Map Image were more complex. In fact, if the interconnected decision process is thought of as a network, then only from those viewing the Map Image did these networks meet the Small World threshold. In the network literature, Small Worlds are networks meeting a specific mathematical relationship between the number of nodes and the connections between them (Watts and

Strogatz, 1998). Such networks have been found in many aspects of both the natural and human constructed world but the common feature is that it is the most efficient type of network for passing information across the complex system (Latora and Marchiori, 2001). While the methods have not yet been developed to analyze eye movements in such a way, perhaps future research will show a quantitative parallel between scanpaths and decision process. Even without such evidence, we can see that the Map Image in this series of studies produced the most efficient, complex, and informed decisions. When participants in either study were asked about their comfort and familiarity with different types of visual representations, all were most comforTABLE with maps. Anecdotally, participants that questioned in post-task about the study and learned of other visual representation styles said they would have preferred seeing a map. This familiarity could be the biggest explanation for why the Map Image experimental groups in each study showed such distinctive characteristics.

4.6. Conclusions

This study, in conjunction with the previous work, shows that a growing number of qualitative and quantitative methodologies can be used to assess the efficacy of different visual representations. These widely varied methods from disparate disciplines used on different participant populations show aligned results. At least in the case of this water resource scenario, the Map Image stands out as different. This difference can be considered "better" if the goal of a visual representation is to promote understanding of the system being portrayed. This result should be encouraging for those interested in the application of geographic information systems for increasing science literacy in both students and in the public. While scientists may prefer cross-sections or box-and-arrow style diagrams to communicate with one another, they may not

be the best for use in textbooks or the ever-growing body of online resources. Keeping the audience in mind, non-scientists today are using maps in their everyday life through user-friendly GPS systems and smart-phones. The next step in this line of research would be to use these mixed-methods to assess the efficiency and effectiveness of maps created with real geographic data in real world environmental scenarios. While this "proof-of-concept" collection of studies focused on static imagery, the next series of studies should look at multiple representation, animations, and interactive maps, such as those being used today by non-scientists. The advancing technologies of TABLEts, interactive whiteboards, and especially eye tracking systems make such research easier and easier, while also providing more and more useful information. Those interested in communicating science must take advantage of and align their methodologies with the advancements in both communication and research technologies.

APPENDICES

APPENDIX I LIST OF SALIENT IMAGE FEATURES

TABLE A List of all major features on three images and explanations for differences between images.

Feature	Map Diagram	Profile Diagram	Schematic Diagram	Reason for Difference
Lake	Surface Area, blue, labeled	Depth Profile, deepening blue, labeled	Labeled Box, blue	Change of View, as most commonly seen in depictions
Portstown	Small cluster of small black boxes, labeled	Profiles of few small houses, steeple structure, labeled above	Labeled Box	Change of view and scale, style of building cannot be shown on map
Townsville	Large, gridded, concrete colored area of many black boxes ranging in size, labeled	Profiles of 3 large, skyscraper type buildings and a few small surrounding buildings, labeled above	Labeled Box	Change of view and scale, only small representation of buildings needed on profile
Farmland	Surface area of farms shown in multi-earth-colored squares next to small boxes (farms) and circles (silos), labeled above	Profile of silo and farm next to town	Labeled box (shared or not shared with town?)	Map allows for a truer scale of area needed for farming, profile is iconic.
Transfer Pipe	Steel colored thin line between lake and aquifer	Cartoon depiction of pipe beginning under lake surface, going across surface, and down into aquifer	A labeled box in between lake and aquifer, steel	Pipe is key feature of all three, connects left to right, or top to bottom sections of image

TABLE A (CONT'D)

Water Recreation	Small docks on lake near boathouses, labeled on lake	Fisherman on pier, sailboat on surface, fish in water, labeled above lake	Labeled box	Profile without true scale allows for representation of local human activities than can't be seen on map
Aquifer	Dotted, labeled area around city	Underground patch depicting porous rock with small amount of blue on bottom represented depleted water	Labeled box, blue	No good way to show underground feature on map view, most commonly seen as dotted or hatched areas on surface represented lateral extent
Money Trade	Green arrows moving along pipeline from city to town, and city to pipeline; monetary icons along arrows and under recreation label	Green arrows along pipeline from city to town, and from town to pipeline; monetary icons along arrows and over lake, under recreation label	Green arrow between city and town boxes, green arrow from recreation to town, and from town to pipeline. Monetary icons at each arrow	Money gained from recreation not shown as arrow on map and profile because lake next to town.
Water Trade	Blue arrows along pipeline, and into lake and aquifer from outside; icons at each arrow, near town label, near farms, under city label, under recreation label on lake	Blue arrows along pipeline, from aquifer to city, from lake to town, and into lake and aquifer from outside; icons at each arrow, above town, above farm, above city, above recreation	Blues arrows connect natural recharge to lake and aquifer, from lake to pipeline and pipeline to aquifer, from lake to recreation and town and farm, aquifer to city. Icons at each.	Arrows not needed on map between lake and its uses or aquifer and city because uses are on top of or adjacent to lake. Arrows are commonly seen on profiles and it has nearly as many arrows as the schematic for this reason

TABLE A (CONT'D)

Ground	Green near lake, brown near city	Single, flat brown color	Unrepresented	Map shows surficial fertility whereas profile only shows beneath surface, irrelevant to schematic
Sky	Not represented	Light blue, daytime sky with sun and clouds	Not represented	Cannot be shown in a map and irrelevant to schematic. Sky features very commonly found on profile diagrams
Natural Recharge	Rivers entering lake, labeled with arrows into lake and aquifer	No representation, label under lake and aquifer	Labeled box, arrows go from single box to lake and aquifer	Arrows not needed on profile due to positioning. Schematic can treat "natural recharge" as single idea with different arrows where other two can show distinct recharge

APPENDIX II: MEMO OF SCENARIO

Dear Mayor:

Tale of Two Cities

The city of TOWNSVILLE is in crisis. TOWNSVILLE relies exclusively on the NERO AQUIFER for its water USAGE. Population growth and increased demand have left the NERO AQUIFER nearly depleted. NATURAL RECHARGE cannot keep up with the increasing human USAGE. TOWNSVILLE is very well-off and is willing to pay large amounts of money for a solution to this water problem.

Meanwhile, the city of PORTSTOWN sits on the edge of LAKE VODA, a massive freshwater reservoir. PORTSTOWN and the surrounding FARMLAND rely exclusively on LAKE VODA for their water USAGE. In addition, LAKE VODA is used for RECREATION AND TOURISM. Although PORTSTOWN receives REVENUE from RECREATION AND TOURISM, this is not enough to meet local economic needs.

The Proposal

Politicians in TOWNSVILLE have become desperate for water and look outside their region for help. They see the struggling city of PORTSTOWN with its own unique crisis, but a bountiful source of water, and believe they can strike a bargain to benefit both cities. TOWNSVILLE engineers design a PIPELINE that could transfer water out of LAKE VODA and recharge their own NERO AQUIFER. They are willing to pay PORTSTOWN large sums of money for access to their fresh water supply. However, this would cause REVENUE LOST TO PIPLELINE in RECREATION AND TOURISM for PORTSTOWN.

The Choice

It now comes down to you, the mayor of PORTSTOWN, on whether or not you will agree to TOWNSVILLE's proposal. Soon you will be presented with all the relevant economic and water data needed to inform your decision. You will need to convince the people of PORTSTOWN of your decision. You will be presenting to a camera for broadcast using an Interactive Whiteboard. More details will be available shortly.

Sincerely,

-Staff

Tell your proctor when you are done reading this and ask any questions you may have about this scenario. Be aware that they can only clarify what is written here and any other information will be given to you shortly.

APPENDIX III: INTERVIEW PROTOCOL

RESEARCH PROTOCOL 1: Audio and Sketch Group
(based on protocols developed for eye-tracking studies by J. Libarkin, S. Clark, and R. Simmon)

Materials Needed

E.V.A.L. Interview Space
Accompanying E.V.A.L. monitoring computers
Interactive White Board
Camtasia Studio 7 with PPT addon
Powerpoint 2010
PointerKeeper1.2 addon for PPT
Memo explaining role-play situation (APPENDIX 2)
One of three Sketch PowerPoint Files per subject containing task directions and image.
Digital Writing Stylus
Consent Form (2)
Stipend money
Stipend Receipt Form
This protocol
Folder with participant's ID, WEB SURVEY print out, interview appointment information, and blank piece of note taking paper.

EXPERIMENTAL PROCEDURE:

1. Make sure the computer with the interactive whiteboard software and the projector are on.
2. To calibrate the whiteboard for use with the stylus, push the pen into the whiteboard and a green calibration screen should pop up. Follow the directions by touching the stylus point to each of the circled cross-hairs. When it finishes, you should be returned to the desktop and the stylus will now operate as a mouse.
3. On the Interactive Whiteboard computer, ONE of the THREE possible PowerPoint files (TurnerWaterSketchTaskMap_Audience.pptx, TurnerWaterSketchTaskProfile_Audience.pptx, or TurnerWaterSketchTaskSchematic_Audience.pptx) should be opened and saved with an ID used for each subject (TWT2011xx.pptx).
4. Iconize this file for now.
5. Open up the TurnerWaterSketchTaskCalibration.pptx file.
6. Begin the Slide Show so the First Slide showing the task directions is on the Interactive Whiteboard. This needs to be done by going to the Addon tab of PowerPoint.
7. Turn the projector off.
8. When the subject arrives, introduce yourself with "Hi. My name is _____ and I will be setting you up for today's experiment. Are you ready to begin?" [If the participant needs to use the restroom or get a drink of water first, allow them to do so and then continue with this protocol]
9. If they are ready or when they return from restroom/drink, seat them at interview TABLE in middle of E.V.A.L.

10. [Once seated, continue...] "The first paper I will be giving you is a consent form to participate in this research. Please take a moment to read the consent form now. If you have any questions, please let me know. When you reach the end of the consent form, please sign and date it where indicated if you agree to participate. I will provide you with a copy of this form for your records." [When finished, make sure they have initialed the audio recording option on page 2. Collect the signed form. Hand them the second copy of the consent form for their records.]
11. Turn off the shutter/standby (so the first slide (instructions) appears on the Interactive Whiteboard)
12. "Before we begin the experiment, we first need to calibrate the instruments."
13. Click on the small blue box in the lower left hand corner and from the dropdown menu, select "Pen"
14. Select the "click to begin recording" button in the lower right hand corner of the screen.
15. "Please join me at the WhiteBoard" Once they have, "You will be utilizing this stylus as part of the task, please read the directions on this slide and click the green box when you are ready" Hand Stylus to participant.
16. They will now begin to draw on the board and speak aloud. When they are finished they will let you know and you are to take the stylus.
17. Use the Red box to select End Show. Discard the annotations.
18. Camtasia will now pop up and ask you if you'd like to continue recording, select Stop Recording. You will now be prompted with a save diaglog, save the file in the calibration folder, you can save over the previous Test file. After this another box will pop up, make sure Produce your recording it checked and hit OK.
19. Now Camtasia studio will open and you can select the video on the left and watch it on the right to make sure their penstrokes and voice were recorded clearly. While watching, "Please make sure that you see these red marks appearing where you draw while completing the actual experiment." If it did not record correctly then you will need to trouble shoot and possibly run it over again and have them speak clearer, etc. Once you are sure it is collecting data correctly, move to the next step.
20. You can close Camtasia Studio (you don't need to save), and the calibration PPT file.
21. "For this study, you will be asked to assume the role described on the Memo I am about to give you. Please read along as I read it to you. Please ask me to clarify and questions you have with this role, your specific task will be described to you after you understand the situation described in the Memo" [Hand them Memo (APPENDIX 2)] READ THE MEMO SLOWLY AND CLEARLY TO THE PARTICIPANT [You may only answer questions pertaining to the information described on APPENDIX 2, questions or comments about the task should be answered "This will be explained in the next part of the study". Any comments or questions about the answer, irrelevant information, or of a personal nature should be politely addressed by "I'm sorry, but I cannot comment on that at this time." When they have no further questions you may move to the next step of this protocol]
22. Now open the TWT2011xx.pptx file

23. Make sure the microphone option is selected and Click Record
24. Click the blue box and select felt-tip pen.
25. Select Begin Recording from the pop-up in the lower right of the screen
26. Hand Stylus to participant. "You will again be utilizing this stylus as part of the task, please read along with me as I read the directions on this slide and then ask me any questions you have about what you are to do" READ THE DIRECTIONS ON THIS SLIDE[You may answer questions relating to either the scenario described on APPENDIX 2a. or the task directions explained on this slide by rewording it for clarification. You may not explain or give them any information not already given from these sources. Questions or comments outside this protocol should be answered politely "I'm sorry, but I cannot comment on that at this time." When they have no further questions, make sure they move onto the next slide by clicking the green box with the image.]
27. "You will be utilizing this image to complete the task, please do not move onto the next slide until you have completely finished explaining your thoughts and finished drawing. Imagine that you are speaking to an audience over there. [Point to wall with Air conditioner] I will be leaving the room while this records. Please knock on the door if you have any problems or when you are finished, I will be in the next room at all times. You have as long as you need to complete the task" [Leave E.V.A.L. and quietly close the door behind you, sit at the monitoring computer until the subject is finished]
28. [If they have any issues that arise due to technical problems or emergencies, do your best to mend the situation, and if possible, allow them to continue the experiment. Record any such interruptions on the blank page found in the subject folder. Record the time and description to the best of your ability.]
29. [When they are finished, enter the E.V.A.L room and retrieve the stylus from the participant] "Have you made your decision?" [Look on the slide to see if either A or B is circle and wait for their verbal confirmation, take the stylus from them.]
30. "I will just be one moment as I save the recording" [Click the Red box and select End Show. Then you will be prompted to Stop Recording?, select Yes. Save the recording with the filename used for the PPT, this time with a .CAMREC file extension. Then save the PPT file, if prompted to Save Annotations?, select Yes.]
31. "Thank you for participating in this study. Here is your stipend" [Count out bills to participant] Please put your name, address and signature on this sheet so we know that you received your compensation. Now that we have completed the study, do you have any questions?" [You are now free to answer any questions about the study to the best of your ability.]

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BEGIN TRANSCRIPTS:

TWT201101

The cost of the pipeline, I believe, would be beneficial to Portstown and getting the water to the city of Townsville would make it profiTABLE for both communities to have both resources [0:00:20.1]

TWT201102

Usage, usage.

(silence from 0:00:07.7 to 0:00:26.0)

Proposed pipeline is going to cost two dollar signs. Recreation and tourism, three dollar signs. Total usage is - two, three, four, five, six, seven – seven raindrops. Let me make sure that's right. One, two, three, four, five, six, seven – seven raindrops. [0:01:06.4]

Alright, now…the usage over here is two, three, four, five. [0:01:21.8] That leaves five raindrops. The natural recharge of one raindrop…

(silence from 0:01:42.6 to 0:01:55.6)

They want to buy four raindrops from us.

(silence from 0:01:57.8 to 0:02:17.5)

One, two, three, four, five, six, seven, eight, nine, ten, eleven. They've got ten. Natural recharges – one, two, three, four, five, six, seven, eight, nine…ten raindrops. And the math just does not add up here.

(silence from 0:02:43.5 to 0:03:01.0)

Okay, well the money situation…Money, you have three dollar signs and you lose two to revenue loss of pipeline so it's three minus two, plus they're going to give you three equals four dollar signs.

(silence from 0:03:53.4 to 0:04:07.5)

Alright now, water…water.

(silence from 0:04:19.0 to 0:04:41.2)

Let's see, you have seven total, no actually you have ten total. So it would be ten minus seven...equals three spare. Three spare, alright. [0:05:20.5]

They want to buy four.

(silence from 0:05:27.6 to 0:05:42.9)

They want to buy four.

(silence from 0:05:44.1 to 0:06:05.4)

That leaves us one in the hole. So…

(silence from 0:06:10.2 to 0:06:26.9)

What it comes down to is…

(silence from 0:06:29.0 to 0:08:36.3)

Should the pipeline from Lake Voda to Nero aquifer be built?

(silence from 0:08:38.9 to 0:08:53.6)

The problem I see is their usage…their usage…one minute. They…have…no…

(silence from 0:09:20.5 to 0:09:35.8)

They have tapped it out.

(silence from 0:09:36.7 to 0:09:52.9)

If they had excess to more they would use it. Dear people of Portstown, after reviewing all the data, looking at the net money, comparing what we're going to get from selling the water and figuring in what we're going to lose, also doing the math with the natural recharge of Lake Voda

and our total usage compared to what we have to sell, what they want to buy, I am going to say that it is not a good idea to build the proposed pipeline. [0:10:55.9]

And the reason is Townsville has tapped out the Nero aquifer. They have tapped it out and if the Nero aquifer was bigger, they would still tap it out. So they want to come into an agreement for a certain amount of water for a certain amount of money – four units of water for three units of money – and that is going to suit their needs now. But will it suit it later?

(silence from 0:11:57.2 to 0:12:11.4)

Once that pipeline is in Lake Voda, if they need more all they've got to do is crank up the pumps and there's not a lot we can do about it. So I say we need to protect our own and protect Lake Voda because once the pipeline is here there's not a whole lot stopping it. [0:12:52.8]

I know that our revenue is short but we need to see if we can make three units of money work because if we let them build a pipeline and sell four units of water Lake Voda will never fully be replenished with our usage and what they want to buy. We'll always be minus one. [0:13:28.0] At maximum we'll be minus one and that's at their usage now.

So I say before we essentially sell our water souls to the aquifer devil, we need to make sure that we can't make three units of money work because once the pipeline is opened up, it's there. It resembles a straw for a reason so I say after reviewing everything, I say that the pipeline should not be built. [0:14:30.2]

TWT201103

Lake Voda, I am here and Townsville are the ones that need the water. We have H2O. This is the Nero aquifer that is losing water. [0:00:41.7] So this looks like the usage that comes from the Nero aquifer…okay. Let me see. So Townsville wants to design a pipeline that could transfer water out of Lake Voda – so this is the pipeline here – and into the Nero aquifer to resupply it. [0:01:24.9] They are willing to pay us a lot of money to do this but in turn we may lose some revenue that would be generated.

So let's take a look here. Lake Voda supplies usage to Portstown, we've got recreation and tourism revenue from here. Lake Voda also supplies our farmland. [0:01:56.4] Our natural recharge is, it looks like there's more of a supply going into Lake Voda than coming into the Nero aquifer. [0:02:11.0]

So the biggest concern, it looks like based on the number of water droplets that are actually feeding into Lake Voda, we would lose – one, two, three, four, five, six, seven, one, two, three, four, five, six, seven, eight, nine, ten, and there's four – so actually we're going to be losing water if we, looking at this graph, if we decide to allow them to build this pipeline. [0:02:48.4]

Now we don't have an unlimited supply of water and while we do need revenue we also need water. So we need to look at some ways before we decide this, we need to look at just how much revenue is actually going to be generated. So you can see here, and here. But we are gaining

three, we're losing two, so we're still going to be having a net profit but how much is the question. [0:03:24.3]

We're losing as much water as we are gaining in money, and what will we do when Lake Voda can no longer supply us with the water that we need because Lake Voda currently is supplying only our town, but now it would be supplying us and recharging the Nero aquifer. So I would need to know here how long this is going to be sustained. How constant is that going to be over time? [0:03:59.1]

So…I'm very torn. I think we need to look at ways…we need to discuss options for generating revenue. How else can we generate revenue? Do we have to build this pipeline? Better H2O resources? It seems that Lake Voda is the only water supply within a reasonable distance to the Nero aquifer. [0:04:53.2]

So we have ten, that's seven…it appears… [0:05:21.6]

Also right now Townsville isn't using though that much water. They're not using nearly as much as we are. So what we will lose in revenue will certainly be made up. It won't be totally made up because here we're losing 2 million and here we're bringing in 3 million. [0:05:58.1] So we'll actually be plus 1 million a year and we're not going to lose as much water as we are bringing in. Because we are only recharging the Nero aquifer, we are not…they are not going to be necessarily using all this water at once.

(silence from 0:06:29.9 to 0:06:45.2)

So we can have a profit. Questions – who will build and maintain the pipeline? Is this going to be a joint venture? [0:07:15.7] What happens if something needs repaired? Who will maintain this pipeline? Is it the city of Townsville or the city of Portstown? That is the question.

I think if we can come to an agreement where we own this pipeline…well if Townsville pays for the pipeline they can own the pipeline but they will have to pay us for the water. I think if we can come to an agreement where we're not losing money on the construction of this pipeline then I think this might be a good idea.

(silence from 0:07:57.2 to 0:08:13.7)

That is my decision. That is what I'm going to say. We will allow the construction of the pipeline. It appears that our natural recharge will be more than enough, according to this diagram, to keep our water supply intact. It looks like we will make up for whatever profit is lost…times two actually.

(silence from 0:08:47.5 to 0:09:03.3)

TWT201104

Okay, thank you.

(silence from 0:00:06.0 to 0:00:38.5)

(chuckle) Okay. So first I'm saying that…that Townsville uses a lot of water. They don't touch. They are saying that our lake has a lot of water and we don't use much.

(silence from 0:00:57.7 to 0:01:06.9)

[What do you sell them?] (ph) It's actually equal.

(silence from 0:01:12.2 to 0:01:27.1)

This is going to be harder than what I thought.

(silence from 0:01:28.5 to 0:01:40.0)

Okay, let's just cut that. Let's say that…we did this, the people of Townsville, and the other half would be used for our farmland and regular use.

(silence from 0:02:00.2 to 0:02:26.9)

Let's take out one maybe.

(silence from 0:02:28.1 to 0:02:53.2)

Okay, creation (inaudible) for Portstown.

(silence from 0:02:57.5 to 0:03:10.5)

They would want four drops.

(silence from 0:03:11.5 to 0:03:48.9)

So they would want four drops, right? Okay. Which would leave us with six. What if we use five totally…seven and the one thing. Okay. Let's use seven, which would be a [seven deficit]. (ph) [0:04:32.1] Is that right? Deficit…

(silence from 0:04:47.8 to 0:05:54.5)

Okay, people of Portstown, we've been given this proposal to share our resources of Lake Voda with our neighbors from Townsville, the wealthy people of Townsville. I know that right now we're struggling financially but it would not be in our best interests currently to take them up on this proposal unless they decrease the amount that they are currently asking for. [0:06:32.9]

The reason why is because our usage would be…once we gave them what they asked for, our usage would leave us in a deficit for our water source. So even though financially we would

make a little bit more money, this is true, at least we would have the income coming in from Townsville, what we'd lose out on tourism and our ability to maintain our farms and just to be able to maintain our natural resources, would really not be in our best interest. [0:07:09.0]

So at this time I would put my support behind vetoing this measure because in the long run I think even though initially you would see this increase in revenue coming in from Townsville, ultimately you would see a decline in our tourism and our declining ability to maintain farmland adequately. I think it would do more damage to our community. [0:07:41.2]

TWT201105

The city of Townsville and the city of Portstown… [0:00:21.8] Right now Lake Voda is used for three water droplets for farmland. Revenue loss to the pipeline, two dollars, natural recharge – one, two, three, four, five, six, seven, eight, nine, ten – ten, we use three. Also recreation and tourism uses two water things. [0:01:17.1] The city of Portstown only uses two. So revenue loss to the pipeline…

The city of Townsville uses one, two, three, four, five – five water droplets. Their natural recharge is only one. Recreation and tourism for Portstown is three dollar symbols. [0:02:01.7] So if there's ten water droplets for natural recharge and Lake Voda then Portstown itself uses three, two… so five, six, seven. [0:02:23.2]

So Portstown uses seven water droplets. Natural recharge is ten water droplets. So that means they have three – wait; one, two, three, four, five, six, seven – yes. And then, so they have three water droplets left over. [0:03:04.6] And the pipeline would use four water droplets and give it to Townsville. Okay. [0:03:31.5]

Revenue loss to the pipeline – Portstown would use their money to build a pipeline and that would use two dollars. And then the revenue from recreation and tourism is three dollars. The problem is that too much water will be taken out of Lake Voda and put through the pipeline to go into Townsville. [0:04:02.3] However, it requires…the pipeline would meet Townsville's requirement because they used five and there would be four coming from the pipeline and one from natural recharge. [0:04:29.3]

So, because Townsville is going to pay us three money dollars, we get…if we were to build the pipeline, we would get three dollars from this proposed pipeline and we'd make three dollars from recreation and tourism. [0:05:03.9] So we have six. However the pipeline would cost two dollars. So there would be a four dollar revenue.

(silence from 0:05:20.9 to 0:05:39.6]

The problem is that Portstown uses seven water droplets so still three would be coming in, I think. One, two, three, four, five, six, seven. That's three left over continually pumped in. [0:06:06.4] So the city of Portstown has three water droplets left over that it doesn't use that comes in from the natural recharge. If four water droplets were pumped over to Townsville, this lake would lose water. I believe it would be a bad idea to create this pipeline because while we

would get revenue - four dollars of revenue from Townsville to Portstown – the problem of it is that water will be lost from Lake Voda that cannot be gained just from natural recharge. [0:06:49.2] And this will make our recreation and tourism go downhill.

Also if there's not enough water in Lake Voda there won't be enough water for farming and this town will have difficulties with water on its own. Overall there should be no pipeline.

(silence from 0:07:13.6 to 0:07:27.7)

Because even though Townsville will get the water it needs and with just the pipeline Portstown will be making a four dollar revenue, there will be a negative one water droplet in the lake and that will cause problems with wildlife, tourism, and farming. [0:08:19.5]

TWT201106

As the mayor of Townsville we have decided that our Townsville does not have an adequate water supply to sustain the growing population of our town. As you can see over here the Nero aquifer is not enough to sustain so the nearby lake over here, Lake Voda, is right by Portstown, here, and Townsville is very well off and can pay large amounts of money to Portstown to get access to this freshwater lake here, Lake Voda. [0:00:38.0]

And as it says in this memo here, Lake Voda is a very large source of income for Portstown, both recreational and with tourism, but as I said before Townsville has enough money and resources to pay Portstown a large enough amount of money to gain access to this freshwater Lake Voda here. [0:01:01.7]

And as mayor, we've come up with a good team of engineers to build a pipeline right here, this proposed pipeline, so that we could end up getting enough water from Lake Voda into here to sustain our town to have enough water there. The only problem is Portstown would suffer from a recreational loss and from a tourism loss. But as I said before, we could pay from Townsville to Portstown for anything that they would have lost. [0:01:38.8]

I think this would be a great idea here. Both towns would be able to benefit. Townsville would be able to have enough water to sustain their population and Portstown would get some sort of compensation from Townsville for the use of the lake. And of course after we use the water there, it can be replenished, cleaned, recycled, and used over again. [0:02:06.5]

So it's really a good situation for everyone and I think that it would be a great idea to go through with this proposed pipeline here because I really don't think…a lot of water would be going over here and that would be revenue loss but as I said before, we could compensate from Townsville to Portstown to make that revenue loss not as bad as it would have been, and it would be helping everybody out. So I don't really see a problem with that at all. [0:02:43.6]

TWT201107

(silence until 0:02:28.6)

Okay, well, based on this diagram of the explanation of the water data and economic data, regarding the question should the pipeline from Lake Voda to the Nero aquifer be built, after looking at it, my conclusion would be that this pipeline not be built. [0:03:02.7]

Given the drawing is a little odd, but given that this lake here is in the center of the chart and studying what branches come in and out of this surrounding area, one of the things to consider for the city of Townsville is the usage, the amount of usage here, is actually nearly equal to the usage of farmland and recreation and tourism for Portstown, which is a fair amount. [0:03:59.9]

The farmland is very important obviously. Lake Voda does get a lot of natural recharge compared to Townsville's only one water droplet here. There will be some money lost from the pipeline that is theoretically going to cancel out two-thirds of the money gained by recreation and tourism. [0:04:41.0] Even though Townsville's prepared to pay for the usage of the pipeline and refilling the aquifer, I do not think that the economic benefit outweighs the draw that this water usage would have on Lake Voda. So I would suggest that we not build this pipeline. [0:05:15.5]

0:02:57.3

TWT201108:

The usage for Portstown is 7 and the usage for Townsville is 5. Lake Voda has 10. So basically Lake Voda has 3 to spare and Townsville wants to get 4. So that means Portstown will have to not use one of its waters, so they could - if they took out 1 water, then they could pay that. That would be like this one. That would be half of their money, but then they would get 4 money. So that's 2. Will give you these 2 dollars.

So by giving up 4 of their water, they'd be losing $2 dollars, but they would be gaining $4 dollars. So yes. They should build the pipeline because this number is so big. Lake Voda has plenty of water to meet the 7 that Portstown needs and these 3 that Townsville needs, and they would fit. They would basically double their money. So yes.

TWT201109:

0:03:02.5 My fellow constituents, as your Mayor, I propose that this is a bad idea for our natural resource of water. And I base that on these numbers here within our own town of Portstown and Lake Voda. We've got 11-point usage with 10 recharge. We're in the negative right there, plus we're going to sell 5, which actually will be 4 because they've got - Townsville has a natural recharge of 1. So we're down 15, with a recharge of 11. And I guess it would all matter what they're talking about here and what we have here. How long can Lake Voda survive? How long can the plants and animals and ecosystem of Lake Voda survive with this type of decline due to usage and natural recharge, which obviously is not equivalent. So as your Mayor, I vote against this. This is not a good idea. Bad business for Portstown. It's bad business for Michigan.

TWT201110:

Okay. So Portstown. It's like it's over - there's a lot of farming that goes on. So hence the need for the water. Actually Portstown is the town with the lake. Townsville is the town that needs water. So they are currently getting 4 units of water from their aquifer that is, as I understand, running out of water. I'm assuming in the same timeframe, the ecology is only replenishing it with 1 unit of water. So they're proposing that they take 4 units of water from Portstown in exchange for 3 units of money. And Portstown by means of this transfer, is also going to lose 2 units of money from tourism and recreation. I'm assuming since that's what they're making their money out of - out of to bank on, rather the lake on.

0:01:25.8 Their usage is right now - Portstown's usage out of Lake Voda is only 2 units, while they are taking in 3 units of money for income from the recreation and tourism. And natural resources just automatically putting 2, 4, 6, 8, 10 units of water back in the lake for lake usage. So there is plenty of replenishment there, although we're using 2 for the town also and 5 for farmlands. So farmlands using 3, towns using 2, recreation is using 2. So there are 7 units out of 10 units that are going in. So there are only 3 units left and Townsville wants 4 units. So we would be putting Portstown at a negative water ratio; for lack of a better term. They're going to be coming up short on water. They are going to be getting 3 units of income in exchange for it, but they're losing 2 units in income. So in essence, they're only getting 1 unit of income to make this transfer.

0:02:56.4 I guess frankly right now, just in looking at the information I have here, as the Mayor of Portstown, I say we turn down the City of Townsville proposal. It's going to put us at a negative water usage and the income that we are going to derive from it is, is minimal in compared to what we're going to lose on it. So I think we're better off just staying where we are and letting Townsville look elsewhere for their water needs.

0:04:13.1 I guess, as I'm looking at this a little further, one possibility would be going back to the City of Townsville and offering them less water. I mean it would still help their water needs. Maybe give them 2, possibly even 3 units. Three units would give us a break-even on our water. If we give up 2 units, that still keeps us in the positive, and negotiate a new price with them. Otherwise, I don't think it's a good choice for Portstown to accept the current proposal of Townsville.

TWT201111:

Okay. As Mayor of Portstown, I have decided that we should build the pipeline from Lake Voda to help us with our Nero aquifer. It is - sorry. I'm a little nervous. This is the first time I've addressed the counsel here. We may lose some tourism, but we will gain revenue and we are suffering financially. In addition to the fact that we will gain revenue, we also are doing a gesture of good humanitarian activity. As you can see there are communications [ph] on here as far as what the water drops.

0:00:52.6 This is the amount of money that will cost the pipeline to be built. In addition to being a good humanitarian measure, it is also a good building block to create a partnership between Portstown and Townsville. It will also help assist in the natural recharge of our Nero Aquifer.

0:01:24.2 Those are the reasons why I think we should do it. So the reasons would be: 1) Increased revenue. 2) It will help assist in building a partnership. So that way, if we ever need any type of resources or assistance, we can call on our neighboring city, building a partnership. And then lastly, it's the right thing to do. It's a good humanitarian gesture.

0:01:16.0

TWT201112:

I'm adding up all the usage for Townsville and Portstown, minus what they already have on the aquifer. Also adding what deferred [ph] land uses.

0:02:16.0 Taking this, I'm subtracting the total away from 0:03:06.5 the city of Townsville does have enough water through their Nero Aquifer to provide all their water needs. They're willing to pay us, the Town of Portstown, fresh [ph] water from their Lake Voda. They have plenty of water, so I feel it would be our benefit to give them 4 units of water. Because right now we're only making 3 units of money through tourism and recreation. But if we were able to give them 4 units of water, we'd be making 4 units of money through giving them our water; selling it to them. That's why I think it would be better for us to give our water because it would end up with us making more money.

TWT201113:

All right. Four more water going out to Nero Aquifer and Lake Voda, what is it natural recharge. We get 1 natural recharge and we use 1, 2, 3, 4, 5. So if they bring in these 4, they'll get the 5 they need. This one uses 1, 2, 3, 4, 5. Let's label those. One, 2, 3, 4, 5, 6, 7. Okay. This one uses 7 water. This one uses 5 water. This one is natural recharge; is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.

0:01:15.8 So they have 10 over here. They only need 7. So we can spare 3. They have tourist things. The tourist things we can get money in. So this way to double their money. We would double the money and it would send 2 money going back to make this pipeline. So we can spare 3. We can spare 3 water. We can spare 3 water. If they need 4. So if they give up one of their recreation tourism ones, that means they'd have 1 less money. So they actually have 1, 2, 3, 4, 5.

Right now they have 3. If this one comes in, they'll have 3 more, which will be 6. So take out 2 for the pipelines. That leaves them with 4. They need another water. So if they take out another water, this can take more money from them. That's slightly more money than they had before and less water and less tourism. Less quality of life, but the Townsville people will have the water they need.

0:03:24.6 How about if Townsville people cut back on that. It's an exchange. It's like helping out neighbors for free, because if Lake Voda from Portstown - if they were to give the water to Townsville like they asked and then they got the money in, they will need to give out more water than they can. Meaning they reduced their recreation tourism and they get slightly more money. So they're kind of equal. I mean that would be the neighborly thing to do.

0:04:39.6 One, 2, 3, 4, 5, 6, 7. They need 7. They need 3 extra. I am going to say no. No, because this will cost a loss of money. If this pipeline thing was at one time - a one-time building thing, then it might be worth it. Because then they'd have 2 extra money, but because there are no indications that it isn't, then I'm assuming you have to staff people on that pipeline.

0:05:29.5 So no. We shouldn't because it will waste money and then Portstown doesn't have enough water or money. Then the trade-off is not good enough to make it worthwhile.

TWT201114:

I'm just trying to FIGURE out where everything is in relation to each other. I don't know why that would matter, but it seems like it could. Because that's the empty aquifer since the lake full of water. I guess I'm wondering how much water Portstown needs if sending all their water to this other aquifer will cause them problems. Or if the only issue is one other than money.

0:00:34.7 So they've got - water 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. Possibly 3. That's 10 waters. Use 5, 7. They'd be sending 4. Revenue loss. That's the revenue loss. Okay. So that's the revenue loss [inaudible], but what about this?

0:01:08.9 It seems that the monetary gain from selling the water to Townsville wouldn't be sufficient to offset the loss of recreation and tourism revenue. They're equal here. Two-dollar sign equals three-dollar signs. So that would probably be obvious. So there is no real benefit to Portstown by doing this. It seems there could be issues with the amount of water they have in the future if they decide to do this.

TWT201115:

0:01:05.1 In Townsville we use this much water. Try to get this [inaudible] gallons. We'll say 5 gallons and Portstown only uses 2. There's enough water coming into Lake Voda. Then we use more water. This is what I was saying to people. We use more water in Townsville than Portstown does. They use a little bit for different things than we do. However, Lake Voda has plenty of water and it's a little bit more expensive to come with this pipe.

0:01:58.4 But I would say that it would benefit all of us and they still will be able to use 1, 2, 3, 4, 5, 6, 7. Then we'll say we use 8, 9, 10, 11, 12. That's 3, 6, 9, 10. And it has enough coming in to need it for farming. They can still use their usage and we can all be happy.

TWT201116:

0:02:55.9 As citizen's of Portstown, we have a great natural resource in Lake Voda. Our neighbors, Townsville, have had recurrent water crises and they've offered us large sums of money to build a pipeline to transfer water from our lake to be used in their city. I believe that because we want to help our fellow citizens, as well as increase economic revenue of our city, that the proposed pipeline should be built.

0:03:50.2 Although this may cause loss of revenue to recreation and tourism for our town, the cost will be more than offset by the pipeline being built. And we will still have enough water to be used for the farmland and for general water usage for our city for [inaudible].

TWT201117:

Seeing that Townsville is using a lot of water compared to what they have in the Nero Aquifer and Lake Voda has - actually hold on. They have obviously a lot more supply coming from the lake and the pipeline would bring this much more water and money. Well it would bring the water over to Townsville and this in turn would bring profits over to the City of Portstown. They've been struggling. So that would help them out. Then they'd lose some other revenue from losing tourism, but in turn, they'd be bringing in revenue there that would benefit Townsville.

0:01:13.4 Their usage right here from the farmland and right here Portstown, is not nearly as much as they have in supply. Even with the recreation and tourism combined. That compared to the actual supply is not a very big portion.

0:02:25.0 So considering whether the pipeline should be built, they are struggling here in Portstown. They're not producing enough revenue or getting enough revenue to support the city and economic needs. If the pipeline was built, they'd be getting more profits coming in right here, compared to what they're going to be losing. That would start helping out the actual city and supporting the economic needs a lot more.

0:02:59.1 At the same time, right here in Townsville, it would be benefitting them because they don't have nearly enough water for their city's needs. The water coming into them [inaudible] because they need water throughout their city, and most cities end up being benefitted by this. I do believe that, yes, the pipeline should be built. Even though there might be a little lost revenue, in turn, they're going to be gaining a lot more money here in Portstown, supporting their economy and Townsville also benefits. So definitely say that it should be a vote.

TWT201118:

It seems that the revenue loss from the pipeline would be minimal to what they're going to pay out more. The revenue they're going to receive, I believe, my question would be with the recharge of the proposed pipeline, would this be a permanent solution to what they're problem is and how long would it take to deplete our lake. And their usage is higher than I believe our usage is right now. Well no. It would almost be double the amount of what our usage is.

0:02:22.1 That could end up being detrimental to our recreation and tourism revenues, as well as our usage in the long run and the usage to our farmland and agriculture, which brings in money also for our community. So the natural recharge rate usage is 5, but the one natural recharge is [inaudible]. Which the depletion rate would be greater than what our natural recharge rate would be. So even though they're paying us for this pipeline and use of our lake, I believe it would be more detrimental to us. So I would vote against the pipeline.

TWT201119:

Lake Voda to the Nero Auquifer be built? So I believe the - just learning of this, believe it should be built. The less wealthier city is providing the wealthier city with something they need. So while tourism dollars may decrease, whether it be a year or two, in the long run it could pay off for the smaller town of Portstown. Meaning that if Portstown offered this to Townsville to help them out in their crisis situation, they make take it the first year or so. But in the long run, Lake Voda may be able to - the aquifer may be able to help them in the long run. Dollars may decrease. So recreation and tourism will be decreased.

TWT201120:

[inaudible] Townsville's water is 5. So this is what they need. Lake Voda has - 5 droplets for Townsville. Lake Voda has 10 available and they have a natural recharge of 1. No. The Nero Aquifer has only one. So Lake Voda has 10 droplets. But Portstown needs 3 for farming and then we have the money part of it. See recreation and tourism provide revenue for Portstown. And they have a usage of 2 for recreation. Let's call it R: and R: revenue. Recreation and tourism.

0:02:04.6 Then they have this much, 3 dollar signs for recreation. If they make this pipeline, Townsville will pay 4-dollar signs. But they would need to take away from this 10, 4 of our droplets for the pipeline. Okay. So this doesn't make any sense to me. They'll have access to 4 of the droplets, which we have plenty of and we need the money. So it would take away 2 of these from us as we give them 4 of our droplets. So then we'll have 6, but then we'll have a total here and here of 5-dollar signs. We would still be ahead with our revenue if we build the pipeline.

TWT201121:

Should the pipeline be built? I'm the Mayor of Portstown. So this natural recharge is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. Right? I think that's really important. I don't want to deplete Portstown too much because, even with money, they're going to be in the same crisis as Townsville if we take too much water away.

0:00:42.6 So Townsville needs 5 waters and they get one of their own. So they need 4 more, which - supposed to be a water droplet, which is what they're asking for from Portstown. Portstown, we use 2 and we also use - uses 2, the farmland. Uses 3 and sports and rec. The money [inaudible]. Sports uses 2. So we use a total of 7. This reveals 10.

0:02:13.4 They're suggesting that they take 4. So we're going to lose 1. We currently in Portstown use 7 and they want to take 4 away. And we only get 10 back. So yes pipeline; no pipeline. Yes pipeline, we'd have negative 1 water and we'd have - here it says we're going to lose 2 dollars, but we're going to gain 3 dollars. So if we say yes for the pipeline, we have plus 1 dollars. So if we say no to the pipeline, then we have plus 3 waters and plus no monies.

0:03:56.1 However, we are in financial crisis. So this is the positive. However, how's the quality of life going to go down in Portstown? I know I live in Granthaven, which is a water town. We really benefit a lot from having - actually I live in Portstown. But I have spent time in other towns where the economy and the whole lifestyle and atmosphere benefit a lot from having the

water sports and recreation and tourism. It creates traffic, but it also creates sort of a carefree type of life, which we loved in Portstown for all these years, despite our economic difficulties.

0:05:07.2 So I propose we give them 3 shares of our water. If that's something they'd be willing to renegotiate. If we gave them simply 3 waters, that would be giving them a quarter of what they asked for. Maybe we can renegotiate. Send 3 waters. However, I do understand that the City of Townsville is growing and 3 doesn't satisfy their usage. If everyone could cut back that would be awesome.

0:06:48.6 If the new proposal is something they'd be willing to negotiate, we would have to ask for less money, which we then wouldn't be ahead as much. I am re-reading the memo here to remind myself of how dire things are in Portstown in terms of finances. So although Portstown receives revenue from recreation and tourism, this is not enough to meet local economic needs. That phrase implies to me that although recreation and tourism does help a town, if it's not enough to support the economic needs, then this happy-go-lucky town fill of tourists and people who love being on the water enjoy themselves all the time. That's probably not what's happening here.

0:07:51.4 People are struggling and we need some economic - we need some help. So asking for less money in a new proposal is no good. That makes me say that despite the fact that things might be cheerful in Portstown because of tourism and living on the lake and that being something I know people are naturally drawn to and enjoy. I think the economic difficulties we've having, tell us that we need to vote yes on this proposal.

0:08:59.6 Our financial situation is too hard to warrant our being slightly selfish for the good things in life. We need to take care of our more basic needs and some of those basic needs are things like public works and all those other such things as [inaudible].

0:09:28.8 So therefore I determined we should vote yes in regard to Townsville proposal to build a pipeline. However, in the future, I do not see a way that we could increase the amount of money that we give to them. So I'm not sure that this is really - this is a temporary fix and they're going to need to find another way to supplement their aquifer that they have depleted.

0:10:19.9 It's difficult. Now I'm rethinking. Because if they are continuing to grow and they ask us for almost all the water for just a little bit of money - I wonder how far away they are. Could they just grow in our area, but that won't decrease the amount of water that they need. They still need this plus how much more.

0:11:08.7 It would also be nice to know if this is enough extra revenue. Is this enough to increase the quality of life in our town? Which is what my rule is. I need to be responsible in terms of our citizens, but also in terms of the natural way that we use our resource here. We have a wonderful resource that obviously other people are interested. They're going to want more water and we won't be able to give it to them in the future.

0:11:59.6 To amend, I think we vote yes on the condition that our neighbor, Townsville, use water-saving, water-conscious, we'll say. I'm struggling with the pen. An abbreviation for

conscious that I just wrote. Water-conscious building techniques while working on their ineviTABLE new growth. That's the only way - I feel like that's the responsible way for us to allow them to use some of our water. So thank you very much. I hope Townsville is willing to negotiate and I hope this is the best decision for our community.

TWT201122:

[inaudible] tourism, Portstown, usage, farm. We've got Portstown itself. Got natural recharge which is about 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. About 10 times the amount of natural recharge than the Nero Aquifer. But it's using usage in here; 1, 2, 3, 4, 5; 2-3 times more than Portstown's usage. So it makes sense to get revenue in here and allow the pipeline to be built for Townsville.

0:01:05.6 Appears that Lake Voda will be able to keep up with both towns. So increased revenue in here and increased water flow here, then Nero Aquifer. Appears everybody will be happy.

TWT201123:

Okay. Let's see. As mayor of Portstown, make usage use total triple times the usage normal. Ten times the usage. It appears to me that we're not going to lose a lot of usage and the lake will pay double for that. Okay. Portstown. I think looking at this that they're not going to require, the City of Townsville, will not require an awful lot of the usage. They're going to need 4 times recreation and tourism. We're going to lose some in recreation and tourism, but I think that the dollars that they'll be paying us, 3 times the dollars, that we're going to make that up plus.

0:01:47.5 So I don't know. I'm guessing I would - recreation and tourism down [inaudible]. I would suggest that we go ahead and let the City of Townsville tap into Lake Voda. And we will come out ahead in the long-run, looking at what they require, the usage they require, and the money that we're going to make from them. I mean we'll lose some in recreation and tourism, but we will make 3 times that in money as what we're losing in money.

TWT201124

Begin [0:00:50.8]
MALE SPEAKER: We have a lack of water here in Townsville and they have posed to pipe some of the water that we have here in Portstown out to Townsville to recuperate and supply them with water they need. Basically the question we're looking at should the pipeline be built, is that going to be equiTABLE and reasonable for what we're looking for in our town? The usage of Townsville, Lake (inaudible at 0:01:33.2) naturally recharges a whole lot of water even more than what Townsville would need. They're willing to supplement our income with lots of money in order to purchase that water.

We will lose some tourism from that (inaudible 0:01:59.9) that. I'm sure that would look kind of weird on a pipe sticking out of the water, but they are willing to really give us some money. So I guess that's pretty much where we're at with that is the money worth the pipeline/loss in water/loss in tourism?
[2.27]

TWT201125
MALE SPEAKER: Okay. The first thing I need to do is make a decision here so I need to look at how much they want to use versus how much we have to give up. So I'm looking at current usage as two drops brings in a revenue of $3. We have Farm Reatlanta using (inaudible 0:00:41.2) three. The town using another two so three, that's at seven we currently use, and there is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 for a Natural Recharge. We are currently using seven. The full pipeline will take four and bring in three more revenue.
[0:01:16.0]
To me it looks like that would exceed our recharge rate even though it will bring in much needed money, it seems to be a Band-Aid and not a solution because that doesn't even take into account the gross of both our city, and farm needs, and recreational needs, and well as the growth of Townsville who's going to naturally be calling for more water as they go. I mean with them using about 1, 5 water already and only one recharge that would put us in the same boat as them, if we agreed to this deal because that would put us over our recharge rate.
[0:02:11.7]
It's like robbing Peter to pay Paul, it doesn't make sense to me so my decision would be to say no to this and look at other avenues to bring in income. So my decision would be to not go with this and I point out to the citizens this reasoning that it would give us no room for our growth. They would be asking for more and more as they went. Our recreation could suffer but more importantly our farmland could suffer then our own usage would be in jeopardy as well. So that's how I explain it to the people that we decided not to go with it.
[0:03:12.7]

TWT201126
FEMALE SPEAKER: Okay. Portsville, I mean Portstown farmland has three water usage, Portstown usage is two from Lake Voda. Natural Recharge is nine water droplets and two water droplets from recreation tourism and the re money for revenue. The revenue loss pipeline will be two dollar sign for the proposed pipeline but three dollar signs will be coming back in and four water droplets will be going out and Townsville uses five water droplets and they get one water droplet for Natural Recharge.
[0:01:19.9]

Okay. So if altogether Portstown uses five water droplets, five water and we our Natural Recharge we gain nine waters plus an extra two waters from recreation, altogether we bring in 11 water droplets total. Wait a minute. Okay. So we bring in 11 waters minus the five we'll still have six waters left over, and if we lose four going to Townsville we'll have two waters left over extra as far as revenue we'll bring in three revenues from recreation.
[0:03:12.7]
We'll lose two and then they'll be one dollar left over but we'll also still be gaining an additional three dollars, which means we'll ultimately bring in four so we'll be actually gaining one extra dollar by giving Townsville four water droplets. So actually it's a good idea because over all we'll have two waters left over and we'll also gain an additional dollar from Townsville so actually we're benefiting from this, because from recreation we're bringing in two water droplets, and we're still at two water droplets and we're gaining in three revenue from recreation tourism,

but I'm recreation and tourism we gain three, but we're getting an additional dollar from actually going outside Townsville.
[0:04:42.8]
So actually we're up - we gain an additional dollar so actually we're actually profiting an additional dollar by outsourcing to Townsville. So it's good for us to lend out the water because as you can see we'll gain two extra water, we'll maintain the same water droplets, which is two, and we'll gain an additional dollar, because at first when we bring in three dollar revenues just from recreation tourism alone, but if we loan it out you still gain back that three from loaning out to Townsville so it's in our best interest and we profit by a dollar.
[0:05:36.3]

TWT201127
MALE SPEAKER: Okay. We can see that from the Natural Recharge into the Nero Aquifer they're obviously short by four waters so they're asking to replace four through the proposed pipeline from Lake Voda, which will meet their demands. The Natural Recharge to like Voda on the other hand is ten units. As far as they're usage is 2, 4, 6, 7, 8 so they have two surplus units as it is and so then maybe two negative units once they went into the proposed pipeline into the Nero Aquifer for Townsville.
[0:01:29.0]
So as you can see they will have to give up something. They can't give up their usage. They can give up recreation and tourism. They could give up some farmland so no matter what they're going to have to give up something neither recreation. They're going to have to give up some or they're going to have to give up some usage on the farmland. As you can see from the tourism loss pipeline they're going to lose two units of money. So going from three units they are going to go down to one unit, but they're going to bring in three units of money. So now we have the one unit from Recreation and Tourism and we have the three units so in the end we're going to four units of money, which would be a benefit to the town in the long run.

[0:02:41.4]
Okay. Basically we have ten units going in like Voda, seven being used so three spare, we're losing four units so we're still, I mean, one negative from what we're using now. However, our income is three money and we'll lose two of that but we'll gain three back so we're going to be one money above. Townsville needs the water because they're four units short so by supplying those four water droplets of water they'll be at the plus one unit of money.
[0:04:11.2]
Okay. People of Portstown. It has come to my desk a proposal of the people of Townsville about a water crisis in their area. Currently they're using four, five units of water however, their aquifer right now is only being supplied one unit of water by Natural Recharge to the system. As you can imagine that is not sufficient to keep them supplied of enough water. They proposed to me that they would build a pipeline between our Lake Voda and their aquifer which would provide them with the four units of water needed to resupply their aquifer and fulfill their water requirements.
[0:05:23.7]
As you all know Lake Voda supplies us with our water as well as to irrigate the farmers and it provides an income source for Recreation and Tourism in our area. As you can see from image our total usage is two units. We have two units for recreation and three units for farmland. That

would equal seven units of water used for us. As you can see though we are supplied currently with ten units of water for recharge into Lake Voda. This actually brings our demand to three units extra so we have water (inaudible 0:06:21.4) however, it's not quite enough.
[0:06:23.5]
In order to give the four units we would be one unit short however, in exchange for this they are offering us a sum of money as you can see here. There are consequences however, to this, which we will end up losing top revenue as you can see here because we will have to forego some water usage for Recreation and Tourism. This because we will naturally need to use the water provide Portstown with water and farmland for the irrigation.
[0:07:10.9]
This is not a bad thing though that we will be losing recreation money, because currently as you can see they're three units of money that we are currently getting in from the Recreation Department, however we will lose two units to that pipeline but in return for building the pipeline we will get three units of money. This will be in the end a surplus of one unit of money. This has led to my decision to build a pipeline between Lake Voda, the Townsville Aquifer.
[0:07:53.4]
This will supply them with the needed money or the needed water to provide all their needs and they will provide us with an extra unit of money increasing us by one quarter of the amount of revenue that we get into this time. We may lose some recreation but in the end makes economic sense, and it will not hurt Lake Voda (inaudible 0:08:22.3). Thank you.

TWT201128
Should the pipeline from Lake Voda to the Nero Aquifer be built? The Natural Recharge of the Nero Aquifer is one water droplet. The usage of Townsville is five. The Natural Recharge of Lake Voda is 10 water and the usage for Portstown is two. So Townsville is using five times the amount of water than the Aquifer recharges, and Portstown is using one fifth of the amount that the lake returns.
[0:00:46.5]
The usage for farmland of Portstown is three droplets. Recreation and Tourism provide revenue for Portstown three dollar signs, and have a usage of two water droplets. If the proposed pipeline is built Townsville will pay four dollar signs to Portstown for access to four droplets from Lake Voda. This has caused revenue loss to pipeline of two dollars from Recreation and Tourism for Portstown.
[0:01:32.9]
All right. The usage for Portstown is two, and the usage for the farmland of Portstown is three so that's really five altogether for the town and the farmland. So the 3 + 2 is 5 out of the 10; 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. Recreation and Tourism uses two more so that's seven. This is usage, this is farmland, and this is Recreation and Tourism, so that's 7 out of 10. Portstown wants to use four, that will put us in the negative.
[0:02:48.0]
This has caused revenue loss to pipeline of two from Recreation and Tourism for Portstown. This has caused revenue lost to pipeline. Okay. Recreation and Tourism gives three dollars and Townsville gives four. So if we give up Recreation and Tourism altogether we'll make more money by shifting out the pipeline, by shifting water down the pipeline, and it will give us enough water.
[0:03:53.6]

[0:04:25.0]
Okay. They need all four. Townsville needs all four to meet their needs. So the only way they will do this, the only thing that is good for Townsville is to take four here. So Townsville won't be interested in doing something less, because it won't fix their problem and the only way we can give up four is either not let the farmers have water, which is a bad idea or not to have the Recreation and Tourism use the water, which could be a bad idea, but the pipeline will bring more money to Portstown.
[0:05:33.5]
Okay. Portstown problem is they don't have enough money coming in. They're economically in trouble. They need to have a source of revenue. So Portstown needs money, Townsville needs water. Townsville is willing to pay Portstown for their water. This is something as a city we need. In order to allow Townsville to take the amount of water they need, which is four more, we are going to have to give up some of our water usage.
[0:07:11.2]
As you can see the town uses two, farmers use three and if we continue our Recreation and Tourism the way we have been that's another two, which is seven waters. We wouldn't be able to give Townsville four on top of that seven because then our lake wouldn't recharge enough because it only recharges 10 water in the same time period. So, what I propose is that we rethink our Recreation and Tourism, because even though that does produce a revenue for us of three dollars. The proposed pipeline is going to bring in four dollars. We're going to earn one more dollar and of course our problem is we need money.
[0:08:29.8]
So I'm proposing that we rethink the Recreation and Tourism, allow Townsville to build their pipeline. We let them take the four water that they need in exchange for the four dollars. We increase our money by one, they end up with the amount of water they need. They're going to get four more so that will be good. They will get the five waters that they need.
[0:09:16.5]
They will both get an increase in the resource that were lacking. Now it is going to hurt our Recreation and Tourism industry, but it's time to move forward and rethink that. And if we do still have – if we do, do the four waters in the pipeline to Townsville we will then be using two for the city, three for the farmers, and four going in the pipeline to Townsville, which is nine, and we still should be able to get some sort of revenue out of Recreation and Tourism on a smaller scale.
[0:10:22.7]
of Portstown. I think this is an excellent proposition for us as well as for those in Townsville.

TWT201129
FEMALE SPEAKER: Okay. Portstown only uses two here. Okay. They're putting three in here and only two of the revenue is going to be lost so you're actually gaining money here. The Natural Recharge is like ten – twice as large as the Natural Recharge of Townsville. No, excuse me, ten or kind of. Okay. Usage, I'm sorry, usage is like three times more than farmland.
[0:01:22.0]
There's usage and then you got the Natural Recharge is ten times greater and you're only taking 4 percent or like 4 percent versus the 3+ the 3 percent of 7 percent going out still leaves extra recharge in like Voda. I see it as a win/win situation because Portstown is actually going to gain

money over, okay. Portstown gain money in the process of what's coming in versus what they're losing. Townsville is actually going to get the water that they need.
[0:02:43.0]
So it's actually going to come out even. Portstown is going to come out ahead for the simple fact that they're making – are going to gain dollars and the Townsville is going to get the water they need. You got usage here. Usage in Portstown minus five usage in Townsville is five and then you got the recharge in Townsville is only one recharge in Portstown is ten so that's an eleven recharge for ten and only gave me four of those which is going to still leave you plenty of natural recharging going on in this area in the Portstown area.
[0:04:26.8]
It's going to leave you plenty of Natural Recharge. There's still going to be plus there. You're going to give Townsville the water that they need for their recharger plus you're going to make money, extra money for the revenue loss. You say you're going to lost X amount of dollars, you're going to gain X more amount of dollars. To me it's a win/win situation for Townsville and for Portstown. Portstown gets the money, Townsville get the water that they need.

TWT201130
MALE SPEAKER: Okay. Thank you. (0:00:33.4) All right. (inaudible 0:00:38.3) is the farmland uses three times the amount of water according to Portstown so it's five times the amount of usage there. And then you got for Recreation and Tourism uses two times the amount of water for that but brings in three times the amount of revenue. Usage it got ten times the amount of Natural Recharge for Lake Voda and you only use the pipeline so it's ten times there and we got a proposed pipeline that's been used four times the amount of water over here. It uses five times the amount of usage (inaudible 0:01:27.4) here.
So it only has four problems. It has one I think that is the way to go. The amount of money that's in engineering from Townsville for, you know, how much they're going to be willing to pay is the same amount that comes back in Recreation and Tourism as the same amount spent to pay for the water usage the proposed pipeline to go to near the Nero Aquifer.
[0:02:14.2]
I mean it should be built. I think we got enough means self sustaining as long as the population doesn't get to out of control. I think it should sustain itself.

TWT201131
FEMALE SPEAKER: Okay. Pipeline to Lake Voda to the Nero Aquifer be built. All right. So let's see, Lake Voda looks like it's going out to the farmland and Recreation and Tourism and they want it to go over to, okay. Lake Voda is on – Portsville sits on the edge of Lake Voda. Oh, I got it. Okay. Nero Aquifer. Okay.

[0:00:54.9]
Okay. So I see there's a lot over here at the lake recharge. I think, okay. So Townsville doesn't have enough water and they use the outside sources. Now if they can get together and use each other as long as the City of Townsville is not going to drain the resources from the Natural Recharge - or from Portstown.
[0:01:45.9]
Okay. So I think I would agree with this as long as it's not going to use up all of the recharge, which I wouldn't think that it would because it's natural, and I think that would be good. I'd think

they both would benefit. My only question is, you know, of course how much would it be for a pipeline to be put through, but I guess that would kind of pay for itself no matter how much it was. Okay. I got it. Okay. Well I agree with that then.

TWT201132
FEMALE SPEAKER: The natural return – (inaudible 0:00:11.2) Okay. So one water thing was five, the Natural Recharge of the Voda is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, is 10. The usage for Portstown is 2, the usage for the farmland of Portstown is 3, Recreation and Tourism for five revenue of Portstown triple and have research of two. If the proposed pipeline is built Townsville would pay Portstown four times amount towards town for access to $4 from Lake Voda. This has caused revenue loss to the pipeline of twice as much for Recreation and Tourism of Portstown.
[0:01:03.6]
So the Natural Recharge of the Nero Aquifer is one so should the pipeline from Lake Voda to the Nero Aquifer be built? So the thing is they don't have enough to meet economic needs. They want to pay me money, Natural Recharge the usage in Townsville so that's one. The recharge (inaudible 0:01:38.9) the usage of Townsville is five so they use five waters. The Natural Recharge of Voda Lake is ten. The usage from Portstown is two so my town is just two, but the recharge is ten. The usage for the farmland of Portstown is two so that's five.
[0:02:01.6]
So this together equals five so that leaves me five left right here. So that's going to count (inaudible 0:02:16.9), the Natural Recharge is one so this leaves six. Okay. So Recreation and Tourism provides revenue for Portstown three times, and have a usage of two. If the proposed pipeline is built Townsville three times as much to Portstown for access to four from Lake Voda. This is a cause revenue loss to the pipeline of double the amount from creation.
[0:03:01.2]
Okay. So this isn't a good idea I don't think because the Natural Recharge of Lake Voda is ten, okay. But their Natural Recharge on the new record is one plus five. I'm going to say no, because I don't think it's a good idea, because there's not going to be enough water even if they pay to do it, because the recharge is ten, but this together equals six that and to charge the farmland is three, the usage in Portstown is two so therefore I get me five.
[0:03:54.3]
I know they're going to pay a lot of money for it but it will still hurt my Recreation and Tourism for Portstown, because they have the usage of two, and they want to pay for the access to four from Lake Voda. This Lake Voda only has (inaudible 0:04:22.4) and they want four for some of them. No, we say no. That is just not enough access for the water. I mean, there won't be enough water to go around to both towns so they're going to have to take their money somewhere else and go somewhere else with it, because even with the money they're giving me I have to worry about water within my community, so I'm going to say no. No.

MALE SPEAKER: So what does that mean?
FEMALE SPEAKER: That means decline.

TWT20133
MALE SPEAKER: Okay. Now City of Portstown, this is the mayor and we have been asked to provide a service to the City of Townsville. They are in dire need of water supply in which they are willing to pay for graciously, and we are losing money in Recreation and Tourism usage.

Now, considering our revenue is low because of the low recreation and tourism there is not enough to meet our local economic needs. So, I am looking at a rectifiable position in order to decide all whether or not to allow Townsville to run a proposed pipeline from our city to their city in order for them to use our natural resources of water in which is a life necessity for the city of Townsville.
[0:01:35.1]
I believe that the income revenue that would be generated by the use of our natural resource of water to supply the city of Townsville, which benefit quite graciously along with what Recreation and Tourism that we would still be allowed to have left even with the eyesore of the pipeline if it be above ground.
[0:02:39.7]
Lake Voda substantiates quite a large amount of freshwater, but looking at the water usage this is the amount of water lake water contains. This is the amount of usage our city accumulates and this is the amount of usage our farmland relies on. Now this is the amount of usage the city of Townsville requires. Townsville requires five units of water. Our city requires two units of water, our farmland requires three units of water. Altogether that adds up to 10 units of water.
[0:04:33.9]

Our Lake contains 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 units of water. As beneficial as agreeing to this proposal would be I believe it would deplete our national reservoir of water, freshwater, which I believe would not benefit our city quite as well as what it may look like in numbers of dollars.
[0:05:24.5]
In order to gain that amount of money through guiding this pipeline over to Townsville to supply their city, our city would ultimately lose our use of Recreation and Tourism. Now granted our Recreation and Tourism fluctuates, there are times when those resources of money income, and revenue are greater than the money from the proposed pipeline would be, and I do not believe that it would be in our best benefit in order to provide this pipeline for Townsville.
[0:06:36.3]

TWT201134
MALE SPEAKER: Well citizens of Portstown as your mayor. I've had a proposal offered to me by the residents of Townsville for here. Now Townsville is in a lot of population growth and the demand has increased for water in Townsville and for long-time we relied on our Lake Voda for our water needs and tourism and recreation and right now the people in Townsville has offered this proposal to build this pipeline, which will go to the city of Townsville and they offered us a lot of money in the economic times for us imports town and despite our recreation and our tourism industry has certainly use a boost.
[0:01:07.2]
Right now, Lake Voda sits between us and we certainly do need some money coming into Portstown given the recent economic downturns that we have been experiencing. The farmland of course relied on our water as well. Now we're looking over proposals. I don't want to jump into anything too immediately, but we do want them to deplete the farmland of the water that you need from the Lake, but at this juncture, the money that Townsville has offered us for the pipeline is very hard to offer - to turn down so I'm relying on the citizens up there, the people in the crowd to speak their minds a little bit about this proposal.
[0:02:14.2]

So the people in Townsville have been using the Nero Aquifer and the population has gone up as the water usage has gone up as well and is drying up this aquifer. Now Lake Voda has a lot of water available so we're trying to come up with a compromise so that we can use some of this water responsibly, because obviously we don't want to shoot ourselves in the foot or effect the farmlands but again, the money from Townsville can certainly help us turn Portstown around, because we've been suffering economically.
[0:03:11.8]
Obviously, our revenue from Recreation and Tourism is not enough to meet our local economic needs, and we've seen this lapse in several years past. We are cleared up for the people in Portstown on whether they want this or not, and we certainly don't want to watch the water levels in Lake Voda increase or the farmland to suffer lack of water as our nation as a whole benefits from Lake Voda for the use of the farmland and our agriculture resources.
[0:04:05.8]
So we leave it to the people in Portstown to come over this decision. I thank you, and I hope you will take these problems and this dilemma into consideration and use your best judgment. Thank you very much.

TWT201135

SPEAKER: Good morning people of Portstown. This is your mayor, and I'm here to discuss an important matter with you today. And as you know, now I want to make sure that everyone can see this illustration here. As you can see, our town, Portstown is right here and we are getting the water from Lake Voda. It is a beautiful lake. [0:01:00.6]

And as you know, we are making most of our revenue from tourism. And as you know again, the revenue that we make off of tourism is not enough to run this city. Portstown. [0:01:20.5]

And at this point, recently we received a proposal from the city of Townsville, which is located down here. And they are having some problems or issues with water usage. And they are not getting enough water. And they are proposing that, proposing a pipeline which will go from Lake Voda through their narrow aquifer to city of Townsville so they can get enough water. [0:02:05.4]

And as you know, the city of Townsville is a wealthy city and they are willing to pay big money. Now the catch is, catch is, this sounds like very, a great business opportunity for us however there is a slight catch which is; if we do put a pipeline from here, from Lake Voda to their city of Townsville, this pipeline could potentially affect our tourism and the revenue that we receive from tourism will decrease. [0:02:45.5]

But good thing into this matter, you know what if we are not making enough revenue to run our city from tourism. If we are not making enough. If we are making enough revenue from tourism to run our city, now that is one thing. [0:03:07.4]

But if we are not, and we need some outside source of revenue to run our city, then I believe and I strongly believe this is a great opportunity for us. Because Lake Voda, as you know, is a big

lake and is more than enough to supply our water needs and I think by sharing this lake with the neighboring city, I think it is a good thing. [0:03:38.6]

To share that supply, share that resource with them. And water is something that is a necessity and we are not selling some commodity, but rather something that is necessary to sustain lives. [0:04:00.1]

So I think it is a great idea to share this water supply with the people of Townsville. And at the same time we are making enough revenue to run our city.

So let me just summarize this whole thing again. The city of Townsville proposed this deal that because they are having issues with their Nero Aquifer, and they are running short on water. And they are asking us if we could put a pipeline from Lake Voda to their city to connect, so they can get enough supply of water. [0:04:39.9]

And not just for free, but they are willing to pay a lot of money. And as you know, for us we are not getting enough revenue from tourism. And yes, by putting this pipeline this will definitely, it will likely to decrease our revenue from tourism. [0:05:03.7]

But if we are not making, if we are not getting enough revenue from tourism to run our city, I don't think there is really an incentive to cling onto this tourism. Why not sacrifice a little on tourism, and get this outside source of revenue, from outside. From Townsville. [0:05:25.4]

And I think it will work out just fine. [0:05:27.9]

For the city of Townsville, they are getting their water supply. It is not like they are getting, you know trying to get some kind of entertainment or something that is unnecessary for sustaining lives. But they are getting a necessity. A supply of water and at the same time we are getting more revenue that we can run our city. Enough to run our city. [0:05:56.1]

I'll make sure, as your mayor, that in negotiation I will make sure that the revenue that we received from Townsville is enough, more than enough from the revenue that we receive from tourism. At least enough that we can run this city. We can maintain our city. [0:06:16.5]

So as your mayor I urge, and I know this construction will take time and this will create some disturbance, inconveniences, and here and there. But I'll make sure in my negotiation with the city of Townsville that we will keep everything to a minimum. Without destroying environment. Without destroying unnecessarily. We'll make sure that they can have their construction for the pipeline just enough. Just enough to put the pipeline without sacrificing or without destroying the natural resources of the environment as much as possible. [0:07:02.1]

So again I believe this is a great opportunity. And I urge you, the people of Portstown, to support this proposal. And I will… And thank you. [0:07:26.4]

TWT201136

SPEAKER: Okay folks. We've called all together today to relay to you some information. We have a sister city in essence that is in need of our help. They are short on water. We have an abundance of like. They want to build a pipeline from our lake into their aquifer to get some fresh water. [0:00:26.4]

They are willing to pay us for this. It would cost us a little bit in tourism and recreation as you can see here. I have no problem with it as your mayor. I would like to convey to you that it would be helping other people out. I don't see how it would have that great deal of an effect on your everyday lives. I guess that they need us, we can help them. I think we should. [0:00:59.9]

As you can see here, there would be a minimal loss for recreation and tourism, and they would more, they would pay us more than enough that would make up for our loss, of tourism and recreation. [0:01:17.0]

So not to mention the building of the pipeline would bring jobs to the area. So that would also help our economy to make up for the loss of the tourism and the recreational revenue that we would be losing. [0:01:32.1]

So I think we should do it. I don't know how long the pipeline would be in terms of mileage, obviously it would have to be long enough. But I don't know how else I could convince you that this is the right way to go outside of the fact that, people helping people is what it is all about. I'm sure if the situation was reversed, and we were in need of water, I'm sure they would extend us the same courtesy and let us build the pipeline from their lake to our town. [0:02:16.6]

So it really is not going to affect your everyday life. That is the point I'm trying to make. [0:02:26.9]

I don't know what a Nero Aquifer is, maybe you do. I do not. I would imagine it is some sort of reservoir that needs to be cleaned, purified, I don't know. As you could see, excuse me, we use this much. They use this much over here. They use a little less than us. This is what we have to work with. So as you could see, we would only be using this much if we help them out. [0:03:04.5]

So this would still leave us, call it a – what is the word I'm looking for – savings, if you will. We make this much of our revenue in tourism and they are willing to pay us this much. So as you could see, we would actually be getting more money from Townsville, than we would be getting in tourism and recreation. And we would only be giving up this much out of our total supply here. [0:03:40.5]

So we would still have this here in reserve, and we would be making this much more money. So as you could see it really is a good idea. Like I said, not going to affect your everyday life. As a matter of fact it will probably make your life better. It is going to bring jobs. And like I said, we would be helping out Townsville that really needs our help. Again, they would probably do the same thing for us. [0:04:10.0]

I have no doubt in my mind. That is my decision, we're going to do this. And I hope you do agree with it, but you're going to have to. So thank you. [0:04:25.6]

TWT201137

[0:00:01.1 unrelated to 0:02:05.6]

SPEAKER: Okay. The way I'm thinking is, it is not very, very important – it is not absolutely important that the recreation usage over the required usage over here in Townsville. I can replenish naturally over here by 10 drops, cover my most important usage and, or I should say my vital usage, and maybe lose just 1 drop over here because it is going to take 4 drops to get all way over here. [0:02:47.4]

So let me think here. Vital usage is my top concern. Vital usage is my top concern because I mean people have got to survive, people have got to live and stuff like that. It is fun to play, it is cool to play, but you have got to live to survive. [0:03:06.7]

I'll say the revenue for the recreation is three, and the pipeline is two. Okay so you're going to lose two. So you are going to lose quite a bit. You're going to lose quite a bit. [0:03:30.3]

For me it is about the people. For me it is about having to help the people survive over here. But you know what I also think is, national recharge yes. It is the minimum. The minimum over here is 4 drops being transferred because you are only getting 1 out of here. You have got to have 4. [0:04:05.8]

So if you take 4 from here, if you take 4 from the natural recharge, that leaves you with 2, 4, 6 and you need 5 on the farm lands, 2 on the recreation. Wow, that is pretty slick. [0:04:30.6]

I'll tell you what we'll do. This is what we're going to do. We're going to back down, we are going to use conservation in the city of Townsville. We won't take as much in the pipe, from the pipeline. Therefore we won't cut, we won't lose as much revenue and so on by building this pipeline here. Conservation, conservation. We'll do that. Everybody should agree to use conservation and the city of Townsville…[0:05:01.8]

You see that is who needs the pipeline though. If not I don't know what they'd do. They definitely need it. So that is why I agree. That is why I agree. It is about vital drops that is being used. I mean you need 5 over here to run this town. You need 5 over here to run this town. [0:05:31.4]

So as the prior usage goes, you need this community to survive. You need this community to survive. You don't want to take much revenue from this community, though. So again, it is up to the people. If the towns would just conserve a little especially in the early part of this deal here. Maybe bring the water drop, maybe bring the 5 down to four and a half, or four even. And even so here as well. And I think it would make all this work. But that is kind of why I think this pipeline should be built. Because the people have to survive. [0:06:04.3]

TWT201138

[0:00:00.6 blank gap to 0:00:34.8]

SPEAKER: Okay. What I'm seeing looks like four drops here. And they are all going this way. But it doesn't look like we're getting too much natural recharge to go to the Nero aquifer. But the usage is getting used up – four, five here, six. Five water drops, four going in. That is usage that is going there. So one, two, three, four, five – we've got five here. One here, but it is all getting used up. [0:01:23.0]

Makes me assume that all that water is being used up, which is why they are proposing to build that pipeline, and pay the money to use the pipeline because they are using all their water up. And looks like Lake Voda from natural recharge it has got a water drop. It is one, two, three, four, five, six, seven, eight, nine, ten. Oh I did it the first time. That is 10 water drops that is of natural recharge. [0:02:09.7]

And as far as usage, we have five here – I'm sorry, three and two which is five. One with one, two, seven. So that leaves three over. It looks like one, two, three, our usage we have one, two, three, four, five, six, seven. And then with 10 to natural recharge, there is three left over. Ten minus three… I'm sorry seven. 10 minus seven, 3. So if we have 3 let's say water droplets of whatever gallons in the millions or thousands, whatever it is. It looks like we're going to get four over there, which looks like that leaves us in the negative. [0:03:23.8]

But it does leave us in a negative 1, which isn't that bad, but it is in the negative. As opposed to having all this water. And along with the recreation and tourism which we have negative it means our recreation too we'll probably lose that. That would be negative. That revenue would be negative but we'll make it up that way. [0:03:48.0]

So by how much negative, how many water droplets negative would it be. Or how much water droplets, the negative 1 water drops would have over here in our city. How much is that converted over to dollars. So if we use our recreation tourism we have 3 dollar signs so we'll make it up this way. [0:04:21.0]

But we're also losing money here to make the pipeline. So I would actually vote for no, because it goes negatively towards us. Even though it isn't – we're not losing a lot of money, we're losing water. If we propose to build the pipeline we will lose, it looks like we will lose 1,2,3,4,5. 5 dollar signs, and we only gain 3 back. From the recreation loss, from the recreation and tourism we'll lose 3 dollar signs from the revenue lost. And then we'll only be gaining 3 back. So that is 2 we'll lose in dollar signs and water. [0:05:21.3]

So in total we'll lose negative 1 in the dollar signs and 2 drops of water. With this you've got to think, losing Lake Voda you lose this. This will be a negative here, so we'll lose that revenue. Which is negative 3. And then you lose negative 2 but you gain that back. So again this is negative. [0:06:01.3]

Negative 1 in the dollar signs is how much money we'd lose, and then negative 2 in the water droplets. But it looks like the city of Townsville, they would gain 4, 5. They would just come out equal. So in time they will probably need more water than that. They would come out exactly equal, which would make them okay. They would be alright, but our city of Portstown we would actually not do so well. [0:06:45.7]

So I would not agree to Townsville's proposal because it looks like they come out even and we come out a little bit short. If we kept everything how it is, we will be using 2 water droplets for recreation. And then 5 over here, which is 7. Which leaves us with extra water to do whatever we need as far as this goes. Portstown water. [0:07:32.4]

If we decide not to build the pipeline, we would have water left over to do as we please with it. We won't lose any money to build this pipeline, we won't lose any money from our recreation and tourism from Lake Voda, then that is all a plus. We could calculate the revenue that we had for our side from the city or whatever. But it doesn't look like a good proposal on our end. [0:08:12.2]

So we could be 2 usage 2, 4, 7. We could be plus 3 with our water. Or we could be… Oh that would be plus 3 and negative 3 in the… Oh I'm sorry, plus 3 and plus 3 in the revenue. So plus 3 water droplets or plus 3 and plus 3 revenue if we don't build the pipeline. Or we can be negative 1 in revenue and negative 2 in the water droplets. So it really doesn't make sense for us to hinder ourselves, hurt our economy, hurt our city, for the city of Townsville to just equal out their water supply. [0:09:19.0]

Even if they do have the money, they have the money but if they are willing to double, if they increase the money, maybe we'll think about it. But we have to come out positive instead of negative. So maybe if they gave us a little bit more, if this increased, maybe they'll be considered. So maybe if we ask them to propose a different amount of money. [0:09:46.1]

Right now as it stands, as this proposal stands, I disagree with it. And would also like to ask for your thought about it, and also not agree with it. I can't sway you that way, but I do have these figures. The positive in the water and the revenue. I believe it is plus 3 in the revenue. Or we can be negative 3 in the revenue and negative 2 in water. [0:10:33.0]

Actually this is a no-brainer when you look at it like this. With proposal and without the proposal. Plus 3 water, plus 3 revenue. Or negative 1 revenue, negative 2 water. [0:11:03.0]

TWT201139

(0:00:05.7 pause to 0:00:13.6)

SPEAKER: The people of Townsville are going to pay us a lot of money to run a pipeline to our Lake Voda, and siphon off some of our water. A lot more than what we, than the estimated cost than the estimated loss of revenue from tourism. [0:00:48.4]

Looks like we get this amount here. We get 3 dollar signs in recreation and tourism from the lake. With the 2 things of water. And that aquifer for the city of Townsville they want… this is how much they can recharge now, but their usage is 4, and their usage is 5. So they are losing water faster than they can replenish it. Which is why they want to pay us a large sum of money. [0:01:46.4]

The natural recharge to the lake, that is right here, that is 10 dots. Whereas the usage totals, the usage is only total here is 2 here, 2 and 2 here. So we got 4, 5, 6, 7, 8,9,10, 11. 10 there. But that and that, that is a natural recharge that equals out. So the lake would actually not lose any – the lake itself would not be losing any water. It would still maintain the same amount that they would be siphoning off for the proposed pipeline. [0:02:45.2]

[0:02:57.3]

And the money that we would lose is only 2 dollar signs that they are going to pay us. And the city of Townsville is going to pay us 3 dollar signs. So the available water would stay the same. We would still have the same amount of water in the lake. The lake would still maintain its level. [0:03:24.0]

As you can see on this flow chart here, we have, we would still, we would be making more dollars. We would still be making more money in the long run over all of this. We would be making 1 extra dollar sign out of all this. And the amount of water would be considered negligible. We do not see, the amount used versus the amount we would lose from the amount of water from the lake, it would be negligible. We would not see a difference. [0:04:09.0]

So I propose that we have a pipeline built from Lake Voda to the city of Townsville for us to make more money. As you can see, we would make, the amount of money we would lose through the tourism and recreation would be less than what we would actually gain from selling the water to the city of Townsville. [0:04:40.2]

(pause to 0:05:12.4)

TWT201140

SPEAKER: The recharge of the Nero aquifer is 1. The city of Townsville is 4. And the natural recharge of the lake is 1. 1,2,3,4,5,6,7,8,9,10. 10. The usage of Portstown is 2. The usage of farmland for the place is 3. Okay then we have to kind of… Recreation to provide revenue of Portstown of 3. And have the usage of 2. So they make 1 dollar sign on the two. [0:00:42.4]

If the proposed pipeline is built, Townsville will pay 4, per 4 which equals 0 really. Portstown at lake 5 Voda. This is revenue lost, after the pipeline of 2 from recreation and tourism for Portstown. [0:01:09.0]

No. I don't think it is going to work. I mean, one I'm thinking. I look at this and I would want more information. You always want more information, right? I mean is Portstown willing to pay more? Is this the only amount of water… I mean. Is there more water. Okay look. They need the

usage of Townsville is 4 and they want to buy 4, but that is going to have a negative impact on the pipeline of 2. And the money they are willing to pay doesn't make up for that loss. [0:01:56.9]

And when is, I mean the other thing is, for how long? For how much? And how much is the natural recharge it is only 1,so how long can that deficit be maintained? Because at one point, well okay. The usage of Townsville acquire. This is the one they want. And they say the tourism is 10. So it could be even, but it is going to cost the pipeline too much money because, how long can it be maintained? [0:02:27.2]

And it doesn't say for how long the deal would go. It doesn't say what they would do to support the actual – to help keep Lake Voda in order, I mean it costs money. I'm still on no. I am no because I just, I keep thinking … You know I process in my mind a lot and so speaking out loud seems a little more disjointed than in my head I swear. [00:03:01.5]

But here is the thing. The natural recharge of the lake is 10, and the usage of Portstown is 2. I'm mayor of Portstown. So that means we have a plus of 8. Yeah that is good enough. That is an 8. And having a plus of 8 means we've got 8 to play with if… Townsville wants 4, which would be 8 minus 4 which would leave 4. And the usage, the recreation and tourism brings in a 3 with a usage of 2. So there would still be 2 left. 2 water droplets left. [0:03:47.3]

So it wouldn't be a deficit to the environment initially. It looks like it is more about, I mean what is the impact to the environment? What will happen to the surrounding land of the lake, if this is put through and more water. Because there is fish, there is wildlife, fish life. There is, not just tourism which is obviously an economic importance to the town, but there is also the impact to the environment around the lake. I'd want a study about what that is. [0:04:17.6]

I'd also want to know how come the pipeline is going to lose 2. How come there is going to be revenue lost of 2 from recreation and tourism. Because maybe is there a way to build, for lack of a better word because I don't know environmental stuff, a dam that would help the lake be higher during peak tourism? Because tourism is not year-round. Unless it is year-round. Is tourism year-round? I'd want to know. Is tourism year-round?[0:04:49.5]

Is there a way to lessen this impact for the money? I mean what is the impact? Is it afraid people can no longer… Can they no longer ski, water ski on the lake? I don't know if they do now or not? I mean what is the lake used for as far as tourism? Are they looking at it? Are they swimming in it? Are they using boats? What is that? And is there another way, is there part another way to make up that revenue lost for tourism? Because we could make those other attractions that could be…[0:05:15.0]

Because I think if it is not a negative impact on the environment, which it doesn't look like it is. It looks like the environment can sustain the people. Which is really important, because you don't want to set up the situation where you are having a … I want to know what the long term impact on the environment would be. I'd want to know what the long term impact on recreation and tourism would be, and could we make it up somewhere else. [0:05:38.2]

I would also want to know who is paying for it. I know the people of Townsville are willing to pay for it. But is that really how it is going to happen? I'd want details on that because it is one thing to say, 'We'll pay for it.' But how does that plan really come together and who do they pay and what do they pay? Do they building of whatever it would take? Or do they pay for the maintenance of it too? I mean what is the long term payment plan for this, and who is responsible if something happens. [0:06:06.8]

Who is going to take care of any tort liability, sorry. It is how I think. I'd also want to know… what else? Because Townsville is operating at a deficit. A deficit of 3 to 1, so that is not good. That is not sustainable. So they are going to need to do something, obviously. They could move to Portstown. That is a thought. They could all move to Portstown. [0:06:44.9]

I guess really everything is, this is long. Do they know how long they are going to sustain this? I mean are they growing? I'd want to know. Is Townsville growing or is it shrinking? Or what does the census say about the number of people that are going to be relying on this water source and for how long? [0:07:04.4]

And what are the long term effects of that? And is this need for now, or is it for the next 10 years, or for the next 100 years, or how long is that need for? Because this lake is probably, the natural recharge of this lake is probably not going to change much, but the people on the surrounding land will. And what will, and I think I've already said this, but what will the effect on the lake be long term, of doing this to the wildlife. [0:07:30.6]

I still think I say no. I wouldn't do it. Not with this… I'd want more information. I'd say no until I got more information about long term wildlife and natural habitat effects. Until I got how long 4 drops would sustain Townsville, I mean it is growing, how long. And then I would also want to know the pipeline expenses is a real thing. Because the people of the pipeline need to be able to make money. Is this in stone, are the people of Townsville willing to pay for the deficit to make up for the recreation and tourism? Is there something else they can do for recreation and tourism? I think that is important too. [0:08:11.8]

So yeah. And is there another way that this lake can be addressed so that this water supply can be transferred at different times. I don't know. I am not an environmental engineer. I do not know how that stuff works. I drink water and I bathe in it, and I'm glad it is there. Sometimes I swim in it. [0:08:31.8]

So yeah that is it. That is all the information I want to be given. Until I could answer that information I would say no. Do not want anymore. [0:08:43.3]

TWT201141

SPEAKER: The city of Townsville is wanting to create a pipeline from Lake Voda to their town because they have depleted their water source. So they have asked us to build this, and they would give us large sums of money. Lake Voda is right here and Townsville is here. [0:00:32.3]

We use the Lake Voda currently for recreation and for your entertainment. There is a lot of natural recharge coming in here. Farmland uses some, we use some. But they would want quite a bit of water in exchange for money. The revenue that we get from Lake Voda would be about the same as the amount from Townsville. [0:01:08.9]

The proposed pipeline goes like that all the way up to the town. It would create less water for recreation and tourism. However I'm not too sure that it would not have an effect on our tourism. I think that if… I think that if they don't deplete it too much, because we have a lot of natural recharge occurring, that we should be able to suffice both. I'm not sure what the townspeople think, that is why I'm asking for your opinion here. [0:02:00.0]

Just looking over the paper and seeing stuff here. Their natural recharge from their Nero aquifer is five times less than what their town uses. They are a pretty big town, but they don't need a – they don't have a water source besides their Nero aquifer. [0:02:34.5]

So I am in support of them using, or creating a pipeline because it would not only bring money for us. It says revenue loss from the pipeline would be 2 dollar signs, but here I'm seeing the sign says 3 dollar signs, and we would get paid 3 dollar signs. I don't understand how that could affect it. [0:03:01.4]

I don't think that this lake is small enough that it would affect it that much. We would still be able to have our beaches and other tourism. We could also limit the amount of water that they pull from the lake. Say the lake is low, they would get less water. They would still need to use their Nero aquifer, and instead of having 4 units, instead maybe only have 3 units. I'm not sure if they would need the fourth one, if they use that one. [0:03:44.6]

Another idea that I would like to see them do, is maybe build something on here. They got a lot of land up here, they can build something down there. Maybe there would be farmland to take away. Or they could have one down here. [0:04:05.6]

I think if they build something like a reservoir down here, and create their own lake Voda. So that is one proposal I would ask them is if, how cost effective it would be for them to create their own. Because I know the pipeline is pretty darn expensive for them. Plus we have to go and lay out the land. And also another effect is who would pay for it if it broke from here to here. Say if it broke right here, would they be in charge or would we? So that is one thing. And there is a lot of questions that I would have to ask them. [0:04:56.4]

To have a full understanding of their project there is also a lot of questions I would have like, 'Why can't you guys do this? Why can't you guys do that?' Or let's see about trying to reduce their usage. They are jumping, 'Oh we just need water.' But maybe we can go through and say, 'Okay let's try and get one of these out.' [0:05:23.7]

If you are following me here townspeople, I think that there would be ways to reduce their water.

Reduce water. There is other methods that we could use. I know we use a lot for our farmland, but that is an income. Maybe we could also, if they want to use the pipeline, we could charge them for the amount of water that they pull out. Charge for water. [0:06:18.0]

I'm not totally opposed to this plan, but we have a lot of unanswered questions here. I like to see income come into our town, but also I like to make our townspeople happy. Just see you guys have fun. I don't know about you, but I personally enjoy jet skiing and boating on the lake. My favorite place to fish is right here. Maybe that area would be depleted if we pulled out from there. [0:06:50.9]

And what about the natural waters that come out here. Are they going to not get at a level where they would still flow in? Because if we pull it far enough out, I'm not sure if that would go out as well. It might have other places to flow. It says that we have a lot of natural recharge here. So can we help them out? I mean I'm seeing quite a bit of water here. There is 10 units compared to the 4 that they want, the 2 that we use, and the 3 that farming uses. So we're only getting 1 unit. And then there is usage here too. So actually it would be under a unit. So I would like to see them use less water, or not even have the pipeline if we can get them to do their own water. [0:07:54.2]

TWT201142

SPEAKER: This is our city, Portstown. And this is Townsville. Townsville has proposed to pay Portstown a certain amount of money in order to take water from our lake, transport it over to their aquifer. [0:00:49.4]

We need the lake's water for the farms and for the town. The only way that the lake derives more water is from the natural water that comes from the ground. [0:01:20.0]

Portstown also gets money from recreation and tourism, but in addition, they would get money from selling the water to Townsville. The revenue derived from selling the water will also add to the revenue from the recreation and tourism. [0:02:07.9]

No I'm sorry, there is revenue lost because of the water taking from the lake. The recharge of the lake, the lake is supplied more quickly through natural recharge than the natural recharge of the aquifer. Townsville uses more water from their aquifer than Portstown uses from the lake. [0:03:03.0]

TWT201143

[0:01:06.3]

SPEAKER: I need to know that you want to know (inaudible at 0:01:14.6).

[0:01:45.1]

SPEAKER: So they are taking 4. City of Townsville, you're taking 4 waters, 1, 2,3,4. But you're using 5. 1,2,3,4, and then you are taking 5. You are using, that is your usage. And you are giving back 1,2,3 dollars back to our town of Portstown. In addition to that, the tourism lost due to the pipeline is 1. So that is really cancelling out these 2 dollars because the tourism nobody want to come and see our town. [0:03:04.5]

But then we are talking that we have some money from recreation and tourism, but that is already because of our own Lake Voda anyway. Off of the top there. So we've got total for Portstown. Portstown you have 1,2,3 dollars coming into Portstown and 1,2,3, dollars coming into Portstown from Townsville. This is total.[0:03:57.5]

Then you have how much going out – so that is 6 total. 2 going out, 4. Lake Voda, but you only have 4 waters then how? I don't see it.

[0:04:27.1 pause to 0:04:32.4]

And then if you just delete totally the recreation and tourism, you just take 1,2,3, not even discussing the recreation and tourism component of things Lake Voda already developed, already has on our own. And the town. And we're talking about the 3 dollars generated from the income from the pipeline. [0:05:07.2]

We're talking about, we have 2 dollars, take away 2 of that from there. We're better off without doing this, I'm sorry. If we're talking strictly financially, we're talking that the city of Portstown is not better off. If we're talking environmentally, with the pipeline, and actually having water for the people of Townsville, I'm going to say final decision is – let me see how do you want me to present this? [0:06:00.2]

Final decision is that Townsville you will not get the proposed pipeline due to it does not seem as if it is cost effective for me as the mayor of Portstown to agree to this proposal. [0:06:23.0]

END TRANSCRIPTS

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