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An Investigation of Coordinates as Mathematical Evidence for Cadastral Surveying in Alberta

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UNIVERSITY OF CALGARY

An Investigation of Coordinates as Mathematical Evidence for Cadastral Surveying in Alberta

by

Matthew Michael Philip Sakatch

A THESIS

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Abstract

This research delves into the topic of coordinates as legal survey evidence for boundary positions. It is spurred by the recently adopted Hybrid Cadastre project in Alberta, Canada and the evidentiary changes concurrent with this initiative. A review of literature pertaining to how survey evidence is assessed historically under the Hierarchy of Evidence, as well as the implications of modern evidentiary initiatives with coordinates is provided. Hypothesis are formed from this literature review and enlighten the qualitative study design.

Key informant interviews apprise of the profession's perspectives on this form of evidence are assessed using qualitative methods. Informants included practicing land surveyors, academics, members of the public, and government officials. A descriptive narrative approach was applied to the informant's feedback to generate emergent themes. Informant feedback was assessed against the themes by incorporating an ordinal scale to provide a parameterized data set. Inferences made from this dataset prime the synthesis and theory development.

In synthesis, an emergent theory on coordinates as evidence is provided as well as a continuum for assessing coordinate based evidentiary initiatives. When properly framed within the legislative framework and in specific *de facto* applications coordinates can govern legal survey boundaries and be considered a *sui generis* form of boundary evidence. An emergent continuum is proposed to provide a metric for assessing future applications of coordinates as evidence in alternate jurisdictions. This continuum is founded in the principles of cadastral management, and ensuring the public's continued faith in the land framework.

Conclusions are provided relating to the adoption of coordinates as evidence currently within the land framework and case law. Ultimately future adoption of coordinates as evidence is a topic that requires legislative intervention to provide for widespread adoption and acceptance.

Preface

This thesis is the original, unpublished, and independent work of the author, Matthew Sakatch. The key informant interviews and data collection described in Chapters 3-4 were covered by Ethics Certificate number REB17-0481-REN3, issued by the University of Calgary Conjoint Faculties Research Ethics Board for the project “Modern Perspectives on Coordinates as Boundary Evidence and the Alberta Hybrid Cadastre” on July 7th, 2017. This approval has been extended and is effective until July 7th, 2021.

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To all of the participants in the key informant interviews for your unique and insightful perspectives of the topic and taking the time to speak with me. Also, for having faith in this research throughout the duration of the study.

Dedication

This thesis is dedicated to my late father, Francis Michael Sakatch. For all you taught me in this life, and for pushing me to finish this after you are gone.

Table of Contents

Abstract.....	i
Preface.....	ii
Acknowledgements.....	iii
Dedication.....	iv
Table of Contents.....	v
List of Tables.....	xi
List of Figures.....	xii
Glossary of Terms.....	xiv
Glossary of Cases.....	xx
Glossary of Legislation.....	xxi
Acronyms and Abbreviations.....	xxii
Body of Thesis.....	1
1 Chapter One: Introduction and Research Problem.....	1
1.1 Introduction.....	1
1.2 Background.....	5
1.2.1 Coordinates as Evidence.....	6
1.2.2 Recent Initiatives.....	7
1.3 Problem Statement.....	9
1.4 Context of the Research.....	10

1.5	Research Objectives and Questions.....	11
1.6	Scope and Limitations of the Research	13
1.7	Thesis Outline.....	14
2	Chapter Two: Literature Review	15
2.1	Introduction	15
2.2	Definitions and Preamble	15
2.2.1	Coordinates.....	16
2.2.1.1	Measurements and Accuracies.....	16
2.2.1.2	Time-dependent Coordinates	17
2.2.2	Boundaries.....	18
2.2.3	The Three Ds.....	19
2.2.4	Framing Coordinates.....	22
2.2.5	Framing Cadastres.....	22
2.2.6	Legal Considerations.....	24
2.2.7	Case Law	25
2.2.8	Statute Law.....	30
2.2.9	Land Administration Considerations	31
2.3	Historical Mathematics and Boundaries.....	32
2.4	International Context	34
2.4.1	South Africa - Learning from the Past	34
2.4.2	Australia – Legal Learnings	36

2.4.3	New Zealand	37
2.5	Federal – Canada	38
2.6	Local – Alberta	40
2.6.1	Early Dominion Lands	40
2.6.2	Block Corner Era.....	43
2.6.3	Delayed Posting Plans.....	51
2.6.4	Hybrid Cadastre.....	52
2.7	Summary.....	55
3	Chapter Three: Methods and Data	56
3.1	Introduction	56
3.2	Study Design.....	56
3.3	Triangulation of Analysis	61
3.4	Data Collection Mechanism	61
3.4.1	Documentary Data.....	62
3.4.2	Key Informant Interviews	63
3.4.2.1	Semi-Structured Oral Survey Questions	64
3.5	Interpretation and Biases	66
3.6	Hypotheses.....	68
3.7	Narrative Approach	68
3.8	Themes.....	69

3.8.1	Coordinates as Governing Evidence	69
3.8.2	Coordinates and Tenure Security	70
3.8.3	Coordinates as Monuments	70
3.8.4	Effects on Daily Practice.....	71
3.8.5	Hybrid Cadastre within Current Legislation.....	71
3.8.6	Requirements of Hybrid Cadastre.....	72
3.8.7	Monuments under the Surveys Act.....	72
3.9	Ethics	73
3.10	Summary.....	73
4	Chapter Four: Results and Analysis.....	74
4.1	Introduction	74
4.2	The Sample.....	74
4.3	Results and Analysis.....	77
4.3.1	Coordinates as Governing Evidence	81
4.3.2	Coordinates and Tenure Security	86
4.3.3	Coordinates as Monuments	93
4.3.4	Effects on Daily Practice.....	98
4.3.5	Hybrid Cadastre within Current Legislation.....	103
4.3.6	Requirements of Hybrid Cadastre.....	108
4.3.7	Monuments under the Surveys Act.....	113

4.4	Summary.....	117
5	Chapter Five: Synthesis and Discussion.....	118
5.1	Introduction	118
5.2	Initial Research Questions	119
5.3	Alignment with Hypothesis.....	124
5.4	Emergent Theory	126
5.5	Emergent Continuum.....	127
5.6	Triangulation of Data.....	133
5.7	Towards a Blended Cadastre	133
5.8	Summary.....	134
6	Chapter Six: Conclusions.....	135
6.1	Introduction	135
6.2	Limiting Factors	135
6.3	Sources of Error.....	136
6.4	Significance of the Research	137
6.5	Contributions to Knowledge.....	137
6.6	Future Work.....	138
	Bibliography	139
	Appendices.....	144
	Appendix A – Ordinal Assessment Raw Data	144

Appendix B – Certification of Institutional Ethics Review 145

Appendix C – Recruitment Email 146

Appendix D – Interview Guide 147

List of Tables

Table 1 – Specifics of Participants.....	76
Table 2 – Average Ordinal Alignment, Median, Mode, and Standard Deviation of Respondent Groupings with Themes.....	78

List of Figures

Figure 1 – The Hierarchy of Evidence, representations of both Common Law and Practice Interpretations.....	3
Figure 2 – Typical Township Monumentation under the Third Survey of the Dominion Land Surveys.....	41
Figure 3 – Quarter Sections and Legal Subdivisions of Sections under the Dominion Land Surveys.....	42
Figure 4 – Typical Block Evidence Monumentation during the 1912-1988 Period of Residential Surveys.....	45
Figure 5 – Example of Typical Evidence found presently in 1912-1988 Block Corner Subdivisions.....	47
Figure 6 – Retracement of Lot 7 Boundaries Example (Ideal Scenario).....	49
Figure 7 – Retracement of Lot 7 Boundaries Example (Alternate, Less Ideal Scenario).....	50
Figure 8 – Theoretical example of Establishing Boundary Positions by Coordinates	55
Figure 9 – General Flow of Induction.....	58
Figure 10 – Graphical Flow of Study	60
Figure 11 – Triangulation of Data	61
Figure 12 – Documentary Data.....	62
Figure 13 – Study Participant locations across Alberta including Canmore (2), Calgary (12), Edmonton (6), and Grande Prairie (1)	75
Figure 14 – Clustered Columns of the Respondent Groups Average Alignment with each Theme	80

Figure 15– Average Alignment of Respondent Groupings and Standard Deviation of the Alignments for the Coordinates as Governing Evidence Theme.....	81
Figure 16 – Average Alignment of Respondent Groupings and Standard Deviation of the Alignments for the Coordinates and Tenure Security Theme	86
Figure 17 – Average Alignment of Respondent Groupings and Standard Deviation of the Alignments for the Coordinates as Monuments Theme	93
Figure 18 – Average Alignment of Respondent Groupings and Standard Deviation of the Alignments for the Effects on Daily Practice Theme	98
Figure 19– Average Alignment of Respondent Groupings and Standard Deviation of the Alignments for the Hybrid Cadastre within Current Legalisation Theme.....	103
Figure 20 – Average Alignment of Respondent Groupings and Standard Deviation of the Alignments for the Requirements of Hybrid Cadastre Theme	108
Figure 21 – Alignment of Respondent Groupings for the Monuments under the Surveys Act Theme	113
Figure 22 – Emergent Continuum for Coordinates as Evidence and Effects on Land	127

Glossary of Terms

Glossary of Terms

Term	Definition
Alberta Land Surveyor (ALS)	<i>An individual who holds a certificate of registration and an annual certificate to engage in the practice of surveying as prescribed under the Land Surveyors Act (Government of Alberta, R.S.A. 2000, L-3).</i>
Alberta Township System (ATS)	<i>A survey framework across the province consisting of quadrilateral townships. Defined through sections 18 through 26 of the Surveys Act (Government of Alberta, R.S.A. 2000, C. S-26).</i>
Ancillary Monument	<i>A generic term used to describe other forms of monumentation than standardized iron posts or monuments. This form of monumentation is discussed in the Canada Lands Legislative framework.</i>
Blended Cadastres	<i>Is representative of a cadastral model in which land is defined through a blend of physical monuments in the ground and coordinates in lieu of monuments. The Hybrid Cadastre fits within this definition. Discussed in detail in section 2.2.5.</i>
Coordinate	<i>A coordinate is a parameterization of polar plan data in a Cartesian reference frame with a specific datum, realization, and mapping projection.</i>
Coordinate Based Cadastres	<i>Presented by Fediow in his 1995 thesis. A coordinate based cadastre is a term he uses to describe a cadastre than incorporates coordinates.</i>

Coordinate Integrated Cadastres	<i>Is representative of a cadastral model in which monuments on the ground are uncommon, and primarily boundaries are defined through coordinates in lieu of monuments. Discussed in detail in section 2.2.5.</i>
Datum	<i>“A datum is a geodetic reference system which included an ellipsoid and an origin against which the latitude and longitude of all other points on the earths surface are referenced” (Government of Canada, n.d.).</i>
Delimitation	<i>As discussed in section 2.2.3 delimitation is the intent to delimit or divide interests in land. This does not include any physical representations of the boundary and is general in nature.</i>
Delineation	<i>As discussed in section 2.2.3 delineation is the act of describing the extents of a boundary through graphical means. It creates the representation of the boundary in graphical means but does not constitute the boundary.</i>
Demarcation	<i>As discussed in section 2.2.3 demarcation is the act of placing marks on the ground to mark the location of a boundary that is described graphically through delineation.</i>
Dominion Land Surveys (DLS)	<i>As discussed in section 2.6.1 the Dominion Land Surveys were the initial surveys of the late 19th century that established the system of survey that Alberta has adopted in the Alberta Township Framework.</i>
Establishment Coordinate (EC)	<i>A coordinate that governs the location of a disposition boundary until such a time as a statutory iron post is placed to demarcate the location on the ground, established under the Hybrid Cadastre Standards (Government of Alberta, 2016).</i>

Geoid	<p><i>As provided by the National Oceanic and Atmospheric Administrations (NOAA) National Geodetic Survey the geoid is “the equipotential surface of the Earth’s gravity field which best fits, in a least squares sense, global mean sea level” (National Geodetic Survey, n.d.). In Canada the geoid is the reference surface for orthometric heights. The most recent height reference frame, Canada Geodetic Vertical Datum of 2013 (CGVD2013), incorporates a geoid using mean sea level for the North American coasts (Government of Canada, n.d.).</i></p>
Governed / Governing	<p><i>In the context of this thesis, and as described in practice the term governed or governing relates to the piece of evidence that defines and takes precedence over the position of the boundary.</i></p>
Hierarchy of Evidence	<p><i>Emergent from case law, the Hierarchy of Evidence is a means of ranking and assessing various types of evidence as it relates to land boundaries. In recent times this has been incorporated into professional practice manuals to ensure that practitioners operate within the juridical interpretations.</i></p>
Hybrid Cadastre	<p><i>A form of coordinate-based cadastre where the positions of the boundaries are determined by a blend of monuments in the ground and coordinates references to a network of control points of defined datum and projection. Established under the Hybrid Cadastre Standards (Government of Alberta, 2016).</i></p>
Land Surveyor	<p><i>A person who holds valid registration with a professional land surveying association as being able to perform the duties of interpreting and establishing boundaries.</i></p>

Mapping Projection	<i>A means of representing positions across a portion of the earths surface in two dimensions for mapping on plans (Government of Canada, n.d.).</i>
Monument	<i>A brass tablet, iron post, wooden post, mound, pit or trench, or anything else used by a surveyor to mark a boundary, corner or line (Government of Alberta, R.S.A. 2000, C. S-26).</i>
Mutatis Mutandis	<i>Stemming from legal interpretation provides a means to compare cases as it relates to the main point at issue without getting caught up in the circumstantial differences to the cases (Thomas Reuters , n.d.).</i>
Obiter Dictum	<i>A Latin phrase which means “that which is said in passing” used in modern legal terminology as additional commentary in a judgement that is taken as said in passing (Britannica, T. Editors of Encyclopaedia).</i>
Observed Coordinate (OC)	<i>A coordinate that is obtained for existing (or placed) monuments and is only included on the plan for informational purposes. In the case of natural boundaries, Observed Coordinates provide evidence of the bank location at the time of survey. These coordinates do not create or govern any boundaries however are witness to the governing evidence in place. Established under the Hybrid Cadastre Standards (Government of Alberta, 2016).</i>
Polar Coordinates	<i>A means of representing relationships between objects in space time through means of distance and bearing from one another.</i>
Practice of Land Surveying	<i>The survey of land to determine or establish boundaries, and generally interests in land (Government of Alberta, R.S.A. 2000, L-3).</i>

Practice of Surveying	<i>The observation of positions on and determination of the form of the earth and includes the practice of land surveying (Government of Alberta, R.S.A. 2000, L-3).</i>
Practitioner	<i>A person who is engaged in the practice of land surveying in a specified jurisdiction.</i>
Precise Point Positioning (PPP)	<i>A means of post-processing static or kinematic GNSS observations using NRCAN's precise ephemerides (Government of Canada, n.d.).</i>
Prima Facie	<i>A Latin expression for "at first sight" which is used to describe a circumstance being taken at first look or face value (The Law Dictionary, n.d.).</i>
Re-establishment Coordinate (RC)	<i>A coordinate created by a Land Surveyor for a lost monument position in lieu of planting an iron post, and as such is the opinion of the surveyor as to the location of the original monument and does not govern the location. Established under the Hybrid Cadastre Standards (Government of Alberta, 2016)</i>
Re-establish	<i>The act of replacing a monument that does not have any traces of the original evidence and the most probably position of the original boundary location is interpreted by a surveyors professional judgement following the evidentiary principles as set out under the Hierarchy of Evidence.</i>
Restoration	<i>The act of replacing a monument in its original position based on traces of the original monumentation.</i>

Reference Frame	<p><i>The means by which coordinates are represented. For example, in a polar system this is accomplished by distance and bearing, while in a Cartesian reference frame it is done with respect to an origin; can be established in two or three dimensions. The fourth dimension in a reference frame would be time. For a Cartesian reference frame time constitutes when the coordinates were observed, while for a polar plan data set, it is when the plan was registered.</i></p>
Sui Generis	<p><i>A Latin expression for “of its own kind of class” for providing the unique nature of a phenomenon. In this case, the use of coordinates as evidence could be considered Sui Generis (The Law Dictionary).</i></p>
Traditional Cadastres	<p><i>Is representative of the traditional framework of defining land through monumentation in the cadastre from historic times to present. In this framework the vast majority of cadastral boundaries are monumented with lack of monumentation being uncommon. Discussed in detail in section 2.2.5.</i></p>

Glossary of Cases

Legal Cases
African and European Investment Company v. Warren and Others [1924] AD 308
Cain v. Copeland 1922 CarswellSask 129, [1922] 2 W.W.R. 1025, 15 Sask. L.R. 529, 67 D.L.R. 581
Esterhuizen's Executrix v. Vermeulen [1867-1868] 1 Buch. 76
Hawkes Estate v. Silver Campsites Ltd. 1994 CarswellBC 196, [1994] 7 W.W.R. 709, [1994] B.C.W.L.D. 1544, [1994] B.C.J. No. 1094, 44 B.C.A.C. 288, 47 A.C.W.S. (3d) 1100, 71 W.A.C. 288, 91 B.C.L.R. (2d) 126
Hegel v. British Columbia (Ministry of Forests) 2009 BCCA 527, 2009 CarswellBC 3173, [2010] B.C.W.L.D. 112, [2010] B.C.W.L.D. 27, 183 A.C.W.S. (3d) 10, 280 B.C.A.C. 1, 474 W.A.C. 1, 78 C.P.C. (6th) 26
Kristiansen v. Silverson 1929 CarswellSask 88, [1929] 3 W.W.R. 322, [1929] 4 D.L.R. 252, 24 Sask. L.R. 106
MacKenzie v. MacKay 2016 PECA 16, 2016 CarswellPEI 66, 271 A.C.W.S. (3d) 667, 72 R.P.R. (5th) 177
McPherson v. Cameron [1868] N.S.J. No. 2, 7 N.S.R. 208
Murray v. Opperman and Erasmus [1904] T.S. 965
Okanagan Radio Ltd. v. Kamloops Registrar of Land Titles 1996 CarswellBC 1930, [1996] B.C.W.L.D. 2475, [1996] B.C.J. No. 1913, 65 A.C.W.S. (3d) 346
O'Neil v. Colonial Gold Mining Company and Escombe [1885]
Richmond Hill Furriers Ltd. v. Clarissa Developments Inc. 1996 CarswellOnt 4746, [1996] O.J. No. 4363, 141 D.L.R. (4th) 536, 31 O.R. (3d) 529, 67 A.C.W.S. (3d) 1024, 7 R.P.R. (3d) 54, 97 O.A.C. 333
South Australia State v. Victoria State [1914] A.C. 283(P.C.), affirming (1911), 12 C.L.R. 667(H.C.)

Glossary of Legislation

Legislation
Hybrid Cadastre Standards Pilot Project (Multiple Versions)
Hybrid Cadastre Standards (Version 1.0 to 2.2)
Land Surveyors Act, RSA 2000, c L-3
Land Titles Act. RSA 2000, c L-4
Manual of Standard Practice (MSP) Alberta Land Surveyors' Association (multiple editions)
Public Lands Act, RSA 2000, c P-40
Surveys Act, RSA 2000, c S-26

Acronyms and Abbreviations

Acronym	Full Text
2D	Two-Dimensional
3D	Three-Dimensional
3TM	Three Degree Transverse Mercator
10TM	Ten Degree Transverse Mercator
ALS	Alberta Land Surveyor
ALSA	Alberta Land Surveyors' Association
ASCM	Alberta Survey Control Marker
ATS	Alberta Township System
BIM	Building Information Modelling
CAD	Computer-aided Design
CGS	Canadian Geodetic Survey
CGVD2013	Canadian Geodetic Vertical Datum of 2013
CLS	Canada Land Surveyor
COGO	Coordinate Geometry
CRCSI	Cooperative Research Centre for Spatial Information
CSRS	Canadian Spatial Reference System
DLS	Dominion Land Surveys
DOS	Directory of Surveys
EC	Establishment Coordinate
GIS	Geographic Information Systems
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HC	Hybrid Cadastre
LTO	Land Titles Office
MSP	Manual of Standard Practice
NAD83	North American Datum of 1983
NATRF2022	North American Terrestrial Reference Frame of 2022
NRCAN	Natural Resources Canada

NZGD49	New Zealand Geodetic Datum 1949
NZGD2000	New Zealand Geodetic Datum 2000
OC	Observed Coordinate
PPP	Precise Point Positioning
RC	Reestablishment Coordinate
RP	Reference Point
UNCLOS	United Nations Convention on the Law of the Sea
UTM	Universal Transverse Mercator

Chapter One:

Introduction and Research Problem

1.1 Introduction

This research reviews the current state of case law, policy, and practice in Alberta, Canada as it pertains to mathematical evidence, particularly planar coordinates, defining legal boundaries. It examines coordinates as evidence primarily in the context of the recently initiated Hybrid Cadastre project in Alberta, which is stirring a potential major change in policy and practice (Government of Alberta, 2016). This study uses documentary evidence and key informant interviews analysed qualitatively.

The argument of this thesis is that the use of mathematics has been ingrained in the cadastre since its formation, and only the weight afforded to this form of evidence in boundary establishment has had a substantive shift as technology has progressed. Mathematical evidence is but one form of permissible survey evidence that is assessed based on the common law Hierarchy of Evidence.

The Hierarchy of Evidence has developed over two centuries of Canadian case law into its current form. Pertinent cases from their era include *McPherson v. Cameron* (1868), *Hawkes Estates v. Silver Campsite* (1994), and *Richmond Hill Furriers v. Clarissa Developments Inc.* (1996). Each case has an influential precedence in terms of boundaries, and along with others are discussed in further detail in Chapter 2. This hierarchy for affirmation of legal land boundaries is employed in the Alberta Survey Framework to an extent¹ and is described in Section 5.2 of the Alberta Land Surveyors' Associations (ALSA) Manual of Standard Practice (MSP) (Alberta Land Surveyors' Association, 2016).

¹ This means that the Hierarchy of Evidence has been adopted into practice manuals to enable a streamlined practice within the bounds of the common law interpretations thereof.

As outlined in the MSP Section 5.2 (Alberta Land Surveyors' Association, 2017), the Hierarchy of Evidence is divided into four tiers, as outlined below:

- 1) Natural boundaries or evidence of natural boundaries;
- 2) Original monuments or traces of original monuments;
- 3) Fences or Evidence of possession reasonably dating back to the original survey;
- 4) Measurements as shown on previous plans of survey

This hierarchy is to be used when an Alberta Land Surveyor is required to perform a retracement survey of property boundaries from an existing survey and guides the Land Surveyor regarding the evidentiary weight that specific types of boundary evidence merit (Alberta Land Surveyors' Association, 2017). This interpretation organizes the hierarchy into four tiers whilst the hierarchy derived from common law has six tiers. This is highlighted in *Hawkes Estates v. Silver Campsites* (1994), where Justice Gibbs cites the hierarchy in abbreviated form as follows:

- a) Natural Boundaries;
- b) Monuments in Place;
- c) Occupation by Owners;
- d) Field Notes, Distances and Angles;
- e) Plans and Intentional Plans;
- f) Areas

The difference in terms of the number of rungs in the hierarchy under the Manual of Standard Practice essentially clumps sections d) through f) of the hierarchy noted by Justice Gibbs together. This generalizes field notes with plans and areas as being of the same evidentiary weight. The variation between the common law hierarchy, and that as written in the MSP (2017) highlights the issue of interpreting coordinates as evidence given the discrepancies between the two. These hierarchies are represented visually in Figure 1 below.

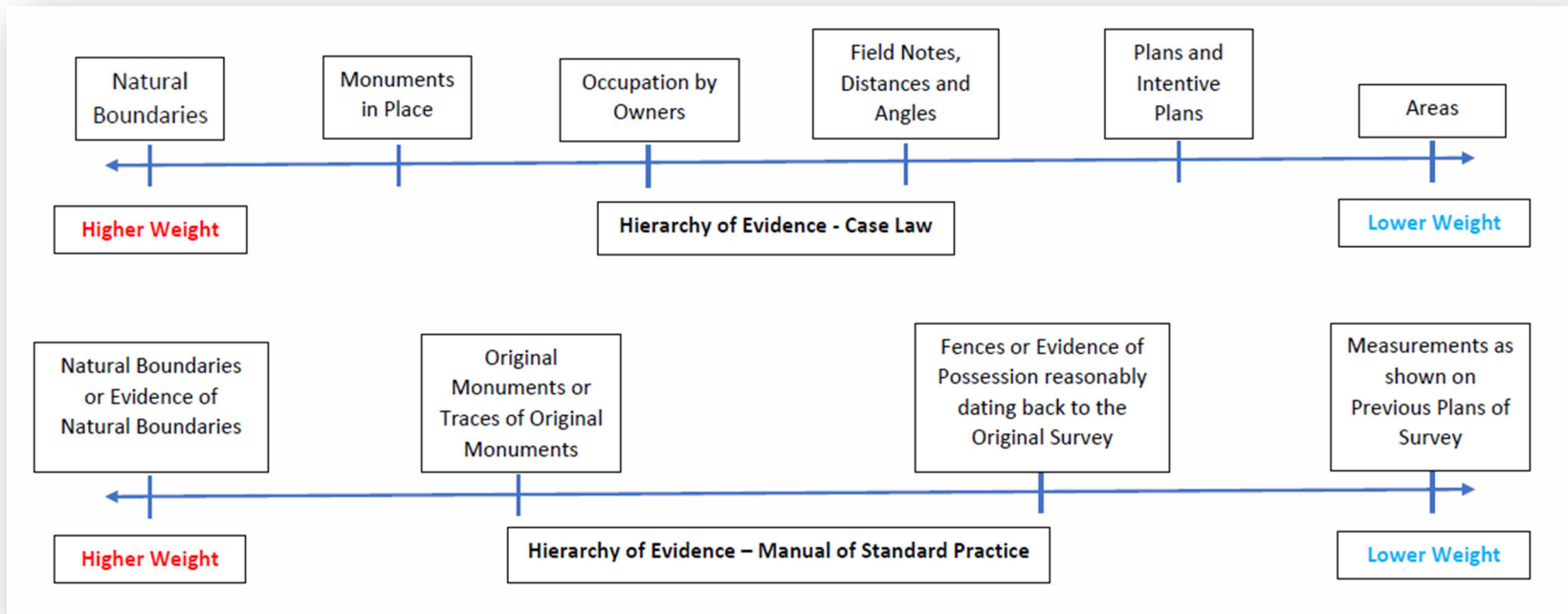


Figure 1 – The Hierarchy of Evidence, representations of both Common Law and Practice Interpretations.

Under the hierarchies noted above, the original monuments that demarcate and define boundaries are given one of the highest weights in terms of permissible legal survey evidence. Only natural boundaries carry a higher evidentiary weight. The practical weight applied to the various forms of legal survey evidence is representative of the quality of evidence. Thus, the difference between the MSP's four tiered versus Justice Gibbs six-tiered hierarchy can result in a variation in differential evidentiary assessments.

Mathematical evidence carries a lower weight in this hierarchy, with no specific reference to "coordinates" as a form of evidence in the existing hierarchy. Rather mathematical evidence such as coordinates is currently destined to be fit (whether appropriately or not) into the 'Field Data' or 'Plans and Diagrams' divisions of the existing hierarchy.

There is a prevalent argument in modern times amongst practitioners that the weight afforded to coordinates as a means of governing a legal boundary position needs to be readdressed. This stems from the advancements in technologies which allow mathematical evidence to often be the best evidence present when re-establishing a lost or destroyed monument.

This research responds to this argument by addressing the common law, legislative law, professional, practical, and public considerations that currently surround the use of coordinates as evidence to provide context for navigable avenues towards the further adoption of coordinates as evidence. Risks and benefits of coordinate adoption moving forward in both Alberta, but also other diverse juridical frameworks are discussed.

The research challenges the precedent that mathematics in the form of planar coordinates are not a suitable form of legal survey evidence with modern technological considerations. The use of coordinates as evidence in defining legal boundaries must be reviewed in order to ensure the cadastre technologically keeps up with the demands of society. These can include needs such as efficient, cost effective, and universally accessible land registries, which are complimented by the security provided by Torrens styled guarantees to title.

As technology progresses and the incorporation of both Global Navigation Satellite Systems (GNSS) technologies (for surveying on the ground) and effective Geographic Information Systems (GIS) (for cadastral management) become more common, it is evident that coordinates are playing a greater role in the daily operations of modern cadastres.

To ensure that future uses of coordinates are pragmatic in balancing the efficiency desired by industry, and the human rights considerations tied to security of tenure and stability in cadastral transactions for the public, the cadastral wide adoption of any future initiatives that have coordinates as evidence requires prudent planning. This also must include a historical review of the influence of mathematics in the cadastre from its foundation.

1.2 Background

In the past two decades the adoption and use of coordinates in the Alberta Surveying Profession has progressed, most notably because of the further integration of GNSS and modern GIS database technologies. Efforts have progressed towards a further digitized profession, relying on coordinates and spatial datasets as a technological adoption brought upon by industries demand for efficiency.

This has changed the day to day minutiae of both the **practice of surveying** and the **practice of land surveying** over the past few decades, in that both are increasingly more dependent on technology. Gone are the days of hand drafting and respective calculations, with the modern times of mathematical points as tools for the profession have become the norm². A common discussion point that has come to the forefront is that of digitized cadastres and placing higher influence on mathematical relationships in defining boundaries. Fediow (1995) initiated the discussions surrounding coordinates and coined the term coordinate based cadastre in his Masters thesis “Towards a Coordinate-Based Cadastre in Alberta”.

² Examples include modern Computer-aided Design (CAD) and Coordinate Geometry (COGO) software packages.

Further examples of this include an article written by McEwen (1994) regarding the legal status of coordinates for property boundaries, the 1999 Coordinate Based Cadastre Test Project Report that was initiated by the Alberta Land Surveyors' Association (2002), and an article by Barry (2004) discussing the similarities with South African cadastral practices surrounding coordinates. Ultimately, no immediate or significant cadastral wide changes occurred, but these early works provided critical insight and dialogue on the next steps towards the adoption of coordinates as legal evidence.

These discussions have not resulted in a widespread materialization of a digitized or coordinate based cadastre. However, they have helped progress the notion of coordinates as a form of evidence as they drive for digitization. This has further highlighted that in any scenario where a cadastre is all encompassing, the use of coordinates to define legal boundaries is a necessary topic to broach.

1.2.1 *Coordinates as Evidence*

The first progression towards coordinate adoption in surveying in Alberta came about when the Surveys Act of Alberta was amended in 1975 to allow for surveys that do not immediately require standard monumentation considerations. These are colloquially known as “Delayed Posting Plans” and are governed under Section 47 of the Surveys Act (Government of Alberta, R.S.A. 2000, S-26). Their intent was a hybridization of physical monumentation and coordinate governed boundary positions to help alleviate monument destruction during the construction phases of large-scale urban developments. These amendments were a legislative means to address a specific problem affecting industry and are highly regulated.

Under the Act, a surveyor can register or file a non-monumented plan with Land Titles Office (LTO) for registration without having every boundary defined by a physically demarcated monument. The internal boundaries can be defined by mathematical coordinates, which must be shown on the plan's table of coordinates. Presently, the positions that are governed by coordinates must be demarcated with a physical monumented eventually. The general requirement is within the first year, but this can be deferred to accommodate construction and monument survivability.

In the end, all the coordinate governed positions must be physically demarcated, or at least attempted to be. Special scenarios requiring alternate monumentation occur and must be noted on the final monumentation certificate. Ancillary³ types of monuments such as lead plugs, magnetic concrete nails, and drill holes can be used as reference demarcations to a boundary position should that position be unsuitable. This is commonly caused by utilities and municipal infrastructure in subdivision developments that are not ideally disturbed by monuments placed deeper than a foot in the ground (as per ground disturbance requirements near buried infrastructure).

Once all the monumentation is placed, and the final monumentation certificate is submitted, the governing coordinates no longer hold the evidentiary weight of a monument. This type of survey product is useful for modern practitioners while balancing the public's interests and the security of the cadastre well. Its effectiveness has been a driving force towards further and more recent initiatives.

1.2.2 *Recent Initiatives*

The next major evidentiary shift in the weight afforded to coordinates as evidence in the province came about as a result of the ill-fated Global Positioning System (GPS) locations plans of the 2000s. These were products that infringed upon the survey professions legislated scope of practice pertaining to boundaries as it allowed non-surveyors to submit plans that referenced legal boundaries. They were a result of governmental policy and directives as established and empowered under the Public Lands Act (Government of Alberta, R.S.A. 2000, P-40). The fix to this complicated time in public land management came in the form of the Hybrid Cadastre, a pilot project initiative begun by the Director of Surveys (DOS) office on July 2nd, 2014 (Government of Alberta, 2014).

³ Not to be confused with the federal definitions of ancillary monumentation that are actually described by the acts. Definition as per outlined in glossary.

This project was unique in that it allowed for a blend of physical and mathematical evidence to be used in defining public land dispositions on crown lands. It adopted coordinates as evidence to a further extent than the Section 47 products. The Hybrid Cadastre allowed for coordinates to govern the position of a legal survey boundary, i.e., essentially to allow the mathematical coordinate to be the legal definition of said boundary location.

Officially adopted by the Government of Alberta on April 1st, 2016 as the “*Hybrid Cadastre Standards for Public Land Disposition Surveys*” it established a new path forward for surveys on Crown lands (Government of Alberta, 2016). The initial standards were further amended and updated on July 31st, 2017 and are considered “version 1” (Government of Alberta, 2017). These standards have gone through various revisions, with the most recent Hybrid Cadastre Standards version 2.2 being released on November 5th, 2020 (Government of Alberta, 2020).

The Hybrid Cadastre operates under the Director of Surveys authorities granted under the Surveys Act (Government of Alberta, R.S.A. 2000, S-26). This interpretation holds for Crown land and effectively elevates Establishment Coordinates (EC) to the evidentiary position held by physical monuments in the definition of legal survey boundaries (Government of Alberta, 2016). The Hybrid Cadastre also outlines other instances of mathematical evidence that can be incorporated into ‘Hybrid’ plans such as Re-establishment Coordinates (RC) and Observed Coordinates (OC). However, both do not have the possibility of governing established legal boundaries, in a manner similar to Establishment Coordinates (Government of Alberta, 2016).

This is the first time in Alberta that coordinates have been given governing status over boundaries without robust and rigid frameworks in place that limits the duration of time that the coordinates will effectively “govern”. The use of coordinates as a form of evidence for the positions of boundary corners in Alberta has progressed significantly over the past few decades and shows a continual trend of increased influence of mathematics in defining modern boundaries. Resultantly, to determine the weight coordinates have as evidence in defining boundaries, it is necessary to examine the role of mathematical evidence as a form of data. Special considerations will be given to the topological relationships that exist with governing coordinates within a given system, and how this reflects on this form of evidence.

1.3 Problem Statement

This work is responding to recent changes to the practice of surveying in Alberta, Canada, specifically the greater evidentiary reliance on planar coordinates in defining public land dispositions under the Hybrid Cadastre Policy (Government of Alberta, 2016). The progression to a greater weight being placed on coordinates versus statutory monuments in modern practice has resulted in uncertainty surrounding legal precedence, practical considerations, and tenure security in the Alberta cadastre.

The use of mathematics has been ingrained in the Alberta cadastre since its beginning. However, the recent changes, specifically the Hybrid Cadastre, impress upon society a need to readdress this form of evidence. To date, the use of mathematics has not been overly complex in the cadastre, and there have been limitations on the confidence given to this form of evidence under evidentiary assessment guided by the Hierarchy of Evidence.

The Hybrid Cadastre policy seeks to increase the degree to which mathematics are relied upon by allowing them to define legal boundary locations indefinitely. This evidentiary shift is a first for Alberta and the ramifications of such a change are yet to be realized.

In extreme scenarios abroad a higher reliance on mathematical evidence and plan data over that of statutory monuments and occupation has been shown to create complex cadastral boundary conflicts. Examples of such scenarios in the adjunct international context of South Africa are discussed in Chapter 2. These examples provide context for the need for further considerations in the adoption of coordinate-based evidence in future cadastral initiatives.

This research aims to explore the practice and policy ramifications that exist when using coordinates as governing evidence for legal survey boundaries in the context of the Alberta Hybrid Cadastre. Furthermore, it presents and discusses the risks and benefits in terms of cadastral security, efficacy of tenure transactions, and the human rights considerations in making these changes to what is permissible governing evidence.

1.4 Context of the Research

Currently, Alberta employs a “Monuments Govern” approach to survey evidence as it pertains to the definition of legal real property boundaries. Commonly the monuments that demarcate a legal boundary are often the best or most reliable form of evidence. This approach is aligned with the current state of case law in Canada and is outlined in the Alberta Land Surveyors’ Association (ALSA) Manual of Standard Practice (MSP) (Alberta Land Surveyors’ Association, 2016).

The most recent development in Land Surveying in Alberta, as discussed above, is the initiation of the Hybrid Cadastre under the DOS office (Government of Alberta, 2016). The project proves to be the first major change in the way in which coordinates are incorporated as governing evidence. At this present time, it is only applicable to public lands in both un-surveyed and surveyed territory.

At the 2015 Annual General Meeting, the Futures Committee put forth a report which postulated the eventual transition of the Alberta survey framework towards a Coordinate Based Cadastre (Alberta Land Surveyors’ Association, 2015). This resulted in a variety of opinions being expressed over the implications of such a transition with no clear position of majority being presented. This issue was tabled and put back to the ALSA Futures Committee to continue working on, and recently culminated in a report titled “Considering Boundary Definition by Authoritative Coordinates” (Janes, et al., 2020).

The implications of the changes in the status of coordinates as governing evidence has the potential to affect society as it pertains to real property. The foundation of security in real property is the ability to exclude others and have an accurately delineated representation of the boundaries of the real property.

The parties that are most affected by issues surrounding the security of real property are the general public and the associated businesses and professions in the Alberta survey industry. Ultimately, the security of real property is intrinsically tied to the stability of the economy. Furthermore, the ability of the public to access an effective and accurate cadastral system is paramount to ensuring vulnerable populations are not taken advantage of and human rights are maintained.

1.5 Research Objectives and Questions

The objective of this qualitative study is to examine how mathematical evidence is currently applied in Alberta and investigate the influence the recent changes to the practice of land surveying, brought about through the formalization of the Hybrid Cadastre (HC), have on tenure security in the cadastre.

The central research question concerns how mathematics in the form of coordinates are used as a form of legal survey evidence under the existing Hierarchy of Evidence and in the light of the recently adopted Alberta Hybrid Cadastre (HC). This is informed by the social, technical, and legal aspects that relate to land boundaries and the progression towards mathematics defining these positions (Ballantyne, et al., 1999).

The specific research questions that elaborate on the central research question are outlined below. A brief discourse follows each of the questions to elaborate on the context.

1. *What is the current system for establishing property boundaries in Alberta?*

The first question sets the stage by discussing how property boundaries in Alberta are being established currently, which incorporated further consideration for the historical ramifications that affect current practice.

2. *How would you place or re-establish a monument in the traditional Alberta cadastre?*

The second question further establishes the basis for how monuments are placed and re-established in the Alberta cadastre. These first two questions establish the basis of the current system of surveying in Alberta as it pertains to evidence and inform the context of the third question.

3. *What are the allowable changes to permissible boundary evidence in Alberta under the Hybrid Cadastre? How do these changes affect Alberta?*

The third question reviews the changes that have occurred in permissible boundary evidence considering the Alberta Hybrid Cadastre (HC) and expands on how these changes affect the current Alberta cadastre. These changes to evidence are compared with the current practice of boundary evidence as discussed in the first two questions, such that an analysis of the divergent interpretations and uses of evidence can be discussed.

4. *How does this compare in relation to the international instances/ experience?*

The fourth question elaborates on the previous question, by contrasting the Alberta scenario with international experiences in the applicable use of coordinates as evidence. This provides insight into the applicable experiences and issues with coordinates as evidence in other jurisdictions and assists in gauging the significance of the evidentiary changes under the Hybrid Cadastre.

5. *How will the prevailing theories on the establishment and security of legal boundaries be affected considering the evidentiary changes of the Hybrid Cadastre?*

The fifth question is intended to review the evidentiary changes effectuated by the Hybrid Cadastre and comparing these with the current theories on boundary establishment and security. This includes discussion of the position of the mathematical evidence set out in the hybrid in the Hierarchy of Evidence, as well as discussion as it pertains to the three Ds of boundary definition: Delimitation; Delineation; and Demarcation (Branch, 2014).

6. *How do indicatory monuments relate to the changes in evidence proposed by the Hybrid Cadastre?*

The sixth question discusses the instance of indicatory or witness monuments and how these forms of evidence relate and differ from the use of coordinates as evidence under the Hybrid Cadastre policy.

1.6 Scope and Limitations of the Research

The scope of the research is centered in Alberta, Canada. It relates directly to the Hybrid Cadastre project, and its use of mathematical evidence for the survey of Crown lands. Each of the provincial jurisdictions in Canada has its own unique legislation and practice. This is not intended to be directly relatable to other jurisdictions that do not align with Alberta's legislative framework.

Select few adjacent jurisdictions are used for comparison in respect to their handling of coordinates as evidence. These include South Africa, Australia, and New Zealand. These are not intended to be substantive reviews of each of these unique international instances, or their juridical frameworks. Publications and academic works from experts in the practice of surveying and academic inquiry in these respective jurisdictions are incorporated to provide contextual learning points from the incorporation of mathematical evidence.

This study will review South Africa, as a key international example, to demonstrate the extent to which mathematical evidence is incorporated in the definition of legal land boundaries in this cadastre. South Africa suites itself as an excellent example as a result of the historic use of coordinates within the juridical framework and highlights practical considerations to consider when attempting to adopt the use of coordinates. This will also provide a comparative analysis of South Africa with the Alberta instance such that the veracity of the newly minted Hybrid Cadastre can be appropriately discussed, and any risks or benefits thereof can be further elucidated.

1.7 Thesis Outline

Chapter One, has provided the outline of the research and the reader should understand the context of the problem and the scenarios the research will be looking at. Chapter Two provides a historical background and analysis of Alberta and its use of mathematics in defining legal boundaries to frame to context of the changes brought about by the Hybrid Cadastre. This chapter also includes a review of literature pertaining to international instances in which coordinates as evidence have been used in established boundaries.

Chapter Three outlines the methodology for assessing cadastres that incorporate mathematical coordinates as evidence through the establishment of an analytical framework. Qualitative methods and key informant interviews are incorporated to provide context to the documentary dataset. The hypotheses that guide the research are introduced, as well as the emergent themes from the dataset.

Chapter Four is the analysis of the data outlined in Chapter Three incorporating a Likert assessment with respect to the themes. The inferences from the qualitative portion of the study are discussed in detail, and further used to triangulate the learnings brought forward from the legal and documentary findings.

Chapter Five provides a discussion and synthesis stemming from the data analysis in Chapter Four. The hypotheses are discussed in context of the learnings of the themes and emergent theory and a continuum for coordinates as evidence is outlined. The initial research questions are responded to with learnings from the key informants.

Chapter Six provides the conclusions from the research and learning points moving forward. Recommendations from the study of adjacent jurisdictions using coordinates as evidence will be discussed. Final remarks regarding areas of future academic inquiry on the topic of coordinates as evidence will be highlighted.

Chapter Two:

Literature Review

2.1 Introduction

This chapter examines the transition from establishing boundaries through traditional means, and that of the modern initiatives such as the Alberta Hybrid Cadastre that incorporate coordinates (Government of Alberta, 2016). It proposes that the transition towards mathematically governed boundary positions requires a different approach in terms of practice, however, is applicable under the current framework given the appropriate circumstances. A historical review informs the significance of this transition to mathematical evidence in terms of practical and statutory requirements.

This chapter reviews the literature pertaining to coordinates in the Alberta context, as well as incorporating learning points from relatable jurisdictions both within Canada and abroad. South Africa is a focus of this due to its historic use of coordinates as evidence. Instances of coordinates being used as evidence within the Canadian confederation will be discussed.

For future reference throughout this chapter, when the term “**governed**” or “**governing**” is used in relation to evidence, it means that the piece of evidence defines the boundary and carries the legal evidentiary weight to do so (i.e., from both statute law and case law).

2.2 Definitions and Preamble

Prior to setting out on the discussion of mathematical evidence as a form of legally governing survey evidence, first the concept of mathematical evidence must be broken down and defined. Furthermore, the effect and use of mathematics in defining land must be hinged on the definable terms that describe the process of modelling, allocating, describing, and registering ownership in land. Finally, the instances in which coordinates are adopted into cadastral frameworks need to be revisited, such that these circumstances can be properly framed.

2.2.1 *Coordinates*

For the purposes of this thesis, a coordinate is a position (x, y, z) on the surface of the Earth at a specific instance in time that is modelled in a reference frame with a specific datum. Broken down into its simplest form, a coordinate is a position in a reference frame represented by scalar values that equate to its displacement from the reference frame origin. An easily visualized example comes from a Cartesian two-dimensional (2D) reference frame, in which the x and y value of the coordinate relate to its difference in the x and y dimensions in relation to the origin.

Modern coordinates in context and practical use are the result of specific positions on the Earth modelled through projections most suited for their relative positions on a plan. Common examples of projections used in Alberta include Ten Degree Transverse Mercator (10TM), Universal Transverse Mercator (UTM), and Three Degree Transverse Mercator (3TM)⁴. The coordinates are realized through either convention means (to gravity and the geoid), or through modern GNSS technologies, and both are related to a reference ellipsoid.

Coordinates are subject to shifts and changes over time, and the grounding control must be updated concurrently. Thus, coordinates related off of modern control points must ensure they use the up to date epochs of said coordinates, which take into account the progressive datum changes. Furthermore, when processing these results through modern geomatics solutions, they must be provided with a confidence interval and not as absolute.

2.2.1.1 Measurements and Accuracies

The presumption of this thesis is that proper methodologies are being employed in realizing positions on the ground. This includes using geodetic grade technologies for achieving these measurements, and the appropriate processing and data analysis is done to ensure these measurements are accurate. Since the scope of this thesis is not to delve into the achievable accuracies of technologies such as GNSS, it is assumed that when speaking of coordinates the means by which they were generated was done appropriately.

⁴ During the pilot phase of the Hybrid Cadastre both UTM and 10TM could be used for mapping projections (Government of Alberta, 2015). The subsequent published standards for the first version of the Hybrid Cadastre changed this to only allow UTM projections (Government of Alberta, 2016).

That being said any initiative into the realm of defining land boundaries by coordinates requires tolerances to be used, akin to other kinds of survey tolerances such as for monuments. The difference in the application with coordinates is that there is no mark of the ground to go and verify that this position is correct. Thus, it is even more incumbent on those generating coordinates in plan products to ensure sufficient checks are performed to validate the congruency of the product to itself (i.e., closing the plan, cross vector checks, etc.).

The assumption for this thesis is that when discussing Establishment Coordinates, they have been derived as per the Director of Surveys requirements under the Hybrid Cadastre policy. These require a five-centimetre relative accuracy and a ten-centimetre absolute accuracy at a 95% confidence (Government of Alberta, 2020). Given the remote nature of the lands in which Hybrid products are often employed, it is recognized that the use of Natural Resources Canada (NRCAN) Precise Point Positioning (PPP) tool is most feasible.

2.2.1.2 Time-dependent Coordinates

As the use of coordinates progresses, the data management of these observations is going to be an area of key concern, as is the period in which they were generated. Coordinates are hinged to the real world by datums, and these change over time as a result of changes in gravity measurements across the earth. These are provided by the Canadian Geodetic Survey (CGS) (Government of Canada, n.d.). The adopted North American Datum of 1983 (NAD83) (CSRS) Epochs are provided for each provincial jurisdiction on the NRCAN webpage (Government of Canada, n.d.).

Successive updates to datums and their realizations mean that coordinates relating to positions on the earth will be continually updating over decades⁵. Thus, when working with coordinates, it is important to ensure the proper datum epoch of the coordinate and possibly apply coordinate transformation to avoid large biases brought about through different datum realizations.

⁵ Currently the Hybrid Cadastre uses NAD83 (CSRS) Epoch 2002 as its datum reference frame. This could update in the future with newer reference frame initiatives and updated epochs.

This will become evident in the future as practitioners are required to go back to hybrid products that use potentially outdated datums. A modern relevant example of changes in coordinate values stemming from reference frame modernizations is the upcoming North American Terrestrial Reference Frame of 2022 (NATRF2022) which is noted as seeing meter level coordinate shifts with respect to NAD83 upon implementation (Erickson, et al., 2019).

For the purpose of this thesis, and since this is an emergent and future area of concern it is assumed that coordinates discussed are all within the same coordinate system realization. This thesis is not intended to delve into the complexities of coordinate transformations between different eras of survey data, seeing as this is already a trend that has been addressed in the past in traditional practice. The acceptance is that in the future it may occur more often as geodesy provides ever more accurate realizations.

2.2.2 Boundaries

This thesis does not intend to perform a substantive review of boundaries, the law pertaining to boundaries, or theories arising from how boundaries are set out. It discusses the applicable uses of coordinates in the context of a boundary. Since modern initiatives with coordinates predicate in defining boundaries, some discussion is merited on fixed versus lost boundaries.

Boundaries in the context of law are highlighted by Halsberry as being “imaginary lines which mark the confines or line of division of two contiguous parcels of land” (Earl of Halsbury, 1973). Simpson (1978) discusses this interpretation by Halsbury regarding surveyor’s aversion to the use of the term invisible, which is further analyzed by Lamden and de Rijcke (1989) as it relates to definitions of land. Ultimately, there is a degree of semantics in the terminology used in defining a boundary.

Whether it be an imaginary or invisible line is irrelevant for this discussion. Ideally, it is best to be thought of as a theoretical plane in space-time that defines a division between two interests in land on the ground. Really, the definition depends on how one wants to frame the idea of a boundary. It can be defined in oral traditions, textual synopsis, geospatial terms, and purely mathematical proofs.

For the purposes of this thesis, coordinates are being looked at in the context of being prima face governing evidence as it pertains to a fixed boundary location (i.e., the Hybrid Cadastre). Furthermore, in this context coordinates can be used to assist with, and for re-establishment of uncertain boundary positions. Essentially, the way the practice is using coordinates under the Hybrid Cadastre is that coordinates are being provided all the same considerations as an original legal monument in the ground.

The wording and means of stating this have progressed throughout the successive versions of the Hybrid Cadastre, with the most recent released on November 1st, 2020 (Government of Alberta, 2020). It is explicitly stated in Section 3.1 (Government of Alberta, 2020) that,

“A coordinate is deemed to be a monument for the purposes of determined disposition boundaries on public lands.”

Cadastral boundaries are fixed boundaries that are framed within the cadastre and established to a survey level quality. They are monumented in standard practice, represented on plans of survey and registered with land registries. In this thesis, primarily the discussion surrounding boundaries means fixed boundaries, which are known, as well as retracement of fixed boundaries. Lost boundaries that are typical of widespread monument destruction and typically require resurvey will be touched on as it pertains to the role coordinate can play in these reconstructions.

2.2.3 *The Three Ds*

In geography and modern science, the generally accepted terminology ascribed to the process and methods of defining land are the three Ds: delimitation, delineation, and demarcation. They represent specific steps in the definition of land, and the rights associated to its use. In order to frame coordinates in context appropriate, these terms must be outlined in detail.

Delimitation in the context of land means the intent by two parties (or more) to create a limit in the physical world, or a boundary, to which rights associated to land can be ascribed or excluded across the said boundary. This includes the rights to ownership, which is the primary driving factor in the intents to delimit.

In defining the extent of a land parcel, delimitation is the first step. In historic international contexts across time this was primarily done through treaty⁶, and as such it is permissible to think of delimitation as an agreement by which two sides agree to a rough position of a boundary.

The specifics of the bounds in these contexts are often generally broad and relate to physical features in the natural world. As such there is a great deal of subjectivity in interpretations of the extents of interests created by the boundary. The clarification of these various interpretations happens during the delineation process (the second step).

Delineation in the context of land comes after the intent to delimit a boundary is agreed to⁷. To delineate a boundary means to describe it in geographic means on a cartographic product, such as the case in modern times, a plan of survey. Textual delineation is possible through relating boundaries by textual descriptions and mathematics to other known boundaries. This is common in early deeds and remains present on modern products such as titles. However, with the current level of integration of plans and with the vast majority of land already surveyed, these descriptions become only relevant in the cases of partial areas of lots.

The process of delineation is the representation of the boundary by mathematical means on a plan that describes it on the ground. The plan's topology of relations, in terms of the vectors between boundaries and the distances and bearings of these boundaries effectuates a representation of the specifics of the boundary such that it can be retraced on the ground through a survey. However, without relation to physical objects on the ground (i.e., monuments from the demarcation process) the delineation of the proposed boundaries effectively is up for interpretation. Thus, it is the third step, the demarcation process that links the delineated product to the specific position on the earth (ground).

⁶ An example that affects Canada would be the Oregon Treaties between USA and the British Empire RE 49th parallel and the Columbia river on the west coast.

⁷ For further review regarding international examples the concepts of Delimitation and Demarcation are elaborated on by Prescott & Triggs (2008).

In international contexts, this means that textually delineated boundaries, affixed by treaty, have a lower threshold for security of tenure than those physically set out and demarcated through monuments. This causes great issues when subsequent attempts are made to interpret these delineations, which are often so historic in nature that the physical features on the ground have drastically changed.

Demarcation in the context of land represents the act of marking the location of a boundary on the ground, often through a monument. The process of demarcation ties a delineated boundary to the physical realm by showing its true location on the ground. The placing of the monument takes the intents of the delimitation and subsequent delineation and makes these interests tangible. As has been held by *Richmond Hill Furriers v. Clarissa Developments* (1996)⁸, it is the placement of monuments and subsequent registration of the delineated product (the plan) that creates the legal boundary. Monuments placed without the act of registration do not create the boundary, rather it is the two acts together that form the boundary.

In international instances (boundaries between states), the boundaries are agreed to in theory through delimitation and delineation. As previously noted, this is often done through a treaty. These agreed to boundaries are rather transient, and up for interpretation until they are marked out on the ground through demarcation. It is this process, and the subsequent agreement of the monument positions by all parties, that conveys the security in the boundary. In instances where there has been a long period of time between the treaties and the eventual survey of the boundary, it is common for disputes to arise in the locations retraced. Modern examples of this include the Himalayan boundaries between India and China. In these instances, the boundaries have not been marked out and lived to, but rather are a result of occupational lines of control that are subject to changes through political strife and successive disputes.

⁸ This case is important to note in that it the procedure required to define a parcel of land. Placing monuments, in the case stakes, and not registering a plan does not amount to creating a boundary.

2.2.4 *Framing Coordinates*

Where do coordinates fit into these means of defining land? A great deal has been written about how coordinates can/should be considered as monuments in recent times. However, because coordinates confer no mark on the ground, it is not apt to include coordinates in the definition of a monument or associate them with the act of demarcating a boundary. This has been supported throughout the successive revisions to the Alberta Surveys Act (Government of Alberta, R.S.A. 2000, S-26), as the definition of a monument remains unchanged as a physical mark on the ground.

To infer that a coordinate is the same as a monument in regard to these terms of defining land would ultimately be an assault on modern definitions. However, if the argument is framed that a coordinate is not the same as a monument (i.e., nothing is placed), but it can be granted a similar evidentiary status (albeit altered for the fact it leaves no mark) then it would fit within the definitions. In general, a coordinate, should rather be viewed as part of the delineation process, in which it represents a position on the boundary in mathematical terms on a survey product.

2.2.5 *Framing Cadastres*

Whenever the discussion of coordinates as a form of legal survey evidence comes up, the discussion eventually digresses to the topic of how to define the cadastre in these instances. This section is not intended to be a substantive review of the concept of cadastres, or how land management and allocation should be managed. Rather it is intended to provide a set of relatable metrics (definitions) under which the thesis can operate. This is done to provide a grounded framework of terms.

In a traditional cadastre in the western world, monuments are the governing evidence and frame the plan data to the ground. Mistakes in plan data and in the placement of monuments do occur. However, the degree of work required with placing monuments and the legislative checks and balances throughout the registration process makes it less common for monuments to be placed in error. Mistakes on legal products, such as plans, are more common due to the inherent human error in drafting and checking of these products.

With the advent of jurisdictions adopting coordinates as evidence, there has been a similar change in the way these cadastres are framed. Fediow (1995) discussed the concept of cadastres that incorporate coordinates as being termed “Coordinate-Based Cadastres”. Further discussions across the world have resulted in terms such as “Legal Coordinated Cadastre” as put forth by Andreasson (2006) in the case of Singapore, and “Millimeter Legal Coordinated Cadastre” as put forth by Carlton Brown in his doctoral thesis (2011). There is a variety of emerging terms that attempt to brand or define how a cadastre that incorporates coordinates should be referred to.

Cadastral instances in which coordinates are not relied upon as evidence in a similar weight/manner to monuments would be termed as the **Traditional Cadastres**. In these cadastres, monuments are the primary evidence and are the legal requirement when establishing boundaries. Boundaries that are defined by coordinate in circumstances, are not allowed to define these positions in perpetuity, and are subject to legislative requirements for their eventual replacement with monuments. Prior to the advent of the Hybrid Cadastre, Alberta would be termed as a traditional cadastre, with the Section 47 plans testing the limits of the concept (Government of Alberta, R.S.A. 2000, S-26).

Those, which incorporate coordinates to an extent as legal evidence but also include monuments in everyday survey practice, would be termed as **Blended Cadastres**. In these instances, there is a blend of governing coordinates and governing monuments, which are interdependent on each other (i.e., the legislative requirements for plans allow for both monuments and coordinates, but not solely coordinates). A modern example of this is the Hybrid Cadastre, and as it has evolved it has been changed to be described as such. Since the Hybrid Cadastre still incorporates some monuments and requires them as a means to hinge the coordinated plan to the ground, it can be viewed as a blended cadastre pushing the concept towards higher coordinate integration.. Should a level of cadastral development and integration take place over the coming decades, the resulting increases in the density of survey products could provide suitable circumstances for a lower reliance on monuments.

Finally, those that are fully integrated digitized cadastres, such as Switzerland (de Rijcke & Lambden, 1989), and only hinge on digital products onto higher order reference control networks, would be termed **Coordinate Integrated Cadastres**. In these cases, there are few monuments to be found, and the primary monuments that are used are from control networks. Monuments placed simply to define the position of a property boundary are uncommon.

In relation to a nation's position in this continuum, an important correlation to note is that jurisdictions with a longer timeline of cadastral development, and a subsequent higher density of cadastral products tend to progress towards mathematics more easily. This provides some realizations of why European countries are more suited to further integration of coordinates as evidence in their cadastral frameworks⁹.

2.2.6 *Legal Considerations*

In Canada, there are effectively two legal systems, common law and legislative law (de Rijcke & Lambden, 1989). The common law system is that of English influence and derives its history back to the early settlement of Canada by the British Empire. Legislative law is law written by the elected government, to deal with issues that pertain to society. It should be noted that this is not a legal document, and these discussions are only intended to provide context for how the practice of surveying is legally framed.

In surveying, common law effects how practice has evolved. Influential cases have provided a progressing context in regard to how boundaries and evidence used to define them should be interpreted. These cases are often the result of complexities arising from the historic systems of survey and address conflicting interpretations as it pertains to boundaries of land. Thus, the Hierarchy of Evidence is not pinned down, but continually changing and progressing as a result of further litigations. Governments are able to use legislative law to effectuate the practice of surveying. These instances often relate more directly to the specific framework that hems in the profession, but in instances across society can be used to clarify eventualities brought up through common law litigation.

⁹ Examples include Austria, Sweden, Poland, Estonia, and Switzerland to name a few.

To date, the Hierarchy of Evidence has not been written into legislative law (i.e., not in statute), and is used in modern practice in professions practice manuals¹⁰. It should be noted that these cases often result in a streamlined interpretation of the hierarchy such that practices can be more feasible. However, conflicts arising between the practice manuals for professionals and the common law interpretations in the setting of legal challenges do not confer any authority on these manuals' interpretations. Rather, they are a derivative of the ever-changing standards of the Hierarchy of Evidence as it evolves through successive case law.

Furthermore, there is the relevant discussion of the perspectives of *de facto* versus *de jure* in all aspects of regulatory frameworks. *De facto* perspectives are the way the regulation, law, policy is actually applied on the ground, while *de jure* is the way it is written. Often times for there are divergent paths for these two and highlight the differences between how the legislation is written, and the requirements to actually implement the legislation on the ground. For the purposes of this thesis, the Hybrid Cadastre policy is reviewed from a *de jure* perspective, with emergent concerns stemming from the qualitative analysis representing *de facto* interpretations.

2.2.7 Case Law

In order to understand how coordinates are framed within current legal pretenses, a brief discussion of key influential cases pertaining to survey evidence is prudent. This is necessary to elucidate how changes to evidentiary assessment come about but to also provide context in regard to the current scenario of coordinates as legal evidence. The Hierarchy of Evidence is the result of more than a century of case law. Throughout this time, it has been interpreted and tested in various means. This is not intended to be a comprehensive review of the case law pertaining to the hierarchy, rather important cases from the context of coordinates will be noted.

¹⁰ An example would be the Alberta Land Surveyors Manual of Standard Practice (MSP), which is updated each year.

The earliest cases that influenced the hierarchy happened before the beginning of the 20th century. *McPherson v. Cameron* (1868) is seen as the earliest reference in Canadian case law in regard to the Hierarchy of Evidence. This case is specifically regarding the description of land on a deed, and the discrepancies between the textual distance description and the actual natural boundary that is referenced in the deed (in this case a beech).

This case is influential because it establishes that the natural boundary is held as a higher piece of evidence than the “course and distance”. In applying this ruling, Dodd J. notes that it is a general rule to accept evidence that man is least likely to mistake, and in this case the distances and course are more likely to be mistaken than the deeds description of the beech as being the corner of the lot (*McPherson v. Cameron*, 1868).

The importance of this in terms of the debate over coordinates, is that coordinates are derived from distances and bearings from known points¹¹. It can then be inferred that there exists a great potential for human error in a coordinate, then something that is tangibly on the ground. As such there needs to be an imperative on creating methodologies in practice to assist in eliminating the potential for simple human mistakes to manifest in the use of coordinates as legal evidence.

Lambden and de Rijcke discuss this concept in the boundaries chapter of Survey Law in Canada¹². The note that the “order of reliability” in evidence as it pertains to the location of a boundary is a result of the court’s interpretation of the thing (evidence) that is least likely to be found in error. Thus, the courts effectively apply weighting of evidence, in which the human component of error and the probabilities of errors are the considerations applied in assigning the weight. They also note that the general understanding is that the second place is for monuments from the original survey, and the fourth place is for measurements.

¹¹ These known points are often Monuments or Features on the Earth

¹² de Rijcke & Lambden (1989) refers to *Greenleaf on the Law of Evidence* (16th Edition, 1896). Of important note is that the accepted common law principles as it pertains to the order of priorities for evidence takes off from the *McPherson v. Cameron* case, and repeats its tenement of “give the most effect to those things about which men are least liable to mistake.”

South Australia State v Victoria State (1914) is an important case of note, because it is referred to in a variety of judicial decisions and in legal analysis of the topic of survey law. It provides excellent commentary on the perspective weighting that must be applied to applicable survey precisions of the time in defining a boundary¹³. Furthermore, it provides context in relation to affixing of a boundary in time, and how these boundaries are not intended in the eyes of the law to be a continually evolving legal fight as future and more accurate survey methods may provide variable interpretations of said boundaries. This basically affirms the common law ideal of occupation, in which if the boundary is agreed to and occupied to, then it should not be upended by future litigation in subsequent decades.

Another influential case in terms of the hierarchy is *Cain v. Copeland* (1922). In this case, the debate was over the position of a fence line. The fence line was built to a monument that was in fact placed in error. However, it was held that it was an original monument since there was no evidence of fraudulent placement. This resulted in two quarter sections not being the representative area as noted on the plan. The restored position of the original monument was to be held over that of the area and plan distance.

This case is important in terms of survey evidence because it affirms that original monuments, whether found in good condition or properly restored govern, regardless of discrepancies with distances on plans. This precedent is further affirmed in *Kristiansen v. Silversen* (1929). These discrepancies were common during the setting out of the early townships and are a result of errors in the chaining measurement technology of the time. Furthermore, it brings into question the effects of coordinates being held as evidence (and referenced to monuments) in the long term as these reference monuments that tie the coordinates to the ground will be subject to drifting.

¹³ Basically, a boundary defined by the means of the day, that has been lived to for a great duration of time, is not considered to be in error just because more modern technology finds a discrepancy in the location. This interpretation is key to minimizing conflict, in that rehashing interpretations of boundaries every time the achievable accuracy of positioning technology increases is both impractical and illogical.

Hawkes Estates v. Silver Campsites Ltd. (1994) is relevant because it provides context of the courts view of the hierarchy of evidence in the *obiter dictum* of the Justice. It is one of the few instances in common case law that it is so clearly stated in a modern context. Previous contexts of these principles from the early 19th century do not provide the clarity of the differentiation measurements thereof. Hawkes does this. This affirmation of the hierarchy is later reaffirmed in case precedent in *Hegel v. British Columbia (Forests)* (2009).

Richmond Hill Furriers v. Clarissa Developments (1996) provides good context in the discussion of evidence and the hierarchy. In this case, the issue pertains directly to a variety of monuments on the ground and how they were built / developed to. The key perspective that arose was that unless the monuments in the ground are referred to in a plan of survey that is registered, they have no weight on the boundary and are simply intermediary work of the surveyor. It affirms that a monument is not given any legal status without the subsequent conveyancing of the land and registration of the plan.

Until the plan is approved, the monuments do not hold weight since they have not been put through the purview of the titling and registration systems review (auditing of the plan). As noted by de Rijcke and Lambden (1989), it is the legal sanction that creates a boundary, and thus for the monuments to be given a legal status, this registration of the plan and issuance of titles for the parcel described by the plan must occur.

Okanagan Radio Ltd. v. Registrar of Land Titles (1996) provides an interesting view as it relates to mathematics in the form of a plan being accepted as evidence. It is in British Columbia, and there is a different historical evolution to their land management and survey framework. However, its jurisprudence is still informative. In this case, the plan data is adhered to as a result of legislative failings of the Crown, and the court does not want to do the job of the Crown in fixing these legislative uncertainties.

As the legislation vests, the judge accepts the map data but notes that this needs to be readdressed by the legislature to fix said issues. A recent and relevant case to note is *MacKay v. MacKenzie* (2016) highlighting in a modern context how the courts view the surveyor's role in disputes over boundaries, and their quasi-judicial role in assigning an unbiased opinion based on evidence to this purview of boundaries.

Ultimately coordinates are still an uncertain legal area. There is yet to be litigation that cements any views of their veracity in determining boundaries. Lambert and de Rijcke make a specific note of this in *Survey Law in Canada* (1989) in speaking on mathematics reliability as evidence:

“Once an area is covered by control survey markers which are not disturbed, the measurements connecting these points and the parcel boundaries may assume significance as reliable evidence. (The writers hesitate to presume the views of the courts on the true significance).”

de Rijcke & Lambden (1989)

This section points to the direction that adoption of mathematical evidence has been ongoing, and these authors note the contention of trying to infer how a court would view such evidence. Even though this was written about three decades ago, it still points to a pertinent fact in the wholesale adoption of coordinates as evidence. The authors continue on to state:

“This situation barely exists in Canada and will not be a strong feature of the survey of parcels for many years to come until the full effect of properly administered survey integration policies are secured and, presumably, the whole concept of numerical definition of boundaries has been tested in litigation.”

de Rijcke & Lambden (1989)

The key here is that even as the modern practice of mathematics in surveying and the adjacent management of land have progressed, there still remains the legal questions of how a court would view this kind of evidence. Since 1989, the level of survey integration has drastically increased, especially with the use of modern positioning and mapping technologies (GNSS, digital photogrammetry, LiDAR, etc.).

Integration of survey boundaries for parcel mapping and cadastral management are common themes in modern cadastres. That being said the adoption of governing mathematical coordinates in lieu of a monument is still tempered in adoption. Without the legal purview and guidance, the full spread adoption of mathematics as evidence is stymied.

2.2.8 *Statute Law*

Statute law or legislative law from officially recognized governments is a key area of the framework that hems in land surveying. It is important to note that the general practices of surveying are often similar across jurisdictions, and specific nuances often arise from the means by which the government has written legislation. Commonalities are often present in legislation pertaining to surveying. However, the framework and emphasis can change.

In some cases, the requirements are set out in the act, while in different polities these may be performed in the regulations pursuant to the act. Furthermore, the means of statutory control over surveying is also a result of the number of times the legislation has been rewritten, i.e., historically older and more stable jurisdictions often have more revised legislation.

In Alberta, the practice of surveying is currently legislated through the Land Surveyors Act (R.S.A. 2000, L-3). This establishes the Alberta Land Surveyors' Association (ALSA) and sets out what the requirements are for the regulation and governance of the profession. It also establishes codes of conduct for practitioners to adhere to.

The Surveys Act (R.S.A. 2000, S-26) pertains to the requirements of surveying in Alberta. This includes establishing the office of the Director of Surveys (DOS) and outlining the duties of the Director. It establishes the Alberta Township system, a carry on from the Dominion Land Surveys, and sets out overarching requirements for surveys. The Land Titles Act (R.S.A. 2000, L-4) deals with the registration of land, and the interests therein. It sets specific requirements in regard to what must appear on a plan of survey, what documents must be submitted concurrent with registration, as well as the registers of land in the province.

The Surveys Act, Land Titles Act, and Land Surveyors Act are three key pieces of statute law that enact surveying in the province of Alberta. They are the foundation of the modern survey practice in Alberta, between establishing the land survey profession, survey specific requirements, and the land administration and registration of land. Further legislation that is pertinent to this discussion is the Public Lands Act (R.S.A. 2000, P-40), under which the scope of the Hybrid Cadastre is operated. The Public Lands Act (R.S.A. 2000, P-40) pertains to the management and allocation of interests on public land, and under the specific survey requirements for dispositions, the Hybrid Cadastre has been incorporated.

For a review of historic statute law that pertains to surveying in the Canadian confederation, refer to Survey Law in Canada (Canadian Institute of Surveying and Mapping, 1989), and specific statutes of the Queen in her Right in Canada.

2.2.9 Land Administration Considerations

Coordinates as evidence will affect the management of cadastral records and the registration of land products. It also provides a benefit in terms of governing coordinates that can be used for modelling cadastral interests. This chapter does not deal with coordinates as evidence in the context of land administration, i.e., the procedural and management of cadastral records. These are practical and management topics not within the scope of this thesis.

It should be noted that to provide clarity in modern instances, often coordinates are discussed in relation to their theoretical use in modelling scenarios for land administration. Initiatives such as 3D cadastre and Building Information Modeling (BIM)¹⁴ are examples of common areas in which coordinates are discussed. The key difference is publications in adjunct fields that incorporate coordinates primarily discuss how to use survey data to further assist in modelling and management of the digital/records side of the cadastre¹⁵.

¹⁴ A modern buzzword that has taken on renewed interest in recent years. The Royal Architecture Institute of Canada notes that the fundamental principles of BIM have been around since the 1970s (Royal Architectural Institute of Canada, 2021). Ultimately it is the culmination of other geomatics technologies and tools (such as GIS and surveying solutions) into a unified system to manage a buildings lifecycle.

¹⁵ In recent times there has been a great deal of interest in BIM and as a result of this there are yearly workshops at the FIG conference that bring together the various areas of Academia to discuss this emergent area of inquiry (International Federal of Surveyors, 2018).

Thus, when reviewing these materials, it is key to understand that the coordinates are a derivative of the survey process and are considered accurate. The scope of these initiatives does not relate to the effect of coordinates defining parcel boundaries on the ground.

2.3 Historical Mathematics and Boundaries

The use of mathematics in surveying, and the means and methods of measurements trace their roots back to the early days of humankind. BM Jones (1964) discusses this as being between 6000 BC and 4000 BC as civilization became more agricultural in nature, opposed to previous hunter gatherer styled society. He noted the limiting factors of land versus the growing population spurred the advent of land becoming a tangible commodity and put value on land in negotiations.

As this progressed, the need to define the land, such that encroachment would not occur, established the need to survey the land, convey this interest into textual or graphic means of reference, and register the parcel in a recording of land interests. Early plans and attempts to establish a quantifiable order to land date back to ancient times of the Fertile Crescent in Mesopotamia (Branch, 2014). Thus, the use of mathematics in defining the dimensions of physical parcels on the ground, and the interpretation of markers¹⁶ (monuments) that ground these measurements, progressed into a necessary practice in the early world.

These practices continued through the various ages (Greek, Roman, and Medieval, etc.) and progressed humankind's understanding of cartography and modelling of the land. The use of mathematics in defining land continued to progress until the times of the Domesday Survey in Norman England (1066); during which time the drive for taxes became an incentive of the state to allocate the land that the monarch ruled (Simpson, 1978). These initial attempts were fiscal registers, or as Simpson (1978) notes a "geld book" and did not incorporate any kind of precise geospatial data.

¹⁶ In these early days they would be stone markers.

Jordan Branch (2014) discusses the effect cartography (and by direct relation mathematics) on geographic conquest, and how advances in people's ability to model and frame the known world with the context of his surrounding changed geopolitical expansionism. The postulation he made was that as people were able to model the world, areas that were unknown to the cartographers became areas of conquest. Modelling and defining land became about money and influence, and the tangible ability to generate taxes from the land when it was registered. He makes a direct link between influences of cartography with subsequent exploration and conquest.

One of the first instances of a mathematical position (theoretical) being used to define a boundary between interests occurs with the Treaty of Tordesillas (1494). Under the treaty, a delimited position in the Atlantic Ocean, a meridian of longitude, was to divide the domains of the Spanish and Portuguese empires. Branch (2014) discusses the importance of this delimitation in relation to the time period, and how it changed people's view of how the world could be allocated. It is relevant because it was legally adhered to, even though no technology of the time enabled these early explorers to precisely determine the limits of the boundary, which proved to be transient¹⁷ in interpretation and retracement.

Further initiatives with mathematics in defining bounds of nations and spheres of influence came about as a result of *Mare Liberum*, and the concept of the cannonball-shot distance from land. This defined a rough boundary on the sphere of juridical influence of a state, and regions beyond this were considered common to all. These principles slowly progressed into treaties on the seas between nation states, which attempted to mete out by textual description the extent of their influence over the seas.

In recent times, with the United Nations Convention on Law of the Sea (UNCLOS), modern boundaries are affixed by mathematical projections from on land baselines¹⁸. These boundaries are often mathematical in nature at the point of intersection between zones of influence (i.e., 200 nautical mile limit of exclusive economic zone) and the high seas.

¹⁷ No fixed interpretation, especially over the years. One ship of sails retraces it through astronomical observations and may be a great degree different than the next ship.

¹⁸ Refer to the thesis by Neil Guy (2000) for more a detailed and substantive review of the history of the seas and the creation of UNCLOS.

Discrepancies of mathematical coordinate-based modelling continues to this day to result in conflicts between nation states as there are variable interpretations for what constitutes the boundary¹⁹.

From the earliest days to modern international treaties, the use and adoption of mathematical boundaries for delimiting spheres of influence has become widely adopted. It is only when the review goes into the more localized scenarios within nation states does the change in acceptance of mathematical evidence (coordinates) occur.

2.4 International Context

Internationally, coordinates have been used as evidence of survey boundaries in a variety of jurisdictions and scenarios over the years. In order to keep the scope of this review on point, only select international instances will be reviewed. These are chosen both due to the importance of the example, but also due to their similarly aligned legal framework and survey development. This review will pick up in the 19th century and continue into the 20th.

2.4.1 *South Africa - Learning from the Past*

South Africa has a long and historic nature when it comes to its development as a nation, and the adoption of mathematics as governing evidence. This comes from the complex nature by which the state of South Africa came into being; with competing colonial powers attempting to hold onto various areas in the not so distant past²⁰. As such South Africa enjoys both a Roman-Dutch and English common law background, based on the areas of colonial expansion. These different legal frameworks, and the legislative developments in these areas resulted in different thresholds for what was considered acceptable governing evidence over boundaries.

¹⁹ It should be noted that in some instances this uncertainty is used for geopolitical purposes as it relates to claims to territory.

²⁰ This history of land tenure is discussed in *Land Tenure in South Africa – Past, Present & Future* by B.M. Jones (Jones, 1964)

As the nation of South Africa coalesced, the divisions between these interpretations created a series of legal cases that pertained to survey discrepancies between plans and monuments. Barry (2004) discusses the use of mathematical evidence in the form of surveyor's diagrams being used in early South African jurisdictions as far back as the mid-19th century. Of note the Cape of Good Hope and Transvaal regions both at times in their past allowed for mathematical evidence on surveyor's diagrams to supersede monuments. This was a result of legislative initiatives that were later proven to be unworkable as a result of the conflicts they created in interpreting measurements (Jones, 1964).

The primary cases of note that highlight the issues surrounding the practice with mathematical evidence versus physical evidence are *Esterhuizen's Executrix v. Vermeulen* (1867-1868) in the Cape of Good Hope. In the Transvaal *O'Neil v. Colonial Gold Mining Company and Escombe* (1885), *Murray v. Opperman and Erasmus* (1904), and *African and European Investment Company v. Warren and Others* (1924). These cases are *Mutatis Mutandis* in regard to the fact that they all deal with mathematical versus physical evidence.

Barry (2004) provides in his Geomatica paper context for each of these cases, as well as relevant graphics of the situation on the ground. He has written on the topic of mathematical evidence in the context of these cases in his more recent ALS News articles relating to *Esterhuizen's Executrix v. Vermeulen* (2015) and *Murray v. Opperman* (2020).

Even though the jurisdictions are different, the key principle is that for a time higher weight was given to the surveyor's diagram than the actual monuments on the ground that were lived by. It should be noted that as a result of these legislative initiatives of the time, the view of the courts in South Africa seemed to be going in a divergent direction of that in Canada. South Africa was placing higher confidence in mathematics on surveyor's diagrams, while in Canada the courts were regulating measurements of record to lower evidentiary standings²¹.

²¹ Refer to de Rijcke & Lambden (1989) and the discussion as it pertains to Greenleaf's summary of late 19th century common law precedents relating to assessment of evidence.

As Barry notes these discrepancies between the two jurisdictions in terms of practice ultimately resulted in a Survey Commission being formed in 1921 to attempt to alleviate these issues (Barry, 2004). After this commission, national survey legislation followed which ingrained the principles of basing cadastral surveys on geodetic triangulation networks.

Further to this, Barry discusses how for a period in the 20th century, it was permissible for the Surveyor General to assign mathematical coordinates to a parcel corner (Ibid). This was not a commonplace practice of the era but shows the progression towards fixing boundary locations through coordinates and the greater confidence placed on coordinates in affirming the boundaries most probable position.

2.4.2 Australia – Legal Learnings

Australia has developed over the past two centuries into a jurisdiction with modern cadastral systems and management. However, this was not always the case, and early directions in the expansion and development of land influenced the means by which the cadastre has been created. First settlements of Australia occurred in 1788, and initial land allocation was done through a deeds-based conveyancing system that lends itself to that of general English law of the time (Dalrymple, et al., 2003).

This progressed in the early 1850s with the advent of the Torrens styled title registration system that looked to alleviate fraud and security issues surrounding deeds. Due to the similarities in Torrens styled title registration with that of Canada, Australia works well as an example under a similar juridical framework²². It is also a very relevant jurisdiction given the influential case law stemming from *South Australia State v. Victoria State* (1914) as previously discussed in section 2.2.7.

²² As it pertains to how land is registered and quantified. Even within Australia context there is a wide degree of variance in these principles, and they were adopted to suite the specific needs of the state/ territory. Williamson (1994) provides a well-rounded overview of the cadastral system within Australian.

The specific history of Australia's cadastral and land development will not be delved into here in detail. The purposes of this discussion is to review modern instances of coordinates being applied in the Australian cadastre, not to provide a substantive review of this jurisdiction. This occurs in the northern territory and is discussed in the recent report from the Cooperative Research Centre for Spatial Information (CRCSI) (Grant, et al., 2018). This report builds on previous work by Williamson (1996) on the concept of coordinated cadastres within the Australian instance.

In the northern territory, the legislation allows for coordinated survey areas, in which the boundaries are defined through delineation via geographical coordinates. These areas are under the direction of the Surveyor General. It should be noted that a key difference between Australia and the Canadian context is the means by which the legislation is written. In the Survey Act of Alberta, monumentation requirements are set out. In the Australian case, these standards are set out in regulations pursuant to the act, which allows for an easier means of streamlining and modifying practice.

2.4.3 *New Zealand*

New Zealand is a relatable jurisdiction in terms of survey practice, and there has been work done in recent times that highlights their advancement of cadastral initiatives as it pertains to coordinates. As noted by Grant et al. (2018) the Australian and New Zealand instances both operate on English legal systems, and a stable land administration that incorporates Torrens titling (*Ibid.*). This is akin to the Alberta and parts of the Canadian cadastral context. That is, derivative of English common law and incorporating a Torrens titling system.

New Zealand is important for context as it pertains to coordinates as evidence due to the physical considerations of plate tectonics and seismic activity (Pearse, 2000). Datum changes are amplified in tectonically active island scenarios and further highlight the necessity for time dated coordinates. To assist in dealing with the discrepancy between the New Zealand Geodetic Datum 1949 (NZGD49) and ground over time as a result of crustal deformations, New Zealand moved to the semi-dynamic datum New Zealand Geodetic Datum 2000 (NZGD2000) (Blick & Grant, 2010).

This incorporates a deformation model for the effects of crustal deformation and enables the generation of coordinates in real time with respect to the reference epoch (*ibid.*). Would it not be for this semi-dynamic datum, the coordinates referenced to control monuments in the ground would be subject to potential gross discrepancies. In environments with changing control networks, the ability to date coordinates and perform appropriate transformations is crucial. This enables the surveyor to bring historic coordinates to the forefront and apply them in modern instances.

Grant et. al. (2018) discuss and provide a metric for the different levels of cadastral scenarios. In this instance, the Hybrid cadastre would fall under Level 5 – Survey-compliant Spatial Cadastre. This is in relation to Grant highlighting in level 5 the coordinates that are “survey complaint” can be used informally in relation to the Hierarchy of Evidence. The divide between Level 5, and Level 6 – Survey Coordinate Cadastre, as Grant et. al. term it, is that coordinates have been adopted into the Hierarchy of Evidence formally.

He notes in his hierarchy of cadastral improvements that Level 7 is a Legal Coordinate Cadastre. The term pre-eminent legal status is used to define this concept. In relation to the management of public lands in Alberta it could be noted that this is the case. Grant notes that no Australian or New Zealand Jurisdiction has adopted this level of cadastral improvement. The Northern Australian territory fits into level 6, where coordinates do have a legal status in the Hierarchy of Evidence.

2.5 Federal – Canada

Since the use of coordinates as evidence is a modern and pressing topic in the surveying community, it is not surprising that their use as evidence has occurred in the federal setting. As it relates to international boundaries and the United Nations Convention on the Law of the Sea (UNCLOS), coordinates are used to delineate interests and zones of exclusion.

For interests internal to these boundaries and within a nation states Exclusive Economic Zone it is also common to use coordinates in defining interests, i.e., for offshore oil exploration interests. This stems from the impracticability of actually placing monuments that are retraceable in the marine cadastre²³.

Offshore leases under the discretion of Canada lands are not physically monumented in the ocean. Rather they are made by coordinates, which are also referenced by offset to grid sections for the bore center. These bore centre coordinates are further references by triangulation to other fixed on land points. It should be noted that in more modern plan instances, a boresight diagram is included to show the location of the GNSS receiver on the rig platform in reference to the well centre.

These kinds of plans are similar to Hybrid Cadastre plans, with the exception being that there are no lease corners, just the location of the well centre since the well is in the ocean. Thus, it is coordinates in reference to triangulated reference evidence, not dissimilar to how Hybrid Cadastre requires Reference Points (RPs) to integrate the plan into cadastral mapping. These also include in instances grid baselines from the GNSS observations, similar to the principles Barry discusses in stating that coordinates are simply topological vectors between reference points (Barry, 2019).

In terms of international boundaries, the use of mathematics is pragmatic in defining interests across vast areas of ocean. That being said, the requirements to hinge and be able to validate these mathematical delineations, and the interpretations of treaties that define spheres of influence between states, is critical. The application of mathematical geometric solutions and a half effect line off of the coastal baselines is highlighted in the Gulf of Maine case between American and Canadian interests (Delimitation of the Maritime Boundary in the Gulf of Maine Area, 1984). It validates the application of mathematical solutions being able to delineate contentious boundary issues between nation states, i.e., offshore fishing interests.

²³ The concept of the marine cadastre as discussed by Barry et. al in (2002) as it relates to defining interests in the oceanic environment.

2.6 Local – Alberta

The cadastral framework that Alberta currently enjoys is a complex one, which has adapted to stimuli over the past century and a half. The practice of establishing cadastral boundaries and the legislative requirements on this practice are greatly influenced by the historical land management practices of the previous century. Therefore, in order to provide a detailed analysis of the influences of these previous land management practices, a historical review of the influences of the Alberta cadastral framework is necessary. The primary focus will be mathematics, and the role it has and currently occupy within the cadastre as it relates to survey practice²⁴.

2.6.1 *Early Dominion Lands*

The foundation of this framework began before Alberta was formally a province and was still inclusive to Rupert's Land. It began in 1869 with the First Survey of the Dominion Land Surveys (DLS), which started just west of Winnipeg (McKercher & Wolfe, 1986). These surveys were intended to establish a township grid system over Rupert's Land such that settlement could begin moving west through the allocation of land.

This township system was established by using both meridians of longitude and baselines established along parallels of latitude (Larmour, 2005). On April 14th, 1872 the *Dominion Lands Act* received royal assent, and surveying of the western Canada became formalized (Regehr & Yarhi, 2017). There would be five surveys in total, of which the Third Survey is considered the most relevant to the Alberta cadastre. The framework that was typical for this system of survey and the positions in which the monuments were placed are outlined in Figure 2.

²⁴ For a substantive review of the historical law and practice of surveying in the Alberta cadastre, refer to McEwan (2007).

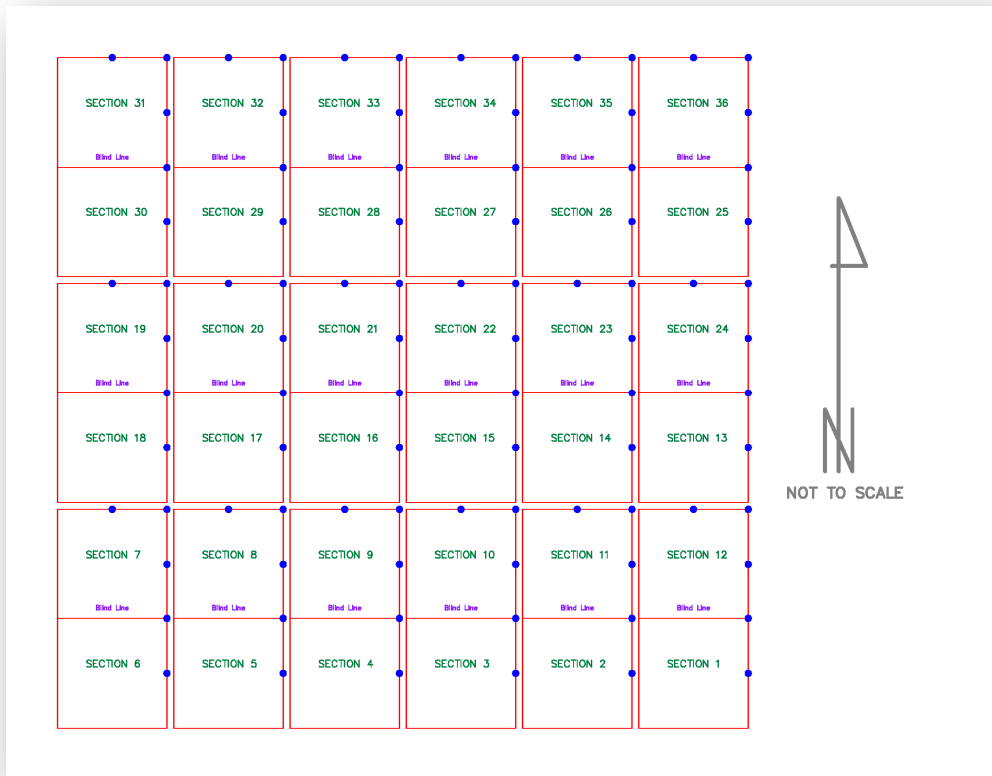


Figure 2 – Typical Township Monumentation under the Third Survey of the Dominion Land Surveys

Since monuments were not placed at all the boundary corners, some of the positions rely on the mathematical plan data between adjacent monuments on the same boundary. This plan distance is subservient to the distance between the original monuments in good condition²⁵, and as a result of the era of their survey these can vary considerably²⁶. Thus, these locations are in effect delineated on a plan, and established by a relationship to mathematical distances between adjacent reference monuments.

²⁵ Assuming they are undisturbed, in good condition, and a practitioner accepts them.

²⁶ A result of the measurement technologies of the time, transit and chaining which can produce significant errors. Furthermore, discussions from historical reviews of the field notes of this time don't provide clarity in all scenarios of what was actually put in the ground for a monument (i.e., even though there is Bulletin 38, there can be variability) (Alberta Land Surveyors' Association, 2015).

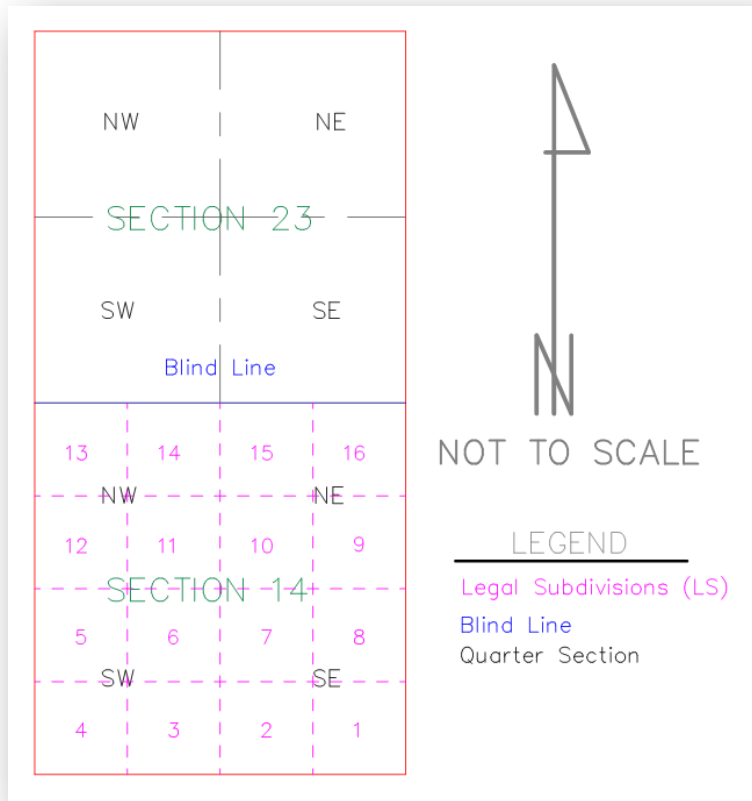


Figure 3 – Quarter Sections and Legal Subdivisions of Sections under the Dominion Land Surveys²⁷

Subsequent surveys of lands surveyed under the DLS system were subject to federal practice guidelines. Once the township and section framework were established, subsequent development included re-divisions into quarter sections, and legal subdivisions (LS) of said quarters. This occurred throughout subsequent decades and human development. Upon becoming a province, Alberta incorporated surveying into its own jurisdiction through statute. This resulted in changes to the means by which boundaries were established from a requirements standpoint. The most notable of these changes in terms of mathematical evidence was the advent of the Block Corner era of subdivision establishment.

²⁷ Adapted from examples provided by McKercher & Wolfe (1986).

During the Dominion Land Surveys (DLS), the concept of the blind line, which consisted of the abutment between north/south sections where there was not a township road established. This is shown in Figure 3 as the blue line between sections 14 and 23. Early surveys did not place monuments at these North Quarter section positions. It was not until 1915 that the practice of monumenting the centre of the section on a blind line (i.e., the north quarter boundary of the southern section) became standardized.

Since the development from the initial surveys west until 1915, a large area of the country was established without centre of section monuments. As such in modern times it is not uncommon to be working in a township that did not have the centre of section monumented in the original setting out survey. That being said, subsequent work by future surveyors often requires that this position be demarcated.

It should be noted that the subsequent demarcation and registration of a plan by a later surveyor showing the centre of the section theoretically governed the position but is constituent of that surveyor's opinion of the position. Since the boundary was never lost in time, these interpretations can be tested in scenarios where large mathematical deflections can occur. It is for these reasons that later in time the Alberta Land Surveyors Association introduced a practice review board bulletin that relates to how to establish the centre of a section.

2.6.2 *Block Corner Era*

This began on February 16th, 1912 and changed monumentation requirements to only require the corners of the block, deflections, and start and end of curves being placed (Government of Alberta, R.S.A. 2000, C. S-26). Lot boundaries between these monuments would be governed by the block corners, and subsequent re-establishment and retracement of these corners would occur through mathematical proportioning of the on-the-ground distance. Prior to this, the practice of defining individual lot corners was to use wooden posts as monumentation, which can still be found to this day in certain surveys in central downtown Calgary neighborhoods. In these pre-1912 instances, wood posts were placed at all lot boundaries, and if found in good condition are still considered governing evidence.

The practice of posting block corners lasted until June 9th, 1988, at which point the requirement was for internal lot boundaries of the block to be monumented as well (Government of Alberta, R.S.A. 2000, C. S-26). This era is important because it further highlights how some positions are effectively mathematically governed, not by a coordinate, but by the distances and vectors between statutory adjacent monuments. In order to show a simplified example of a subdivision during this period, a rectilinear block subdivision is simulated in Figure 4 below.

The curve scenarios from this time period tend to be the most complex in terms of boundary re-establishment. Thus, these scenarios have been avoided to prevent the key tenements of the issue to be detracted from by using more complex examples. Figure 4 highlights the position that monuments were posted in standard scenarios under this time period. Boundary positions that lie in-between these monuments are determined from these block monuments and using the distances established on the plan. Since the monuments are subject to some movement over time, it is standard practice to proportion the distance found between these monuments in the field and the plan distance and equally distributing any differences across all the lots that use these monuments.

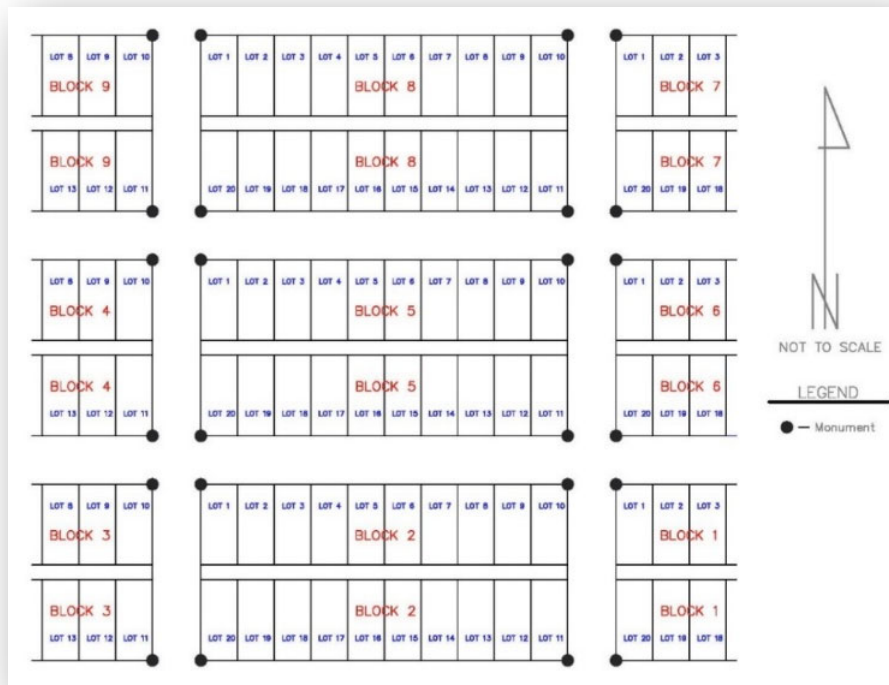


Figure 4 – Typical Block Evidence Monumentation during the 1912-1988 Period of Residential Surveys

Overall, it appears to be a fairly robust system during the initial setup of the block, however having to work with this framework over extended periods of time have highlighted some of the difficulties with this form of boundary establishment. Over time, these block corners go missing, and as a result of specific practical considerations are not often replaced or required to be restored during a municipal survey, with the exception being in the cases of a legal plan registration. In an ideal scenario, traces of the original evidence are available, and the monument is able to be restored in its “original” position.

This is not always the case, and in instances where no traces are found, or a monument is disturbed, a re-establishment of the monuments position is required. Often during the practice of retracing a boundary in this scenario, a surveyor has to go further and further away from the original block to find original governing block corners to base the proportioning on. This leads to a greater amount of surveying work in the long run, whilst if a higher degree of monumentation was required during this time, the surveys could be more streamlined over the decades.

For the most part, surveys that do retracements of cadastral boundaries on plans from the block-corners-governs era ultimately do not find all the block corners. It can be noted that the maintenance of this block framework is only a requirement under current practiced standards when a legal plan is registered, and as such when other municipal products like Real Property Reports are performed, the cost metrics of these kind of surveys dictate that restoration of block corners is not possible.

Furthermore, since the Real Property Reports (RPRs) are not a legal product, and not registered at Land Titles²⁸, there is no oversight to ensure that the cadastral framework is maintained in a manner that akin to registered plans²⁹. A simulated example of the type and amount of legal evidence in the form of statutory monuments that one can expect to find during a block corners retracement is shown in Figure 5 below.

²⁸ They are not under the scope of the Alberta Land Titles Act (R.S.A. 2000, L-4).

²⁹ Registered plans are subject to scrutiny by Land Titles Officers as set out by the Land Titles Act. These officers look for compliance with both the Land Titles Act, as well as the Surveys Act (the legislation cross-correlates).

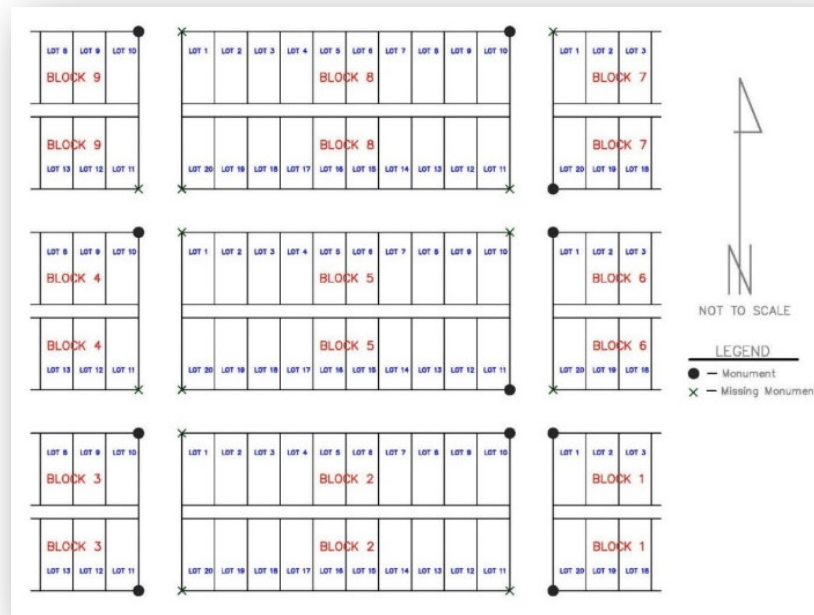


Figure 5 – Example of Typical Evidence found presently in 1912-1988 Block Corner Subdivisions

The figure highlights the principle that surveys that occur on land established under these block corner plans ultimately becomes an instance of the “law of diminishing returns”. Basically, the further you go out from the block you are surveying in, the less reliable the evidence is in re-establishing the most probable location of the lost monument. This is partially a result of survey precisions of the era, as well as the potential for crossing plans that integrate together. Of equal importance is giving a valid consideration to the precision capabilities of survey measurements at the time of the survey that placed the original monuments and weighing this into the evidentiary assessment on sparse scenarios over great distances.

There is a variety of scenarios in which a land surveyor may be required to retrace and mark out the location of the boundary of a lot under the conditions of missing monuments. These can include surveys for the valuation and sale of property such as Real Property Reports (RPRs), as well as instances occurring in the event of clarification of the boundary being required between owners through a property line stake out.

In both instances, a surveyor would be required to find enough governing evidence from the original plan that created the title to define the boundaries therein described. Ideally, the block corners of the original block still exist in an undisturbed manner and can be observed and used to establish that proportioned epoch of the distance between these monuments as established by comparing the distances represented on the plan and the real-world measurements at that time³⁰.

This is necessary to equitably handle the slight movements of these artifacts (monuments) over time so they do not negatively impact boundaries between neighbours and ensure the promotion of stable boundaries. Small relative changes can be placated by the public if they do not have a significant or consistent nature of being re-litigated or debated over time. During this period, the use of block corner monuments and their interpretation as governing evidence for these plans in practice is guided by the Hierarchy of Evidence as defined through common law jurisprudence.

Only monuments that are referenced on the plan and used during its subsequent registration with land titles are given the highest degree of “governing” status in terms of the Hierarchy. Often during this period, shorter lot bars were used to define the lot line positions between block corners during construction, however it is instructed in practice, and through interpretation of the hierarchy that these are not to be granted the same weight as original monuments. They are instead to be viewed as supporting evidence that relates to the history of how the developments on the specific parcel were put in place³¹. This difference in interpretation is a result of what was legally applicable as a statutory monument during this period and aligns with the discussion in *Richmond Hill Furriers v. Clarissa Developments* (1996) surrounding demarcation through monumentation and subsequent plan registration being requirements of validated monuments.

³⁰ Proportioned epoch is used here to represent the proportioning between the two monuments at the given epoch in time they were found. One of the problems with these Block Corner era surveys, is that subsequent developments on the same block over decades can find differences in the distances between these monuments (as they shift over time).

³¹ Where the lot bars are is where that time period viewed the property lines. These can be informative for the intent of fence lines if they are brought into question at a later date by newer development.

Two simple instances of retracing the boundaries of Lot 7, Block 8 of the specific theoretical plan are outlined in Figure 6 and Figure 7 below. Figure 6 highlights the instance that is ideal, in which all the original block corners for Block 8 are still intact and in good condition. These are then used to proportion the distances between them to establish the respective distances between lot lines along the frontage of the block. In these proportioning scenarios, roads and lanes are held as fixed.

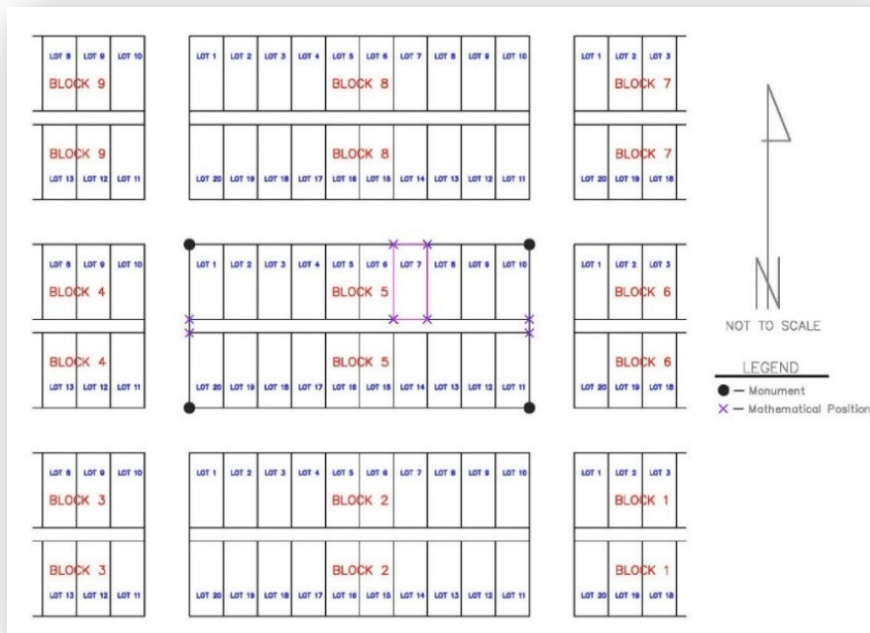


Figure 6 – Retracement of Lot 7 Boundaries Example (Ideal Scenario)

Figure 7 highlights an instance when only some of the original block corners are located, and the surveyor is required to do a more extensive search of the surrounding blocks evidence. The assumption under these scenarios is that these blocks were all set out on the same original plan registration. Under this scenario, some re-establishment of the most probable location of the original block corners is required. The location of the missing block corners at Lots 10 and 20 of Block 5 must be re-established prior to proportioning of the lot lines. In this example, this would be done from the adjacent found monuments in Block 2, 4, 6, and 8.

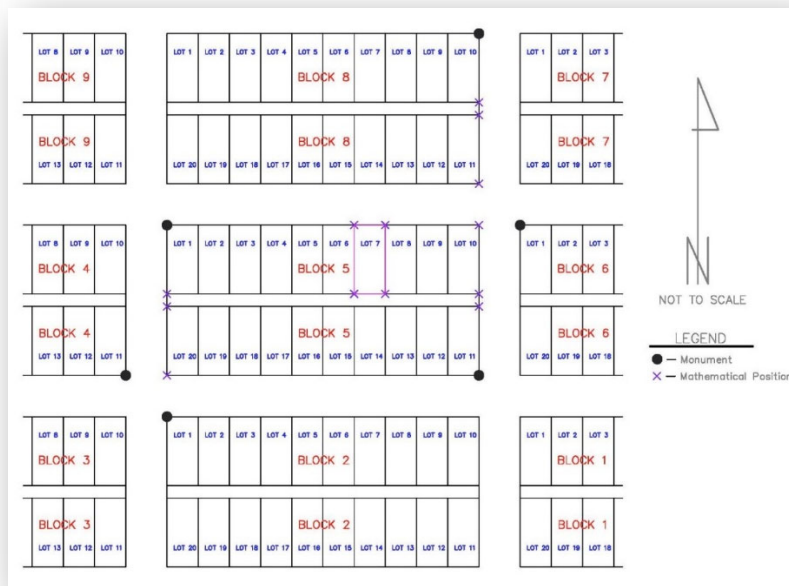


Figure 7 – Retracement of Lot 7 Boundaries Example (Alternate, Less Ideal Scenario)
 In Alberta, there are existing neighbourhoods where a substantial percentage of the original monumentation has been decimated over time. In these scenarios, often complex issues and creative solutions arise when attempting to retrace and re-establish boundaries. In extreme scenarios, neighbourhoods may need to be resurveyed as per the provisions of the Surveys Act (R.S.A. 2000, S-26) and through the direction of the Director of Surveys³².

These scenarios require the Hierarchy of Evidence to be closely applied, and sufficient weight given to the occupation nature of physical residential developments in securing boundaries. Re-establishment solutions in scenarios of constrained degrees of physical monumentation should ensure not to artificially create land disputes through trying to adhere to the most technical answer from the available evidence. Sufficient weight should be given to existing boundaries that are lived to through occupation and the physical improvements that represent this peacefully coexistence, fences.

³² Director of Surveys duties as set out by the Surveys Act.

Modern solutions should not attempt to use the historical plan data to a degree that would imperil this balance and upset the interpretations of these boundaries that have not been lost. In extreme scenarios, fence lines may no longer represent that interpreted legal boundaries between the lots, and whole neighbours could require easements of encroachment from neighbour to neighbour to resolve such situations.

2.6.3 Delayed Posting Plans

A substantive change in terms of evidentiary requirements happened during 1988 in Alberta. Changes to the requirements for establishing legal boundaries under the Surveys Act³³. Section 45 consisted of a requirement to effectively demarcate every boundary location with a statutory monument (Government of Alberta, R.S.A. 2000, S-26). This was potentially a result of some of the cadastral uncertainties that occurred during the previously discussed Block Corner era, as these pieces of evidence aged, were disturbed, or wiped out over the successive decades.

There was a greater focus on security of tenure moving forward in subsequently developments, however, the cost for monumenting these new survey products was indeed greater. This era caused some concerns regarding large subdivisions and the requirement to post monuments prior to registration. This resulted in entire areas, in which a substantial degree of monumentation would be disturbed prior to the completion of the development.

Subsequent work in these areas becomes difficult from a practical sense. When monuments were placed to define lot boundaries they would often be disturbed by construction and have to subsequently be fixed. Often the cost of proving and fixing these errors in subsequent survey work was not feasible, especially under products such as RPRs. These do have to be fixed in scenarios of legal product registration, such as a plan that would have to go to land titles. Thus, during this time, there was greater certainty in monuments remaining, however those monuments that remained were often disturbed. Furthermore, they often required more extensive and exhaustive evidentiary field searches in order to obtain enough valid evidence to interpret or retrace a boundary.

³³ Difference between Surveys Act 1980 and Surveys Act RSA 2000.

These factors made it more common for practitioners to use Section 47 plans, which allowed for the posting of internal boundaries to be delayed until after the majority of the earthwork was completed (Government of Alberta, R.S.A. 2000, S-26). This type of survey product proved beneficial in large scale multi-year subdivision projects as it alleviated monument destruction throughout construction. Under Section 47, the external boundary must be monumented and registered sufficiently, however the internal boundaries are able to be established by coordinates for a period of time. Generally, this is one year from the initial registration of the product. However, in extenuating circumstances a variance can be applied to allow further time.

Under this product, the coordinates effectively govern these internal boundary locations, however, they have a time limit. Eventually, they must be replaced by a monument or at least attempt to be replaced. It is common in these types of developments to find some positions unsuitable for the placement of a monument due to utilities or other obstructing infrastructure. These are often then established through offset forms of ancillary monumentation such as lead plugs and drill holes.

2.6.4 *Hybrid Cadastre*

The most recent initiative in the adoption of coordinates as evidence is the Hybrid Cadastre. It represents the first time that coordinates have been able to “govern” the position on a legal survey boundary, potentially forever. . This change is a result of the years of pressure from the industry to allow the adoption of coordinates given the progressive advancements in measurement technologies and the repeatability thereof. For the purposes of this thesis, the specifics of the various versions of the Hybrid Cadastre will not be delved into as it relates to technical details, rather the overall effects of imparting this higher legal weight on coordinates as evidence will be discussed³⁴.

³⁴ The focus is hinged on the concept of coordinates as evidence governing, not the minutiae of the practical requirements and how these have changed between successive versions. The overarching principles of allowing coordinates to govern boundary locations has remained consistent.

As defined in the Hybrid Cadastre Standards for Public Land Disposition Surveys (2016), the Alberta Hybrid Cadastre (HC) is a policy that governs the surveying of public land dispositions on crown land through the incorporation of coordinates as a form of evidence. This form of cadastre has been classified in the definitions provided by the standards as a form of coordinate-based cadastre, in which positions of legal boundaries are determined through both coordinates and legal monuments.

This is a transition from the wording in the initial standards (published April 1st, 2016), which indicated that the Hybrid Cadastre should be referred to as a “blended cadastre”(Ibid.). It should be discussed that between the first edition (April 1st, 2016) of the Hybrid Cadastre standards, and the most recent update (version 2.2) on November 5th, 2020 (Government of Alberta, 2020) there have been some changes in terminology and practical requirements.

Early instances of the standards had higher integration and intersection requirements, which in more recent versions have been alleviated. These were common areas of concern that arose from the key informant interviews, and it shows well that the framework is adjusting to the practicing professional’s unique perspective of on-the-ground ramifications.

In this framework, there are three types of coordinates which can be incorporated into surveys of public land dispositions, which include Establishment Coordinate (EC), Re-establishment Coordinate (RC), and Observed Coordinate (OC) (Government of Alberta, 2017). Each of these types of coordinates has its own unique purpose and correspondingly different requirements and instances of applicable use.

Establishment Coordinates are defined under the standards as a coordinate that can govern the location of a public land disposition boundary (Ibid). This coordinate governs this position until such a time that monument is placed to demarcate the boundary location. It should be noted that there is no time requirement to the demarcation of these coordinates. This appears to be a practicality measure, granted the standards only give permission for the use of Hybrid Cadastre survey plans of crown lands often in un-surveyed territory.

The other two forms of coordinates that are defined under the Hybrid Cadastre, Re-establishment Coordinates and Observed Coordinates, are not granted authority to govern the position of a disposition boundary (Government of Alberta, 2017). Re-establishment Coordinates are a modern approach to incorporating coordinates into re-establishment, and act only as that surveyor's opinion of the original monuments' location, and "does not govern the location" (*Ibid.*).

Finally, Observed Coordinates are a form of observation, which can only be provided on a plan for information purposes such as observations to existing monuments, and in instances of natural boundaries these provide temporal evidence of the location of the natural boundaries bank (*Ibid.*). These coordinates can in no way act as governing, and their use of evidence in natural boundary scenarios must adhere to the principles of establishing the movement of said boundaries.

In practice the hybrid cadastre allows for the majority of boundaries on plans to be established through coordinates, with integration requirements to an affixed number of ground control points³⁵. Essentially, the plan is tied to the survey fabric by these on the ground points, and should they be destroyed or go missing, subsequent issues can arise in practical retracement. In these scenarios, the higher integration and redundancy requirements as it pertains to intersection of adjacent development and survey evidence can assist in retracements of mathematical coordinates³⁶. A theoretical illustration of one possible scenario in which coordinates can be used to define boundary positions is provided in Figure 8.

³⁵ In the case of the Hybrid Cadastre, two physical monuments are required on Hybrid plans. Furthermore, there are requirements for the maximum distance these monuments can be from those plan positions established by coordinate.

³⁶ Under the earlier versions of the Hybrid Cadastre, higher integration requirements meant that more adjacent kinds of development (dispositions) were required to be intersected. This highlights an important concept in the beginning of any blended or coordinate based cadastre initiative. Until a sufficient densification of infrastructure (and plans defining infrastructure) is created, there needs to be a greater onus on integration requirements to ensure security of registered interests.

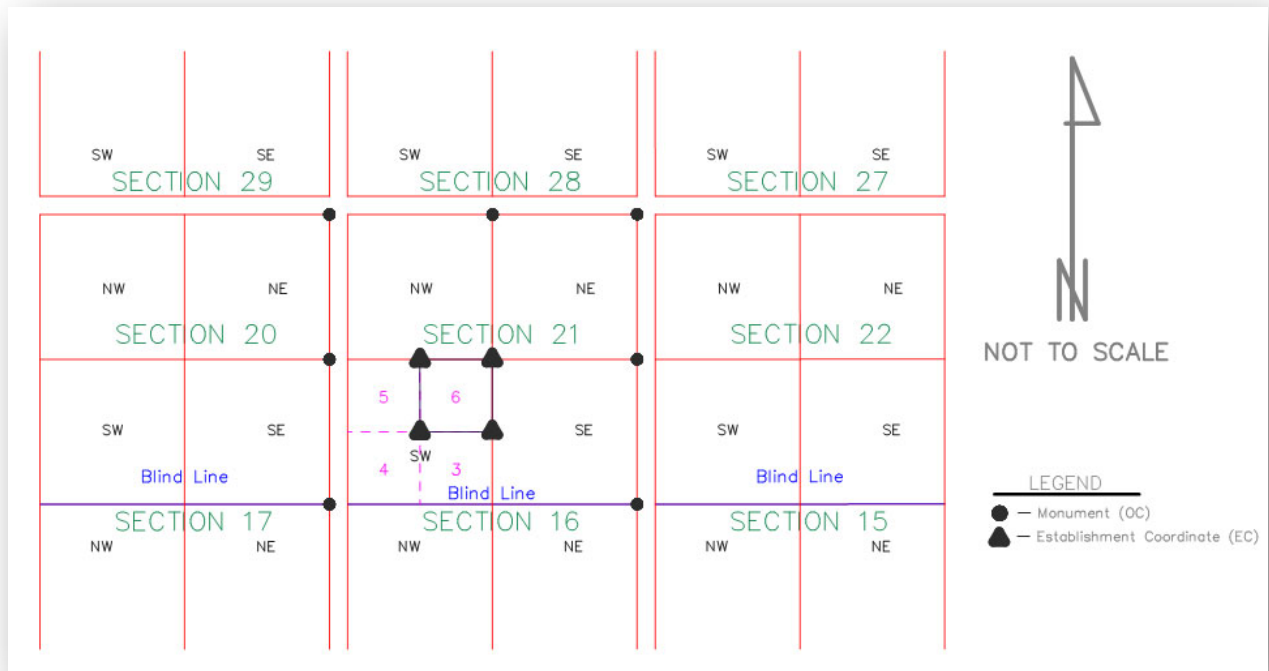


Figure 8 – Theoretical example of Establishing Boundary Positions by Coordinates

2.7 Summary

This chapter frames the meaning of coordinates as evidence and defines the various views of the cadastre from the perspective of evidence. It outlines the influential legislation, case law, and practical implications that effect surveying in Alberta, and the use of mathematical coordinates as evidence. A historical review of coordinates and mathematics in defining boundaries is included, and transitions into the modern technological sphere of surveying in recent times. Mathematical coordinates in the context of international boundaries, select international and federal (Canadian) instances, and provincial examples are discussed. Finally, the context of coordinates in the Alberta Cadastre is reviewed from its foundation to modern initiatives such as the Hybrid Cadastre.

Chapter Three:

Methods and Data

3.1 Introduction

This chapter presents the methods of inquiry into the central research topic of mathematical coordinates as legal survey evidence. The overarching hypotheses that guide the inquiry is presented and discussed in context. It provides a description of the data and sources incorporated into the study, including legal cases, statute law, regulations, and policy manuals. As discussed in the previous chapter, the current state of coordinates as legal survey evidence is not definitive and interpreted in a variety of means worldwide. To provide context of these interpretations in the Alberta scenario, semi structured key informant interviews are incorporated. A narrative analysis of the responses from the interviews provides emergent themes which are assessed using a 5-point Likert scale (Lalla, 2017).

3.2 Study Design

The objective of this qualitative study is to provide a practical context towards the topic of coordinates as evidence, and how they are perceived by those who practice in land. When the study began, it was guided by the literature review. Stemming from the literature review was a set of hypotheses that attempted to reconcile or test the research questions. These hypotheses ground the creation of the questions in the interview guide that was used in the key informant interviews throughout the study.

The study is a descriptive narrative analysis of the responses provided by the key informants in semi structure interviews. This descriptive analysis focuses on thematic identification of common attributes to the concept of coordinates as evidence (Riessman, 1993). These assist in the post-interview generation of emergent and relevant themes relating to the topic of coordinates as evidence within the Alberta context. A 5-point Likert scale assessment of these emergent themes against the interview dataset is incorporated (Lalla, 2017).

The sample size of the study was informed by both the depth of material to be covered and the depth of inquiry possible in a master's thesis. Michael Patton discusses how there is no fixed rule in qualitative research as it pertains to what constitutes a proper sample size (Patton, 2002). Rather, he discusses the variability of this determination in sampling based on the specifics of the study. For this study, a sample size of 20 was the initial expectation. This was informed by the specificity of the topic acting as a hindrance to participants as well as the short window of time that the Hybrid Cadastre has been in effect. The concern was that it would be hard to find practitioners that had performed these surveys.

The semi-structured nature of the interviews also informed this sample size since the expectation was that the interview guide would be a starting point for the discussion to begin from. This enables extensive and rich details pertaining to how coordinates as evidence are perceived and being used. Given that this research pertains to the Hybrid Cadastre and the recent practice of using coordinates as governing evidence under this, and that Alberta Land Surveyors' are the only ones allowed to produce a Hybrid product, the sample was geared towards discussing the initiative with practitioners.

The objective of the sampling was to achieve a diverse respondent set, and as such also looked for those willing to participate from adjunct realms such as academia, other jurisdictions of practice, public employees working for the government, and non-practice aligned affected parties such as landowners. There were no predeterminations in regard to the makeup of the dataset as it pertains to who the respondents were.

The incorporation of induction and a descriptive narrative method that is adopted in this research has been applied in the field of geomatics engineering by Jones (2017) in his Master's thesis. He builds on the method adopted by Barry (1999) in his Doctoral thesis *Evaluating Cadastral Systems in Periods of Uncertainty: A Study of Cape Town's Xhosa-speaking Communities*.

The inductive approach was chosen because of the complex nature of the problem of coordinates as evidence under the Hybrid Cadastre. Blackstone (2012) provides a good overall description of the process flow of induction in *Principles of Sociological Inquiry – Qualitative and Quantitative Methods* and is shown in Figure 9.

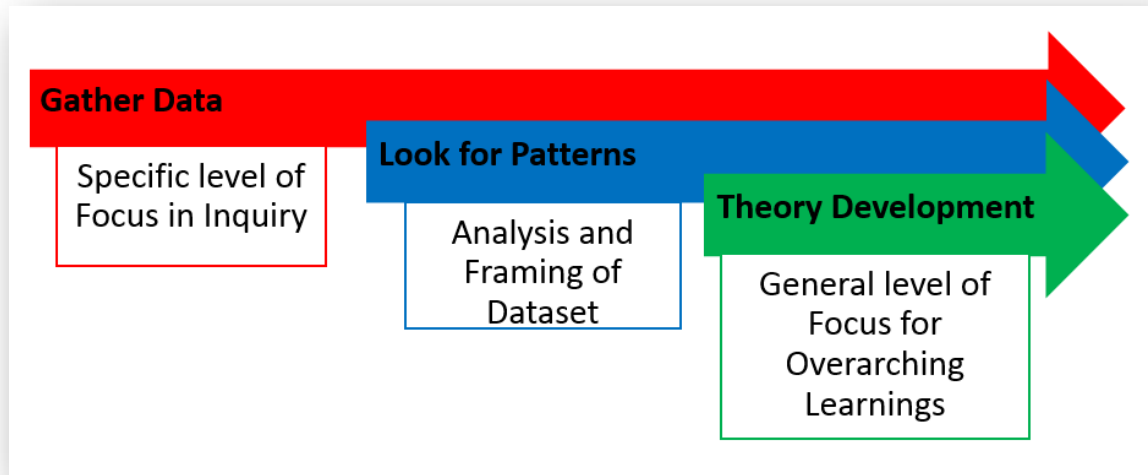


Figure 9 – General Flow of Induction³⁷

The initial hypothesis and research questions are intended to provide the information required to focus in on the topic of coordinates in practical surveying. For this study, the questions asked to the respondents were not varied as a result of insights gleaned from previous interviews, rather the sample set had a consistent pre-set interview guide as approved by the ethics³⁸.

Through induction, the data collected throughout the key informant interviews is analyzed for common patterns and emergent themes. Stemming from these themes, and the ordinal assessment of them against the data set, provides for an emergent set of propositions that assist in developing the theory of how mathematics as evidence can be applied as governing evidence over boundary locations.

³⁷ Adapted from Blackstone (2012).

³⁸ The exception to this is certain conjoined and group interviews, in which the questions were answered throughout the discussion, but were not done in a formal question and response.

A graphical overview of the flow of the research, from the start of the study (research question generation) to the conclusions is provided in Figure 10. The themes generated in the “Post Data Collection” step is indicative of the narrative analysis of the responses for key and common themes across the data set. The ordinal ranking in the “Results” step provides some level of quantification to the results so that an aligned or non-aligned position with the theme can be inferred.

This thesis uses the mean of the respondent’s ordinal rankings to calibrate the qualitative alignment between a respondent grouping and the themes. Standard deviation of the mean alignment of respondents to the themes is used to quantify the magnitude of disagreement of the participants within the grouping. A low standard deviation signals greater agreement between respondents and the mean alignment of the group. A high standard deviation signals greater disagreement between respondents and the mean alignment of the group. A higher standard deviation also signals themes that may need further inquiry and discussion to address divergent points of view on a theme.

This prescribed application of standard deviation to qualitative research contrasts with the use of standard deviation as a measurement of data precision in quantitative research. The qualitative characteristics of this dataset and the small sample size means that use of standard deviations for statistical testing of data distributions in this research would not provide meaningful results.

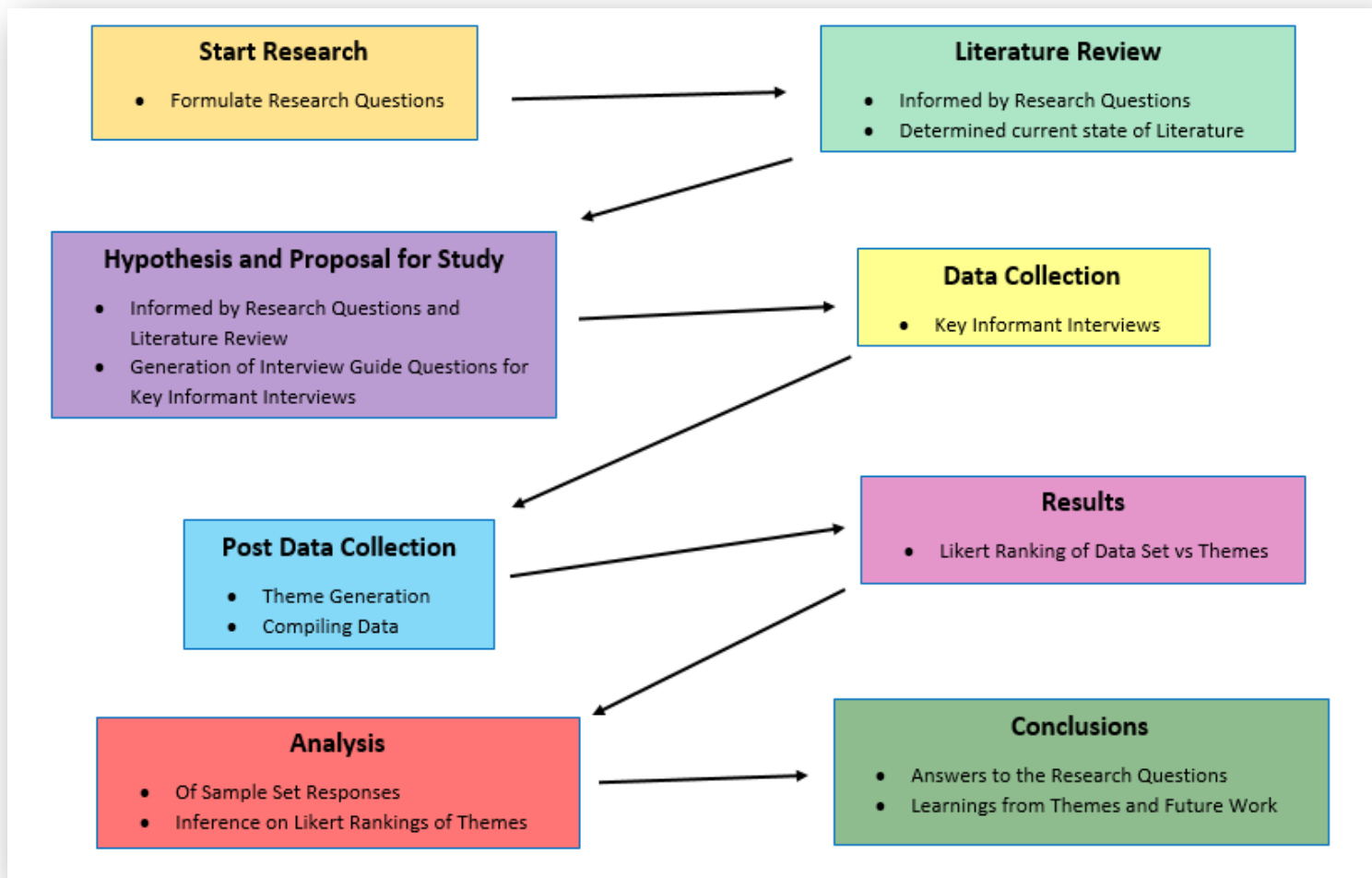


Figure 10 – Graphical Flow of Study

3.3 Triangulation of Analysis

A triangulation of the analysis of the key informant interview data with the case and documentary analysis provides a unique perspective on the changes stemming from the Hybrid Cadastre’s adoption of coordinates as evidence. This triangulation is outlined in Figure 11. The interviews form the qualitative portion of the triangulation, with the documentary review comprised of the statute law, regulations and policies. The case law is indicative of the juridical positions on the main topic, which is the veracity of mathematical evidence. This triangulation of insights gleaned from the interviews data with the historic positions expressed in the case law as framed by the documentary is elaborated on in section 5.6

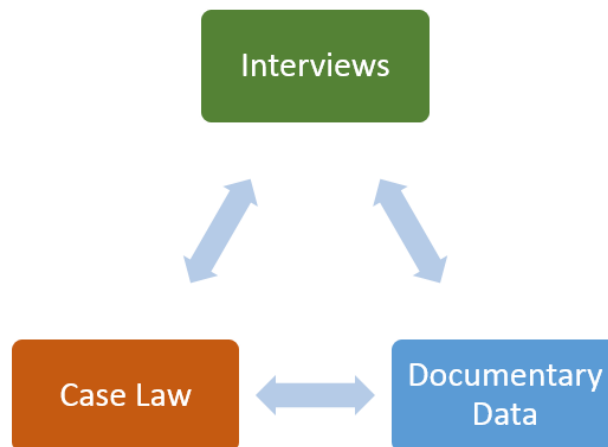


Figure 11 – Triangulation of Data

3.4 Data Collection Mechanism

The initial documentary data collection began prior to the ethics application. This guided the proposal and spurred the qualitative portion of the study. As the study progressed, this documentary data review continued in-situ with the key informant interviews. This allowed for context of the research interviews to be further guided by learnings from those previously interviewed. Ultimately, this provided a refinement to the focus of the study as it was being informed by pertinent perspectives from the ground.

Since the study took place over a longer duration, there have been successive revisions to many policy documents and regulations. These have been discussed in the introduction and literature review, which highlight the progression of the concept of coordinates as evidence in practice. The key informant data collection began in August of 2017 and progressed through and into 2018. Further follow up and clarifications of the transcripts occurred throughout the research period. The ethics approval is covered until July of 2021.

3.4.1 *Documentary Data*

The context of the research required a legislative review of the specific jurisdictions as it pertains to land surveying primary. Adjacent field of land administration, registration, and public governance touch on this area of interest. This review culminated in the literature review presented in chapter 2 relating to the topic of coordinates as evidence in pertinent jurisdictions. It is this review of literature that informed the scope and direction of the qualitative inquiry portion of the study. Furthermore, it provides insights into the current legislative framework in Alberta, and elsewhere, and how coordinates as evidence can be framed within these. The types of documentary data reviewed in this study are shown in Figure 12.

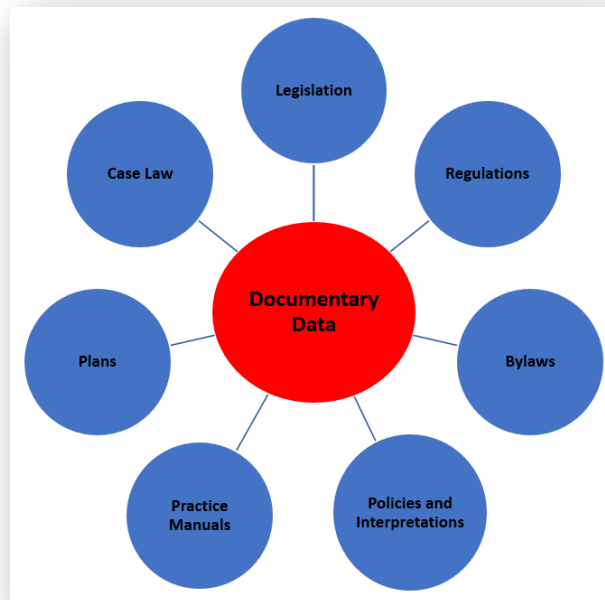


Figure 12 – Documentary Data

Documentary analysis included review of cases, case studies, and examples that provide context to the use of mathematical coordinates in defining survey boundaries. The substantive portion of this content is contained in Chapter two in regard to the cases stemming from case law. In terms of real-world examples, perspectives provided from some of the key informant interviews highlight the complexities in working with mathematical coordinates as “governing” evidence. The learnings from these case studies are presented in the results and analysis (Chapter 4), and discussion and synthesis (Chapter 5).

3.4.2 *Key Informant Interviews*

The research includes key informant participation to provide context of the new measures in regard to professional practice. Aligned with this is the procedural and day to day survey practice areas of concern that need to be reviewed. New procedures and checking processes are required for survey products, from field management to final plan drafting and implementation. The key participants consist of a diverse group of professionals. These include professional surveyors and engineers in a variety of roles. From private practice in municipal or oil specific divisions to those advising the implementation of the new initiatives. Furthermore, discussions with official offices and bureaucrats relating to these initiatives are included, as well as the perspectives of landowners.

There were 21 key informant interviews performed during this study. These occurred in professional offices across the province and included locations such as Canmore, Calgary, and Edmonton. The group was selected through initial invite to participate, as well as further contact at the recommendation of participants as the study progressed. Initially, it was hard to get participants to come forward due to the newer nature of the Hybrid Cadastre initiative. More detailed information pertaining to the key informant group, including quantitative statistics of sample is provided in section 4.2

As the study progressed, there was a greater interest of participants than the scope allowed for, and some degree of selectivity was required to ensure a balanced grouping. Initial preference was given to those responding to the initial call out, which produced about half of the expected participants (study sample guided to be around 20 informants). Final spots nearer the end of the field time were assigned based on availability and accessibility. At this stage, preference was given to government and alternate stake holders seeing as the initial call out resulted in a greater emphasis on land surveyor perspectives.

The outline of questions that guided the semi-structured key informant interviews is presented in the next section. It should be noted that this outline was intended to guide the interview, however in many instances acted as a primer to spur further discussion on the topic. The participants were only asked to respond to those questions that they were comfortable with.

3.4.2.1 Semi-Structured Oral Survey Questions

The interview guide of semi-structured oral survey questions is divided into two main topic areas: boundary theories and the Alberta Hybrid Cadastre. The boundary theories section of questions relates to the means by which boundaries have been defined traditionally and how a transition to mathematical evidence may affect security of tenure in this traditional setting. The second section relates directly with the Alberta Hybrid Cadastre and focuses on practical implications under this initiative.

Boundary Theories

- 1) *Describe your professional experience with land surveying for the establishment and maintenance of legal survey boundaries.*
- 2) *What jurisdiction do you practice in?*
- 3) *How are boundaries defined and maintained in your jurisdiction? Has this changed since you started?*
- 4) *In the jurisdiction of your practice, how is legal survey evidence assessed? How is mathematical evidence i.e., coordinates, interpreted in this evidentiary assessment?*
- 5) *For tenure security, do you believe that coordinates are equivalent, more than, or less secure than physical monuments?*
- 6) *Where do you view mathematical evidence or coordinates in the Hierarchy of Evidence in the current system?*

7) *Do you foresee any risks or benefits in terms of tenure security and legal status of survey boundaries in a transition to coordinate defined boundaries?*

Alberta Hybrid Cadastre

8) *Have you prepared and submitted Hybrid Cadastre plans under the Alberta Hybrid Cadastre?*

9) *Describe your experience with the plan requirements and submission process.*

10) *What are your thoughts on the survey requirements as set out by the Director of Survey for the Alberta Hybrid Cadastre policy? Are these sufficient? What might improve these standards?*

11) *Were the practical requirements that came out of the pilot project sufficiently informed and implemented in the resulting policy?*

12) *How has the initiation of the Alberta Hybrid Cadastre affected the management and operation of your survey practice?*

13) *What are your thoughts on the legal ramifications of the Hybrid Cadastre in the context of current statutory legislation?*

14) *In your opinion, what do you interpret monuments as under the Surveys Act?*

15) *Do you feel that case policy informed practice, or practice informed policy?*

3.5 Interpretation and Biases

The interpretive framework that will be applied for the qualitative analysis is that of a post positivist viewpoint (Creswell, 2013). This hinges on the perception that it is impossible to separate out biases when observing phenomenon, and as such the biases inherent from the research must be identified and discussed. In this research, the methodological approach to inquiry follows the graphical flow of the study as presented in Figure 10, and reviews each respondent's feedback through the ordinal alignment with the key themes.

Inductive insights from the respondent's feedback as it pertains to the topic of mathematics as permissible evidence are inferred and related back to the learnings from the literature review, i.e., the case law, and the current legislative framework. This stems on being able to approximate the position of a participant based on the feedback provided in their responses, even if a key word is not said, but other similar ones (and positions) are provided. Given the semantical nature of terminology in surveying, and without delving into discussions on each and every definition, some inferences must be made.

Assumptions in the framework are that views of the respondents are informed by their experiences, and discussions are kept to theoretical and higher-level topics surrounding the adoption of coordinates and the Hybrid Cadastre. Some procedural and technical scientific material and standards are discussed briefly, with the assumption being that the standardized practice of surveying is well understood, and the Hybrid Cadastre is new and still in a state of change.

Furthermore, the framework is hinged on the understanding that the topic of coordinates as evidence is at the intersection of legal, social, practical (surveying and engineering) fields of inquiry, and often key topics are ones in which there are grey areas in interpretation. In the case of social problems, these can include systemic and wicked problems aligned with the management framework of such initiatives (Kolko, 2012).

Biases inherent to the sample size (i.e., the statistics of the responses) are that the majority of the proponents are professional land surveyors, and as such the perspectives of the sample are heavily weighted towards them. Since the research delves into a topic that is directly in the scope of practice of land surveyors (as they are the only ones who can prepare hybrid products), it makes sense that their willingness to participate in the study was greater.

The bias stemming from the government participants is that they are often on the side of the initiative as it ties into their employment. These interviews are used for understanding the procedural and management decisions of adopting a policy that enables coordinates to govern boundary positions indefinitely and provide a rationale for the validity of their initiative within the current legislative framework.

The potential biases stemming from the landowner participants is that they are financially invested in the security of their boundaries. Furthermore, as is common with abstract topics such as establishment of legal survey boundaries and coordinates as evidence, it is only those who have been forced to delve into these topics that are willing to participate. Reasons vary, but often times landowners who have had issues with boundaries are more willing to discuss these topics. More importantly, because they have had to deal with them in the past, they are fairly well versed in the material and can keep up with the discussion.

Biases inherent in narrative theme generation are a part of any qualitative inquiry, with the researcher's perspectives. The researcher is an articling pupil with the Alberta Land Surveyors Association, and since he is not practicing, any biases related to the success or failures of these initiatives from a business perspective is non-existent (no financial ties to the initiative). The researcher's background is geomatics engineering and land surveying.

Biases inherent in the 5-point ordinal assessment of theme alignment are that of potential mis-ranking or misinterpretation by the researcher. The themes ranked using this method relied on the thematic narrative review, which provided key phrases and statements of the respondents. These key phrases and statements were correlated with the ordinal rankings, such that it was not the researcher's intuition applying the rankings, but the respondents' statements.

3.6 Hypotheses

The initial hypotheses stem from the original ethics approval and provide an early means of assessing the newly minted Hybrid initiative within the legal context of the Hierarchy of Evidence. This set of hypotheses was used to guide the generation of the interview guide and are discussed in relation to the results in Chapter Five.

Hypothesis 1:

Formalization of the Hybrid Cadastre in Alberta and the changes to evidence, specifically regarding coordinates, requires a change to the Hierarchy of Evidence to incorporate coordinates.

Hypothesis 2:

Formalization of the Hybrid Cadastre in Alberta does not require formal change to the Hierarchy of Evidence but rather a change in the emphasis on how coordinates are handled.

Hypothesis 3:

Formalization of the Hybrid Cadastre in Alberta does not require formal change or a change of emphasis from the perspective of the Hierarchy of Evidence in order to adopt the use of coordinates.

The premise of these hypotheses is to ascertain how the Hybrid Cadastre should be viewed in terms of the common law Hierarchy of Evidence. Since there is still an outstanding lack of review by the courts on this topic, as a result of no litigable avenues as it pertains to coordinates, and with previous views putting a narrow perspective on mathematics as evidence, there is a pressing need for the alignment of the respondents with these hypotheses.

3.7 Narrative Approach

The descriptive narrative approach incorporates the identification of common themes between the semi structured interviews (Riessman, 1993). These themes are analyzed with respect to the dataset using a 5-point ordinal scale to assign ordinal values to the responses (Lalla, 2017). The valuation is used to approximate the degree of alignment with a participants views and the common theme stemming from the overall dataset.

In this instance, a score of five indicates that the participant's responses strongly align with the theme, while on the opposing end a score of one indicates that the responses do not align with the theme. A score of four is indicative of a respondents position being slightly aligned, a three represents a neutral position, and a two is representative of being slightly non-aligned with the them. The themes that are assessed are emergent trends or commonalities across the dataset from the respondents and are informative of the practical implications of coordinates as evidence.

3.8 Themes

The emergent themes generated post-interview are considered the key areas of interest within the topic of coordinates as evidence in Alberta in context of the Hybrid Cadastre. These are outlined below, and in each case, what constitutes high versus low alignment with the theme is defined. This also allows for a rudimentary qualitative assessment of the themes to provide further learnings, which are discussed throughout the analysis in chapter 3 and synthesis in chapter 5.

3.8.1 *Coordinates as Governing Evidence*

The first theme concerns the concept of coordinates as governing evidence, i.e., being an acceptable form of evidence for legal survey boundaries. A high alignment (5) is indicative of the respondent supporting the concept of coordinates as governing evidence without reservation.

A ranking of slightly aligned (4) is indicative of respondents who support the concept of coordinates as governing evidence, practices and use coordinates, however, still generally prefers monuments in practice. A neutral alignment (3) signifies the respondent is somewhat supportive of the concept of coordinates as governing evidence but has concerns as it pertains to their widespread use and view it as more applicable to special scenarios. A slightly non-aligned (2) ranking is indicative of a respondent who is not totally against the concept of coordinates as governing evidence but would prefer to see a more solid groundwork in terms of legislation prior to adoption. Finally, a high non-alignment (1) is provided for respondents who do not support the concept of governing evidence and view the current system as sufficient.

3.8.2 *Coordinates and Tenure Security*

The second theme relates to the tenure security concerns stemming from the adoption of coordinates as governing evidence in lieu of monuments. The assumption in the context of this theme is that this would result in a lower density of monuments. A high alignment (5) is indicative of the respondent supporting the adoption of coordinates and does not foresee concerns relating to security of tenure stemming from this. A ranking of slightly aligned (4) is indicative of a respondent who foresees a few issues with tenure security relating to coordinates being adopted as evidence, but they are minor, and the benefits far outweigh the risks. A neutral alignment (3) signifies a respondent who foresees concerns with the adoption of coordinates as it pertains to tenure security, but it is not a deal breaker. They are minor and workable concerns. A slightly non-aligned (2) ranking is indicative of a respondent who does foresee risks with the adoption of coordinates as evidence as related to security of tenure, but if they are handled appropriately could prove beneficial. The adoption of coordinates as evidence is not completely objected, but there are significant concerns. Finally, a high non-alignment (1) is provided for respondents who foresees tenure security issues stemming from the adoption of coordinates as evidence that need to be alleviated prior to moving forward with this kind of evidence as governing.

3.8.3 *Coordinates as Monuments*

The third theme relates to whether the concept of coordinates as governing evidence can be treated the same as original monuments under the Hierarchy of Evidence. This stems from the Hybrid Cadastre policy, in which Establishment Coordinates are treated as monuments. A high alignment (5) is indicative of a respondent viewing coordinates and monuments as the same under the Hierarchy of Evidence. A ranking of slightly aligned (4) is indicative of a respondent who views coordinates as almost akin to monuments under the Hierarchy of Evidence and as a form of *de facto* monument. A neutral alignment (3) signifies that the respondent is not against an elevated status for coordinates but is not agreeable to the alignment of coordinates and monuments. They may serve similar roles in instances such as Section 47 plans. A slightly non-aligned (2) ranking is indicative of a respondent who holds a narrow view as it pertains to the alignment of coordinates and monuments under the Hierarchy of Evidence and would like to see judicial perspectives prior to working with them. Finally, a high non-alignment (1) is provided for respondents who do not view coordinates and monuments as the same under the Hierarchy of Evidence.

3.8.4 *Effects on Daily Practice*

The fourth theme pertains to the effects of the Hybrid Cadastre on the management and operations of the respondents' survey practice. The assumption here is that the advent of the Hybrid Cadastre has affected survey practice by requiring new methods and procedures, as well as implementation and testing thereof, to handle the H.C. products.

A high alignment (5) is indicative of a respondent who has had their practice impacted by the advent of the Hybrid Cadastre. This could include processes, training, and client relations. A ranking of slightly aligned (4) is indicative of respondents who have witnessed some impact on their practice as a result of the advent of the Hybrid Cadastre. A neutral alignment (3) signifies that the advent of the Hybrid Cadastre has had a slight impact on respondent's survey practice. A slightly non-aligned (2) ranking is indicative of a respondent who has not been overly impacted in terms of survey practice by the Hybrid Cadastre. Finally, a high non-alignment (1) is provided for respondents whose survey practice has not been impacted by the Hybrid Cadastre.

3.8.5 *Hybrid Cadastre within Current Legislation*

The fifth theme is related to participants' views of the Hybrid Cadastre policy within the current legislative framework governing the surveying of legal boundaries. The Hybrid Cadastre operates as a policy within the Public Lands framework and is administered by the Director of Surveys office. It does not affect lands that are privately held, and its adoption without changes to the surveys act pertaining to what constitutes a monument is the key point of contention.

A high alignment (5) is indicative of a respondent viewing the Hybrid Cadastre as fitting within the current legislative framework as it is a policy under the Director of Surveys direction. A ranking of slightly aligned (4) is indicative of a respondent who views the Hybrid Cadastre as fitting within the legislation for the most part with a few minor amendments required. A neutral alignment (3) signifies the respondent's views the Hybrid Cadastre as somewhat fitting within the legislative framework but could benefit from legislative amendments. A slightly non-aligned (2) ranking is indicative of a respondent who narrowly views the Hybrid Cadastre as fitting within the legislative framework and this initiative would benefit from legislative amendments. Finally, a high non-alignment (1) is provided for respondents who view the Hybrid Cadastre as not fitting within the legislative framework.

3.8.6 *Requirements of Hybrid Cadastre*

The sixth theme relates to the requirements set under the Hybrid Cadastre for practice and whether they are sufficient in establishing practice with coordinates. A high alignment (5) is indicative of a respondent viewing the requirements set out under the Hybrid Cadastre as sufficient. A ranking of slightly aligned (4) is indicative of a respondent who views the requirements set out under the Hybrid Cadastre as mostly sufficient and could use one or two revisions. A neutral alignment (3) signifies a respondent viewing the requirements set out under the Hybrid Cadastre as somewhat sufficient but could use a series of improvements. A slightly non-aligned (2) ranking is indicative of a respondent who views the requirements set out under the Hybrid Cadastre as barely sufficient and require systemic improvements. Finally, a high non-alignment (1) is provided for respondents who view the requirements set out under the Hybrid Cadastre as not sufficient for the intents of the program.

3.8.7 *Monuments under the Surveys Act*

The seventh and final theme relates to how monuments are defined and viewed by the profession under the Alberta Surveys Act. Monuments are defined under the Surveys Act as being something that physically marks the ground. A high alignment (5) is indicative of the respondent viewing that in modern times as a direct result of the increased confidence in coordinates through higher precision technologies, and therefore it is permissible to consider coordinates and monuments the same. A ranking of slightly aligned (4) is indicative of respondents who view coordinates as almost the same as monuments and view the adoption of the Hybrid Cadastre as being the driver for their widespread adoption.

A neutral alignment (3) signifies respondent's views on monuments as physical marks in the ground but who is open to the idea of coordinates holding an alternate monumentation status in the future. A slightly non-aligned (2) ranking is indicative of a respondent who still views monuments as physical marks on the ground; is amenable to coordinates adoption as evidence in limited circumstances currently. Finally, a high non-alignment (1) is provided for respondents who view monuments as physical marks on the ground, and coordinates do not fit this definition. If coordinates are to be used widespread in a manner akin to monuments, legislative amendments are required.

3.9 Ethics

This study received ethics approval on July 21st, 2017 from the University of Calgary Conjoint Faculties Research Ethics Board. The approval is attached in Appendix B – Certification of Institutional Ethics Review.

The privacy of the participants is paramount. The study asked in the consent letter for the privacy preferences of the participants. This included whether they wanted to be confidential, have their companies name involved and being quoted. The data was kept in an anonymized form, in which critical identifying information was removed. Study participants were given pseudonyms in the transcript generation to further protect their identity.

This study received funding from the Queen Elizabeth II scholarship, L.R. Dick Newby Award, and the Cadastral Research Chair at the University of Calgary. These forms of funding are not political in affiliations.

3.10 Summary

This chapter provides the overview of the methodology that is applied to assessing the data provided by the key informants, as well as presenting seven hypotheses. The study has been designed to provide a balance between the documentary perspectives of mathematics and evidence, that of the profession, and those who actually practice with this form of evidence on the ground. Ideally the results stemming from this will provide context on areas of concern in working with coordinates as evidence and provide recommendations and potential solutions.

Chapter Four:

Results and Analysis

4.1 Introduction

This chapter presents the research results. They are first presented in terms of the sample of key informants. The sample structure is discussed as it relates to the relevance it can provide to the research. The results stemming from the ordinal assessment of the qualitative data set are discussed, and an analysis of these results as it pertains to each of the key themes is presented.

Stemming from this analysis is key learning points and avenues for further research inquiry. These will be discussed in more detail in the synthesis and discussion chapter.

4.2 The Sample

The sample of participants for the study took place in Alberta, Canada. Key informants ranged from a variety of areas in the province. The researcher resides in Calgary, and there was a bias towards a greater number of participants from within the Calgary area. Participants outside the Calgary area were a result of recommendations from participants in regard to further potential participants that the researcher should follow up with. These recommendations related to pointing the researcher to practitioners that had experience with Hybrid Cadastre products. Seeing as the Hybrid Cadastre project is still in its infancy, it was difficult to find practitioners willing to participate, due to the fact that many had no practical experience with the Hybrid Cadastre products. The specific locations of participants across the province are outlined in Figure 13.

Overall, there were 21 participants, with six from Edmonton, twelve from Calgary, two from Canmore, and one from Grande Prairie. The Grande Prairie informant was the only phone interview and was a result of scheduling difficulties of travelling that far north. The remainder of the interviews were held in person. There were two separate trips to Canmore for late afternoon sessions and the Edmonton trip was able to be facilitated in a single day.

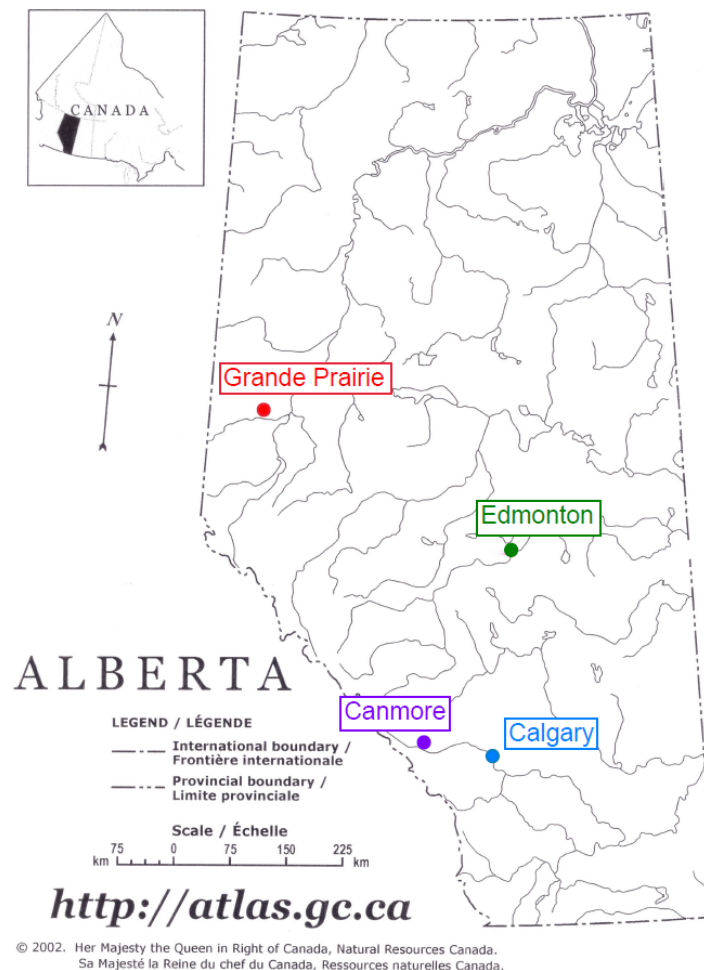


Figure 13 – Study Participant locations across Alberta including Canmore (2), Calgary (12), Edmonton (6), and Grande Prairie (1)³⁹

The specifics of the participants divided up by their grouping as it pertains to their jurisdiction, field of practice and the type of interview are outlined in Table 1. The participants were grouped into four primary categories for the data analysis. These included land surveyors, government officials or public servants, academics, and landowners. Overall, there were fourteen surveyor respondents, five government respondents, one academic respondents, and one landowner. The surveyors' interviews were the most structured and followed the interview guide question by the question. There were a few exceptions, where questions were missed and followed up on prior to the end of the interview or instances in which participants declined to respond.

³⁹ Modified for the purposes of this thesis. Sources from Natural Resources Canada (Government of Canada, 2021).

Table 1 – Specifics of Participants

Group	Number of Participants	Jurisdiction of Practice				Field of Practice			Interview Type		
		Alberta	Canada Lands	Alberta and Canada Lands	Not Practicing	Oil & Gas	Municipal	Not Applicable	Individual	Conjoined	Group
Surveyors	14	11	1	2	0	8	6	-	12	2	-
Government	5	-	-	-	5	-	-	5	-	-	5
Academics	1	-	-	-	1	-	-	1	-	1	-
Landowners	1	-	-	-	1	-	-	1	-	1	-

The participants in the study were practitioners across Alberta, Canada Lands, and those who practiced in both Alberta & Canada Lands. Those that were not practitioners in the land surveying profession were ranked as “not practicing”. There were eleven practitioners from Alberta, one from Canada Lands, and two from both Alberta & Canada Lands. Evidently, since this research is focused on an initiative that effects those practicing within Alberta, i.e., the Alberta Hybrid Cadastre, it follows that the greatest number of respondents would be practitioners from this jurisdiction.

The makeup of the participants field of practice from the key informant sample group includes those working primarily in oil & gas infrastructure, municipal surveys, or are classified as not practicing for the participants that are not land surveyors, i.e., academics, landowners, and government employees. There were eight respondents who practiced in oil & gas, six practicing in municipal, and the remainder were listed as not practicing. The oil & gas area of practice work more on un-surveyed territory, i.e., outside the boundaries of cities and the developed survey fabric, and in areas of resource and infrastructure development. These areas are often public lands and are allocated through dispositions. This aligns with the scope of the Hybrid Cadastre, i.e., public lands, and it is expected that this group is to have more experience with these products.

The municipal group are those who primarily practice in urban scenarios, and often are working on privately titled freehold land for residential, community, and infrastructure developments. These participants are not expected to have as much experience with the Hybrid Cadastre products as a result of these products not being allowed on private lands (i.e., lands not governed under the Public Lands Act (R.S.A. 2000, P-40)).

The approach to the key informant interviews and qualitative data collection was unique in that it blended an approach of individual, conjoined, and a group setting. These were done at the participants requests and provide critical insights into key themes of the research topic. As the research had difficulties getting participants throughout the study, any feedback, whether it be conjoined or group settings, was most welcome. There were twelve individual interviews, four conjoined, and five classified as one group.

The conjoined and group interviews were less structured than the individual ones and as such were more difficult to assess in the following quantitative data analysis of the respondent's feedback to the semi-structured interview guide. This is due to the fact that often questions were answered collectively by the multiple participants, or in cases where only one of the participants would respond with the remainder following their lead. In almost all cases, the questions were covered in entirety throughout the discussion, but not read out throughout with the normal query response decorum. This can be attributed to the conjoined and group settings making this style of back and forth response hard, given the variety of opinions and spurring discussion.

4.3 Results and Analysis

The ordinal 5-point assessment was performed on the respondent data set to provide a means of quantifying the respondents' views such that an approximation of the degree of alignment between the participants and the emergent themes could be established. The results from the 5-point ordinal scoring of the participants alignment with the respective themes is presented in Table 2. The average, median, and mode of the alignments are presented, as well as the standard deviations for each of the respondent groupings. An average for the respondent groups across the themes is also provided.

Table 2 – Average Ordinal Alignment, Median, Mode, and Standard Deviation of Respondent Groupings with Themes

Theme	Data	Oil & Gas Surveyors	Municipal Surveyors	Surveyors Combined	Government	Landowner & Academic	Total
	Size	8	6	14	5	2	21
Coordinates as Governing Evidence	Avg.	4.5	3.2	3.9	5	2	4
	Median	5	3	4	5	2	4
	Mode	5	3	3	5	2	5
	Std. Dev.	0.8	0.4	0.9	0	0	1.1
Coordinates and Tenure Security	Avg.	3.3	2.8	3.1	5	1	3.3
	Median	3	3	3	5	1	3
	Mode	3	4	3	5	1	5
	Std. Dev.	1.4	1.2	1.3	0	0	1.5
Coordinates as Monuments	Avg.	3.5	2.3	3	5	1	3.3
	Median	3.5	2	3	5	1	3
	Mode	5	2	2	5	1	5
	Std. Dev.	1.5	1	1.4	0	0	1.6
Effects on Daily Practice	Avg.	3.1	1.6	2.5	NA	NA	2.5
	Median	3	1	3	NA	NA	3
	Mode	3	1	3	NA	NA	3
	Std. Dev.	0.8	1.3	1.3	NA	NA	1.3
Hybrid Cadastre within Current Legislation	Avg.	3.2	2.3	2.8	5	NA	3.5
	Median	3	2.5	3	5	NA	3
	Mode	3	3	3	5	NA	3
	Std. Dev.	0.8	1	0.9	0	NA	1.3
Requirements of Hybrid Cadastre	Avg.	3.4	3	3.3	5	NA	3.9
	Median	3	3	3	5	NA	3.5
	Mode	3	-	3	5	NA	3
	Std. Dev.	0.7	0	0.7	0	NA	1
Monuments under the Surveys Act	Avg.	2.8	1.2	2.1	5	3	2.9
	Median	2	1	2	5	3	2
	Mode	2	1	1	5	3	5
	Std. Dev.	1.5	0.4	1.4	0	0	1.7
All	Avg.	3.4	2.3	3	5	1.8	3.4
	Std. Dev.	1.1	0.8	1.1	0	0	1.4

Instances that do not have a number, are indicative of the theme being either inappropriate given the structure of the respondent grouping, or due to the respondents choosing not to answer specific questions in the interview guide that inform the theme. This only occurred with the Government and Landowner & Academic groupings and is partly a result of the smaller sample size for the groups, five and two respectively, and the context of their perspectives on the topic of the Hybrid Cadastre.

Since the Government grouping is not practicing in the Hybrid Cadastre, but overseeing it, certain questions are not relevant. For the Landowner & Academic grouping, the participants have no experience with the specifics of the Hybrid Cadastre, and as such cannot provide feedback in the context of the themes specific to this initiative.

The Government grouping was assigned the same ordinal value given that these respondents participated in a collective group interview. Furthermore, this subset represents the affirmative view of being in favour of the Hybrid Cadastre initiative, seeing as it is directly overseen by the government. As such, the Government grouping was ranked as a highly aligned to the themes. This alignment provides for an upper trend line to the dataset, and ultimately provides a good contrast to the other respondent groupings. As previously noted in the interpretations and biases discussed in Chapter 3, there is an assumed bias with the Government respondent set because they are inherently tied to the adoption of the Hybrid Cadastre as it is a government initiative.

The Landowner & Academic grouping was a conjoined interview, and as such the responses for these two participants were ranked alike. The feedback from these respondents was an instance of them answering the question collectively, and as such it was impractical to attempt to rank these respondents' alignments with the themes divergently.

A graphical representation of the average alignment from each of the informant grouping analyzed, i.e., the Oil & Gas Surveyors, the Municipal Surveyors, the Surveyors Combined, the Government, and the Landowner & Academic, with respect to the themes, as well as an average for eaching grouping across the themes is outlined in Figure 14.

The feedback from the respondents to the questions in the key informant guide were varied. In terms of the conjoined and group interviews, the format of these was quite varied and did not directly relate to the written questions. The topics of the interview guide were discussed, but in a much less formal manner. These instances represent the extremes in the data set, consisting of the Government group, which is for the adoption of coordinates as evidence. The divergent perspective comes from the Landowner & Academic grouping, which vests more towards individual property owners' concerns pertaining to the marking of boundaries.

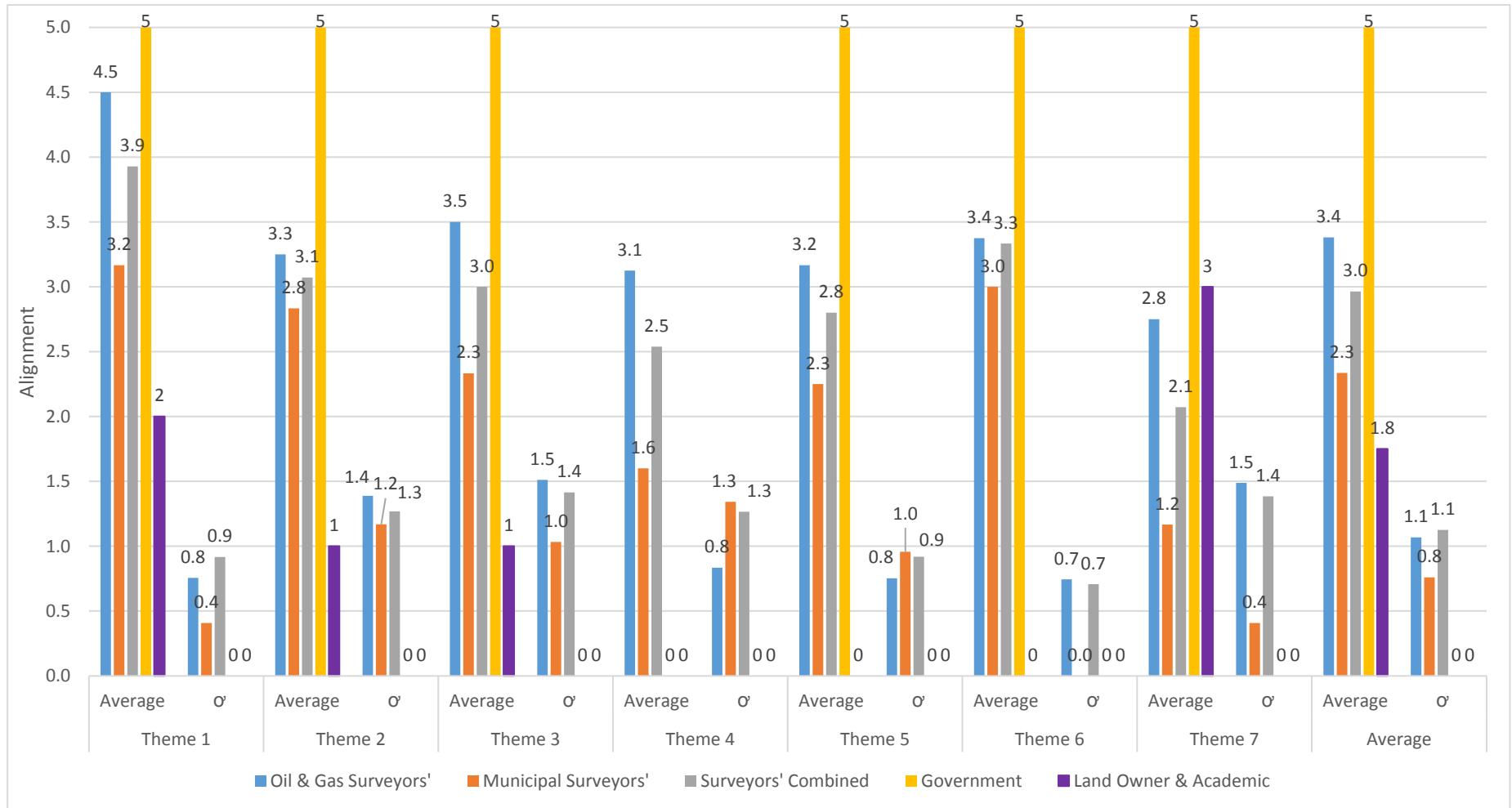


Figure 14 – Clustered Columns of the Respondent Groups Average Alignment with each Theme

The ordinal 5-point assessment provided insights into the various respondent group’s alignment with the respective themes. These results are analyzed and discussed below and provide learnings and context of the respondent’s groupings as it pertains to the central research topic of coordinates as legal survey evidence. For each theme, the results from the ordinal assessment are analyzed within the grouping, as well as across the groupings of participants. Specific insights and leanings are incorporated into the discussion and conclusions presented later in chapter 5 and chapter 6.

4.3.1 *Coordinates as Governing Evidence*

The first theme deals with the concept of coordinates as governing evidence being an acceptable form of evidence for legal survey boundaries. The metric established for alignment with the theme is previously discussed in section 3.8.1 and is restated here for the purposes of the analysis. The average alignment of the respondents’ groupings and their standard deviations are presented in Figure 15.

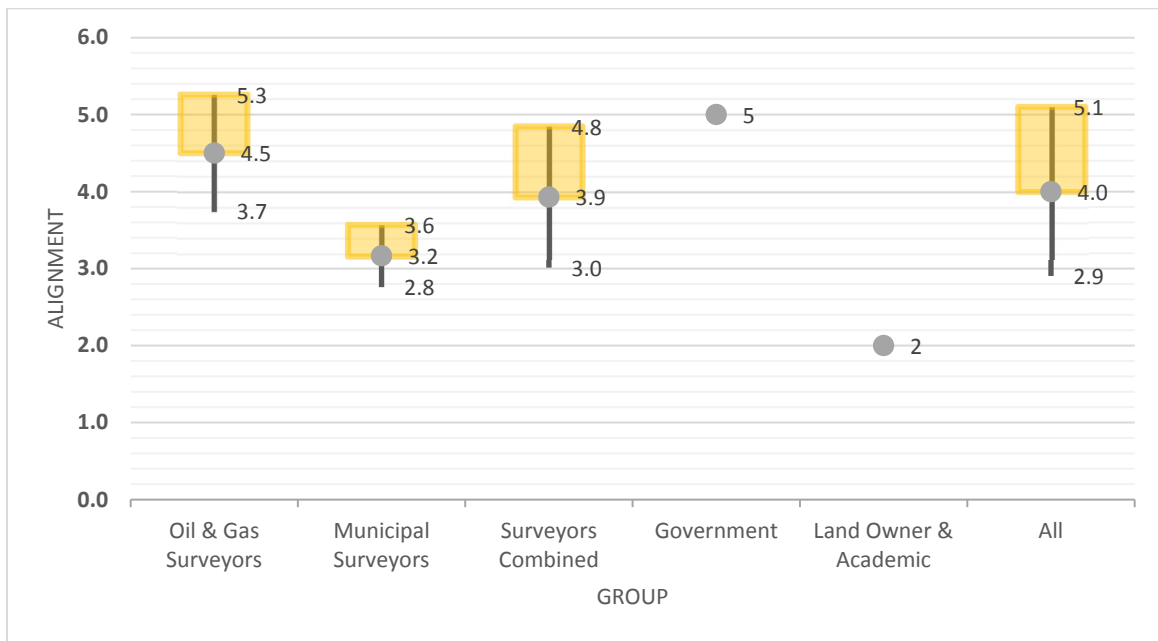


Figure 15– Average Alignment of Respondent Groupings and Standard Deviation of the Alignments for the Coordinates as Governing Evidence Theme

The Oil & Gas Surveyors grouping of respondents averaged between slightly and highly aligned (4.5) with a deviation of less than 1 rank, i.e., 0.8. In contrast, the Municipal Surveyors grouping provided an average of just above the neutral alignment, i.e., 3.2, with a small deviation of 0.4. The average for the Surveyors Combined grouping was just short of slightly aligned with the theme (3.9) and provided a deviation of close to rank 1 (0.9) The Government grouping was highly aligned with the theme granted that it pertains directly to the Hybrid Cadastre initiative. The Landowner & Academic grouping was slightly non-aligned (2) with the theme of coordinates as governing evidence. Overall, the alignment of the respondents was slightly aligned (4) with a deviation of just above rank 1 (1.1).

Oil & Gas Surveyors

The Oil & Gas Surveyors respondent grouping was quite well versed in the subject given that the topic of coordinates as evidence and the Hybrid Cadastre vest directly within their field of practice. The average alignment for the Oil & Gas Surveyors respondent grouping was notably higher than that of any other group, with the exception of the Government⁴⁰ grouping. Of the respondents who identified as Oil & Gas Surveyors, five were highly aligned, two were slightly aligned, and one was neutrally aligned with the theme. The Oil & Gas Surveyors on average vest closer to highly aligned with the theme of coordinates as governing evidence.

The five respondents ranked as highly aligned with the theme had a general view that coordinates were governing evidence. They viewed the coordinates as the same as monuments placed with intent and did not see a difference between the two even if one is not placed in the ground. This intent was seen as stemming from the practitioner creating the plan and signing the statutory declaration.

A common view provided was that governing coordinates were not a new phenomenon, but just being progressed from the Section 47 framework, with the difference being the requirement to eventually monument the position. When the respondents were pressed on this topic it was put to the researcher that the evidentiary assessment would follow the same as under a traditional plan.

⁴⁰ As previously discussed, the government grouping is ranked as a result of their inherent ties to the project succeeding, thus they provide the highly aligned viewpoint.

The difference being that instead of retracing the monuments in the ground for the coordinate's position, it is the monuments that define the coordinates that must be retraced. One participant in this grouping even went as far as to note that coordinates should be considered as a new monument type.

The two respondents that are slightly aligned with the theme viewed favourably the concept of coordinates as governing evidence. A commonality between these respondents was their preference towards monuments, even though they saw the benefits and use in adopting governing coordinates as a pragmatic tool in the future.

This can be attributed to the respective bias of the respondents having practiced under a traditional monument driven cadastre for a period of time prior to the adoption of the coordinates as governing evidence under the Hybrid Cadastre. This was further discussed by one of the practitioners as it related to the confidence. They felt in having a monument they could see on the ground, versus coordinates on a plan, and this stemming from what they were used to.

The respondent that was neutrally aligned was supportive of the concept of coordinates as governing evidence to the degree in which it has been implemented under the Hybrid Cadastre regime. It was noted that even though the respondent does work with hybrid plans, there was a vast preference to seeing monuments in the ground.

Municipal Surveyors

The Municipal Surveyors respondent grouping was overall less supportive of the concept of coordinates as governing evidence. The average alignment of this grouping was between neutrally and slightly aligned, with the value being closer to neutral (3.2). The deviation in these responses was fairly low (less than half a ranking) and as such the average alignment can be considered well informed to the grouping. Of the respondents in the grouping, one was ranked as slightly aligned, and five were ranked as neutrally aligned to the topic of coordinates as governing evidence. Overall, the Municipal Surveyors are more neutrally aligned with the topic.

The participant that was slightly aligned had a diverse experience in the use of Section 47 plans. Often the discussion was focused back towards these products, which provided valuable context for how the municipal practitioners adopt coordinates as evidence. It is inferred that this practitioner's greater acceptance of monuments as governing evidence stems from this experience. Furthermore, discussion surrounding the benefits of having governing evidence in large subdivisions during construction alleviates the concerns with monument destruction. Given this context, this participant viewed coordinates as being equivalent to or more secure than monuments, seeing as they were not there to be destroyed by grading machinery.

The five participants that were neutrally aligned from this grouping all discussed their experiences with Section 47 plans. It seemed that it was the constraints established under this framework for how long a coordinate can govern a position that was most appealing to these participants, with even a few stating that they generally support the concept of coordinates as governing evidence given there is a limitations on its use. One of these pressing limitations addressed by the majority of these respondents was in regard to the public access to this coordinate data. There was a common concern that the public could misinterpret this information as it pertained to boundaries. These coordinates are geodetic grade, and if the public attempts to use them with lower quality technologies it could result in confusion surrounding boundaries.

Ultimately, this makes sense given the practical implications of coordinates in Municipal settings. There is a greater risk for conflict stemming from boundaries defined by these types of evidence should misinterpretations or discrepancies arise. Furthermore, the practitioners in the municipal scenario are used to statutory timelines for when coordinates should be replaced by monuments under Section 47 plans, and as such may hold this principle more to heart (Government of Alberta, R.S.A. 2000, C. S-26). Finally, it is the common trend among the municipal participants that they do not have the experience or perspective of working with coordinates under the Hybrid Cadastre, and as such are lacking in perspective on how this framework is established.

Combined Surveyors

The Combined Surveyors respondent group represents the average of all of the land surveyors' perspectives. When averaging out the Municipal and Oil & Gas Surveyors the resulting ranking is just under slightly aligned with the concept of coordinates as governing evidence. It should be noted since the two groupings have somewhat divergent perspectives on this topic, the resultant deviation in this grouping is close to a full ranking value.

Landowner & Academic

The Landowner & Academic respondent grouping was slightly non-aligned with the theme of coordinates as governing evidence. This stemmed from the perspectives of the participants as it related to municipal boundaries. The participants are unfamiliar with the Hybrid Cadastre, and their responses reflected their experience.

In municipal settings, adjacent homes are very close together, and the participants were uneasy about the idea of the boundary between their respective lots being defined by a mathematical coordinate that can be changed in the office. Ultimately, this grouping was not completely against the concept seeing it as a common theme in discussions of the future of the cadastre, but they definitively wanted to see a greater degree of legislative initiative to properly frame the topic prior to adoption in their neighbourhoods.

Government

The Government respondent grouping was highly aligned to this topic due to the legitimacy of their initiative, the Hybrid Cadastre, vesting in the fact that coordinates are capable of being governing evidence. Under the Hybrid Cadastre only Establishment Coordinates (ECs) are provided governing status over legal boundary locations (Government of Alberta, 2017).

4.3.2 *Coordinates and Tenure Security*

The second theme is related to the tenure security concerns that stem from the adoption of coordinates as governing evidence in lieu of monuments. This included the participants discussing concerns in terms of both risks and benefits. This theme has an underlying assumption in terms of context that higher coordinates adoption will result in lower density of monuments. The metric established for alignment with the theme is previously outlined in section 3.8.2. The results of the ordinal assessment of the second theme in terms of average alignment of the respondents' groupings and their standard deviations are presented in Figure 16.

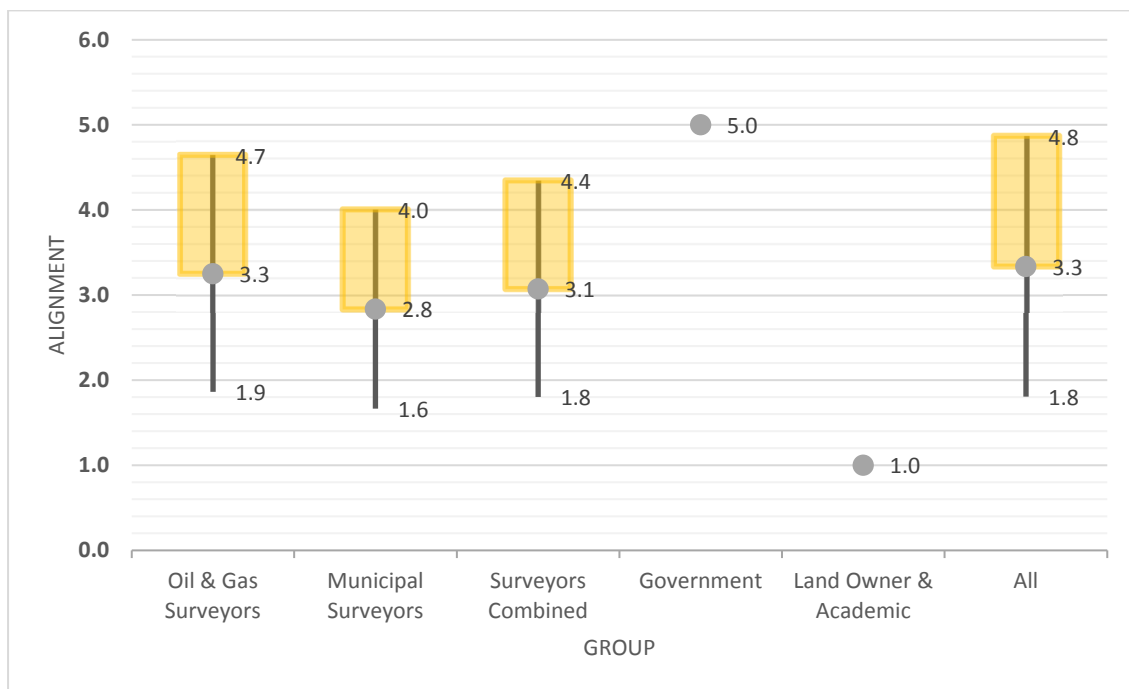


Figure 16 – Average Alignment of Respondent Groupings and Standard Deviation of the Alignments for the Coordinates and Tenure Security Theme

Across the respondent groups, the alignment of this theme ranked lower on average with the exception of the government grouping. The government was ranked as strongly aligned with the theme given that in their context, under the Hybrid Cadastre, there are no tenure security issues as it is just another tool in the toolset for surveyors on public lands. The Oil & Gas Surveyors grouping average alignment was above neutrally aligned (3.3) on this theme and the Municipal Surveyors average alignment was slightly below neutrally aligned (2.8).

The Surveyors Combined grouping essentially puts the average alignment as neutrally aligned to the theme (3.1). The Landowner & Academic grouping provides an alignment of high non-alignment with the theme. The three surveyors' groups also saw a high degree of variation in alignments, with the deviation being over one ranking in value (1.4, 1.2, and 1.3 respectively). Overall, the respondents collectively were between neutrally and slightly aligned (3.3) with the theme with a deviation of more than one rank (1.5).

Oil & Gas Surveyors

The Oil & Gas Surveyors respondent grouping was on average neutrally aligned with the theme (3.3) with a rather large deviation (1.4). This points to a large degree of variability in the alignments of the respondents to the theme and highlights the contentious nature of the topic of coordinates and security of tenure. The average alignment of this respondent group shows a greater average alignment than the Municipal Surveyors grouping. This can be attributed partly to the different spheres of practice and the potential for tenure problems.

In Oil and Gas surveys, there is a lower risk of problems with the security of tenure in land given that the majority on these instances in which coordinates can be applied or would be applied are in remote locations. Further to this, the interests that are defined by these under the Hybrid Cadastre are generally industrial and resource based in nature and are established under the Public Lands Act⁴¹. The interests surveyed out are only provided by the government for use, and generally do not constitute ownership of the land rights⁴². This provides a probable context under which the Oil & Gas Surveyors respondents are less concerned about the tenure security as it pertains to coordinates as evidence.

Of the respondents in this grouping, two were highly aligned, one was slightly aligned, three were neutrally aligned, and one was slightly non-aligned. No respondents were strongly non-aligned with the theme. The two respondents who were highly aligned with the theme viewed coordinates as not causing problems in terms of tenure security.

⁴¹ Dispositions, Leases, and Licenses as discussed under the Public Lands Act (R.S.A. 2000, P-40)

⁴² An example of this would be an oil lease, the company owns the rights to extract the minerals under the land and applies for a lease to build a wellsite and extract this resource. The title to the land however does not transfer to the company. The company has an interest on public land, which is what dispositions are intended to provide for.

The caveat here was the presumption that the framework for practice with coordinates is well set up and robust (akin to how they are using Hybrid Cadastre). In these instances, the respondents perceived coordinates as having higher confidence from their perspective, while a spike or other monument can often go missing and the coordinate will not.

The respondent who was slightly aligned with the theme provided context in regard to the issues pertaining to working with coordinates and not having physical ground checks as a means to “ground truth” them when they are adjusted. This stems more from the office and plan generation side in terms of confidence, and the respondent notes that you have to ensure prudent due diligence in checking coordinates. Ultimately, the respondent discussed the need to trace the coordinates back to their creation in order to understand if they were acceptable.

The process described is similar to retracing a plan to the first registration/monumentation. This could affect security of tenure in private hold lands if the adoption of coordinates as long-term evidence becomes widespread, and mistakes in the drafting process are not caught. Hence the need for proper office procedures and checks between field to plan generation.

The three respondents who were neutrally aligned with the theme provided context in regard to practitioners that are working with coordinates under section 47 products. These respondents had a variable degree of experience as it related to the hybrid products as a result of the vast number of scenarios that a Hybrid Cadastre product can be used as a tool towards. All three respondents supported the view that the use of coordinates had risks associated with it in terms of tenure security, but not so much as to stop the adoption of coordinates widespread.

One of the respondents related the risks with security of tenure stemming from coordinates back to the *McPherson v. Cameron* (1868) principle of the Hierarchy of Evidence that related to the highest weight granted to those things that humankind was least likely to mistake. This respondent was in favor of using monuments and agreed that the adoption of coordinates in defining land was achievable but held a preference for monuments.

The other two respondents both provided feedback in regard to tenure security risks that they perceived with public availability and access to coordinated datasets. They both felt that a monument provided better security for a position but accepted that coordinates were feasible. The risks stemming from this is the denigration of the profession, and misinterpretation of boundaries by members of the general public with positioning technology that is not capable of achieving the precisions of survey quality coordinates. This could cause complications in regard to the public understanding of boundaries and results in a greater conflict amongst neighbours.

The respondent who was slightly non-aligned with the theme had a preference for monuments as a result of previous experiences. The low alignment with the theme stems from the respondent's views of risks associated with coordinates in principle. The respondent's views aligned with the two views of the neutrally aligned informants above in regard to risks associated with misinterpretation of coordinates by the public. The respondent also expressed concerns in working with coordinates over the long term as there are changing datum and coordinate systems considerations, and this could potentially lead to further complications in security of boundaries.

Municipal Surveyors

The Municipal Surveyors' grouping was on average slightly below neutrally aligned (2.8) with also a large deviation (1.3), although not quite as high as the Oil & Gas Surveyors respondent set. It should be noted that these two groupings have slightly different number of participants, eight versus six; hence, they should not be numerically compared at face value. As with the Oil & Gas Surveyors respondents this degree of variability in alignments across the Municipal Surveyors group highlights the contentious nature of the topic of tenure security and coordinates as evidence.

This points to an emergent gap in the further adoption of coordinates among practitioners, with the two main streams of practice within the profession having somewhat divergent perspectives. In regard to the respondents in the Municipal Surveyors' grouping, two were slightly aligned, two were neutrally aligned, one was slightly non-aligned, and one was strongly non-aligned with the theme. No participants in the municipal group were strongly aligned with the theme.

The two respondents who were slightly aligned with the theme did not have pressing concerns with the adoption of coordinates as evidence pertaining to tenure security. They viewed the issues of security stemming from coordinates as a function of the implementation of the coordinate framework and not as an issue with using this kind of evidence. The two respondents who were neutrally aligned with the theme perceived coordinates as not causing major issues in terms of security but did note some risks that could affect this. Public misinterpretation could be one of them, and instances in which coordinates are governing but dispute monuments in the field.

The respondent who was slightly non-aligned with the theme perceived the advent of coordinates as evidence as being less secure than monuments in terms of tenure security. This stemmed from the respondent's viewpoint that monuments were physically in the ground, and coordinates could be mistaken or misinterpreted by those not trained to work with them. This correlates with the neutrally aligned respondents above.

The respondent who was highly non-aligned with the theme viewed coordinates as being less secure than monuments. This stemmed from issues surrounding landowner confidence in the cadastral framework. The respondent viewed the use of a monument to mark a boundary as providing good security for the boundary and confidence for the landowner in the location of their boundary. This participant also aligned with the others on the topic of risks associated with the public misinterpreting coordinates.

Combined Surveyors

The average alignment of the Combined Surveyors respondent group was slightly above neutrally aligned and had a significant deviation of greater than one rank. This is indicative of the divergent views within and between the Oil & Gas and Municipal Surveyors groupings.

Landowner & Academic

The Landowner & Academic respondent grouping was assigned a high non-alignment with the theme. This view stems from the perspective of the landowner in terms of the variability of boundaries currently.

The respondents have a rich oral history of boundary issues as it pertains to their experiences with properties they have owned. The property that was the subject of the respondents' interview, or the basis of their experience, has been continuously owned since 1972.

The respondents have had issues with their lot boundaries in the 1912 – 1988 Block Corner era stemming from successive re-interpretations of these boundaries. That is to say they have had issues in the traditional monument driven cadastre, specifically related to municipal blocks established during the Block Corner era.

In this instance, these boundaries were never lost and occupied continuously throughout the subsequent development. There is possessory evidence showing the boundaries that have been lived to from historic times to current. Subsequent development and re-interpretations have resulted in the compression of the block and an example of encroaching lot lines. As a result, easements have had to be applied for the municipality to provide some legal remedy of the subsequent encroachment.

The respondents viewed the changes to their lot lines as subsequent re-adjustments of the block with respect to the updated ASCM coordinates. This is further affirmed by the respondents as it pertains to evidence, seeing as there is very little in this area. The respondents attest that some of the monuments are even original wooden posts and take a narrow view of incorporating this kind of evidence with confidence given that flooding issues are systemic to the area.

Acknowledging that they are not surveyors and have never pressed their concerns in a legal setting, their perspective stems from peaceful occupation and the issues that can result from coordinates even within the traditional cadastre, in which monuments are heavily relied upon. A further concern of the respondents is the variability of their property reports across the decades, which are not consistent within themselves, and in fact dispute the modern plan boundaries⁴³.

⁴³ Evidently, due to the plan boundaries being compressed resulting in the lots of encroachment across the block.

Granted all of these issues present in what is considered the stable traditional cadastre, in which monuments are standard, it is evident that the respondents have concerns with coordinates defining boundaries. The concern is that there is nothing on the ground to represent their boundary and given the issues they had in the past with the specific property, coordinate-defined boundaries could aggravate these issues.

The respondents provided favourable views towards physical monuments being placed in the ground at their lot boundaries, as is the practice currently and has been since the end of the Block Corner era. The rationale for this was that with something physical in the ground on their lot boundaries, perhaps the issues systemic to their neighbourhood would have been addressed in the past, prior to having to apply for an easement.

Government

The Government respondent grouping was assigned a high alignment with the theme as it pertains to supporting the adoption of coordinates as evidence and the view that this adoption will not cause tenure security concerns. This view relates to the government's initiative as it pertains to coordinates as evidence under the Hybrid Cadastre only being relevant on public lands. In these instances, there are not private freehold titles that actively abut each other, and as such the potential for tenure security issues pertaining to individuals is non-existent.

The developments on public lands are in general resource-based in nature and are not often stacked right next to each other. Even in instances in which interests on public lands may be in conflict or have a dispute over a boundary defining the disposition extents, the fact that the Alberta Crown is the owner is unlikely to cause a conflict pursuant to lands that it collectively owns. The assumption here is that in a scenario like this, the boundary confliction would be resurveyed and alleviated to provide clarity for the disposition holders of their interests.

4.3.3 *Coordinates as Monuments*

The third theme relates to whether the concept of coordinates as governing evidence is akin to monuments in status under the Hierarchy of Evidence. This probes the topic of the feasibility and acceptance of considering governing coordinates in a similar manner as original monuments under the Hierarchy of Evidence. Often times respondents who were aligned with this view used the intent of marking a boundary and the intent of creating a boundary with that type of evidence (i.e., coordinate since there is no mark) as the rationale for treating coordinates akin to original monuments.

To further elaborate, this boils down to the fact that the coordinate is the intended piece of evidence to establish said boundary position when the boundary is first created through registration. The metric established for alignment with the theme is previously outlined in section 3.8.3. The average alignment of the respondents to the theme is provided in Figure 17.

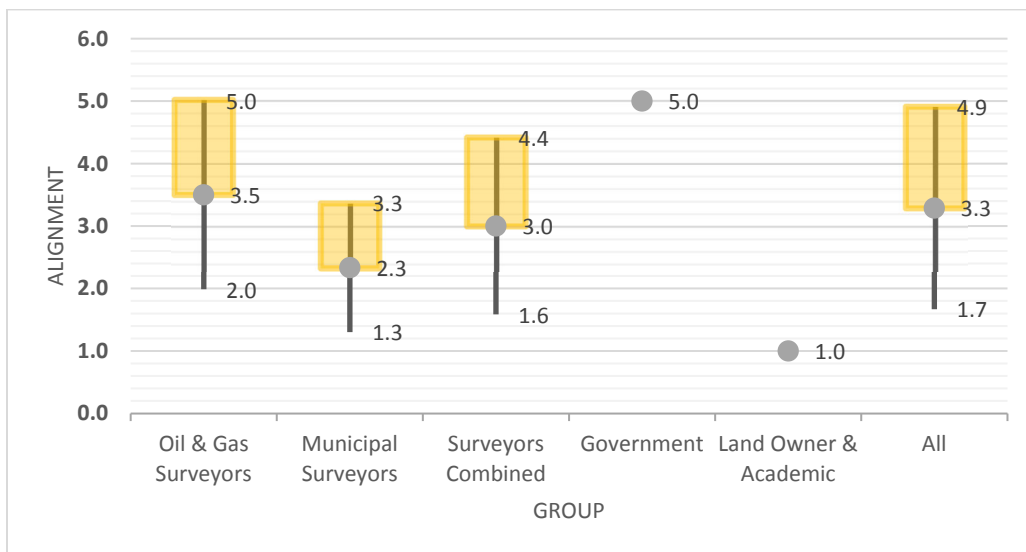


Figure 17 – Average Alignment of Respondent Groupings and Standard Deviation of the Alignments for the Coordinates as Monuments Theme

The results from the 5-point assessment highlight that the Oil & Gas Surveyors respondents show an average alignment (3.5) between neutral and slightly aligned with a large amount of deviation in responses (1.5) across the theme. In contrast, the Municipal Surveyors respondents are slightly non-aligned (2.3) with the theme, with a deviation of exactly one ranking.

The Combined Surveyors grouping averages out to neutrally aligned (3) with the theme, and also has a high degree of deviation in responses (1.4). The Government grouping is highly aligned with the theme of coordinates as monuments under the hierarchy. Finally, the Landowner & Academic grouping is highly non-aligned (1) with this theme. Overall, the respondents were slightly above neutrally aligned (3.3) with a deviation of close to two ranks (1.6)

Oil & Gas Surveyors

The Oil & Gas Surveyors respondent grouping is on average between slightly aligned and neutrally aligned (3.5), with a large deviation of 1.5 ranks. This points to the variation across the dataset and highlights the divergent nature of the responses. The Oil & Gas Surveyors respondent grouping included three strongly aligned, one slightly aligned, two neutrally aligned, one slightly non-aligned, and one strongly non-aligned with the theme.

The three respondents who were highly aligned with the theme all viewed coordinates as a monument granted that it was applied to a plan under the Hybrid Cadastre. They discussed that mathematical evidence in terms of plan distances and bearings was lower on the hierarchy, and that only coordinates placed with original intent was definitive of them being considered a monument under the Hierarchy of Evidence. It can be said that these respondents accepted coordinates as being akin to monuments under the Hierarchy of Evidence given their use under the context of the Hybrid Cadastre.

The one respondent who was slightly aligned with the theme agreed that coordinates were feasible as monuments under the Hybrid Cadastre but had concerns with this because of what could be a monument under the Hybrid Cadastre. The respondent viewed a double standard in terms of other traditional means of monumentation (iron spike, or bars) not being allowed on a Hybrid Cadastre plan as a monument that could be placed.

Contradictorily, these types of monuments from other plans adjacent to and intersecting a hybrid plan are allowed to be considered monuments. Outside of the bounds of the Hybrid Cadastre, the respondent viewed coordinates as the same as mathematical evidence, but it was the feasibility of the initiative that ranked this respondent accordingly.

The two respondents who were neutrally aligned with the theme viewed coordinates as something that could be transitioned to in the future but did not view coordinates as monuments under the Hierarchy of Evidence. The one respondent noted that he viewed coordinates as evidence of occupation, i.e., an observation of a position on the ground at a specific time. The other respondent viewed the adoption of coordinates as evidence, similarly, as providing a position of a monument, and needing to be checked by a future surveyor. Only once a degree of checks had been performed was the reliability of this coordinate considered acceptable to define the boundary. Both respondents noted preferences towards monuments in the ground.

The one respondent who was slightly non-aligned with the theme strictly viewed coordinates as the fourth rung on the Hierarchy of Evidence as measurements shown on previous plans of survey. This respondent did not view coordinates as being the same as monuments, and even though he had worked on some Hybrid Cadastre plans was still unsure on the use of coordinates as monuments. Ideally, this respondent would like to see further clarifications of what constitutes a monument and what constitutes a coordinate in the legislative framework.

The one respondent who was highly non-aligned with the theme strictly viewed coordinates as mathematical evidence, and on the lowest rung of the Hierarchy of Evidence. The respondent had worked with hybrid products but felt troubled by the elevation of coordinates to a higher position in the Hierarchy of Evidence simply as a result of the greater measurement capabilities of modern technology. In this respondent's view, the Hierarchy of Evidence cannot be changed simply because emergent technology makes the use of coordinates easier and more pragmatic.

Municipal Surveyors

The Municipal Surveyors grouping provided an average of slightly non-aligned (2.3) with a deviation of rank one. This points to a lower overall alignment with the theme across the Municipal Surveyors grouping. One was slightly aligned, one was neutrally aligned, three were slightly non-aligned, and one was highly non-aligned with the theme.

The one respondent who was slightly aligned with the theme viewed coordinates as a measurement being lower than monuments in the Hierarchy of Evidence. Given that this was a municipal practitioner, the further discussion surrounding how coordinates could become the best form of evidence (in lieu of missing evidence) provided the slight alignment with the theme. This provides context that the respondent views coordinates as evidence as useful and is open to their further adoption in the future practice. Finally, the respondent noted issues that occurred with monuments under Section 47 products, in which monuments could be placed in error and the coordinate provided the best estimate of the position and highlighted the discrepancy.

The one respondent who was neutrally aligned with the theme did not view coordinates and monuments as the same, but as each filling different roles as it pertains to Section 47 plans, which was the area of the respondent's expertise. This practitioner views coordinates as being a good indicator of where the monument on a section 47 product should be placed and accepts the usefulness of coordinates in this regard. The key here is the respondent views a coordinate as governing as per the legislation for the time period prescribed but views a monument as distinctive and different to a coordinate in terms of definition. The coordinate only holds the place for the construction phase, and then a monument is placed.

The three respondent who were slightly non-aligned with the theme did not view coordinates and monuments as the same under the Hierarchy of Evidence and vested towards the legislation. A common trend was the discussion of coordinates being used to provide an estimate of a monument's position (in Section 47 circumstances), but they collectively placed monuments higher than coordinates in the Hierarchy of Evidence. These respondents align with the idea that coordinates can be a form of evidence but view them different than monuments.

One respondent even discussed the perspective of coordinates being a witness to a monuments position, which would align with the premise of coordinates being evidence of occupation. This provides an interesting avenue to discuss, given that witness monuments are a common occurrence in Part 2 lands under the dominion surveys to provide for instances in which monuments cannot be placed⁴⁴.

⁴⁴ Part 2 lands are those discussed under the Surveys Act that relate to the Alberta Township Framework as established by the previous Dominion Land Surveys of the West.

The one respondent who was highly non-aligned with the theme did not view coordinates as monuments under the Hierarchy of Evidence, and instead viewed them as a form of possessory evidence. This is telling as the respondent notes that even with possessory evidence checks must be performed, because it is not possible to determine when it may have been constructed (i.e., a fence) and perceives coordinates as requiring this same degree of inspection. Taking a coordinate at face value does not infer an accurate boundary position, and only assists in solutions to the position. The respondent also discusses the issues with checking coordinates in the event that they did not relate to an identifiable piece of possessory evidence. The example discussed was that of a fence corner found versus an empty yard with no indication of possession.

Combined Surveyors

The Combined Surveyors respondent group is on average neutrally aligned (3) with a large deviation (1.41) of greater than one mark. This points to a divergence between the two respective fields of practice.

Landowner & Academic

The Landowner & Academic respondent grouping is ranked as high non-alignment with the theme. This stems from the previous experiences with issues pertaining to boundaries in the traditional monument driven cadastre. It is of importance to note that those who have occupied land for a long period of time often do not generate positive experiences from shifts in boundaries. Furthermore, since the respondents understand what a monument is in previous legislative context, modern *de facto* interpretations stemming from practice are not aligned with their view of the definition.

Government

The Government respondent grouping was highly aligned to the perspective of coordinates being perceived as monuments under the Hierarchy of Evidence. This stems from the Hybrid Cadastre initiative and the fact that the standards *de facto* assign coordinates to the status of monuments. This alignment is fairly biased in the sense that it would be impractical for the government not to be aligned with this, seeing as then their initiative would not have any merit to stand on.

4.3.4 *Effects on Daily Practice*

The fourth theme addresses the changes to practice that have been brought about by the Hybrid Cadastre. It focuses on the management and operations of the respondents' survey practice in light of these new measures. This theme probes for insights into whether there has or has not been an impact on the respondents' practice. The metric established for alignment with the theme is outlined in section 3.8.4. The alignment of the respective respondent groupings to the theme is presented in Figure 18.

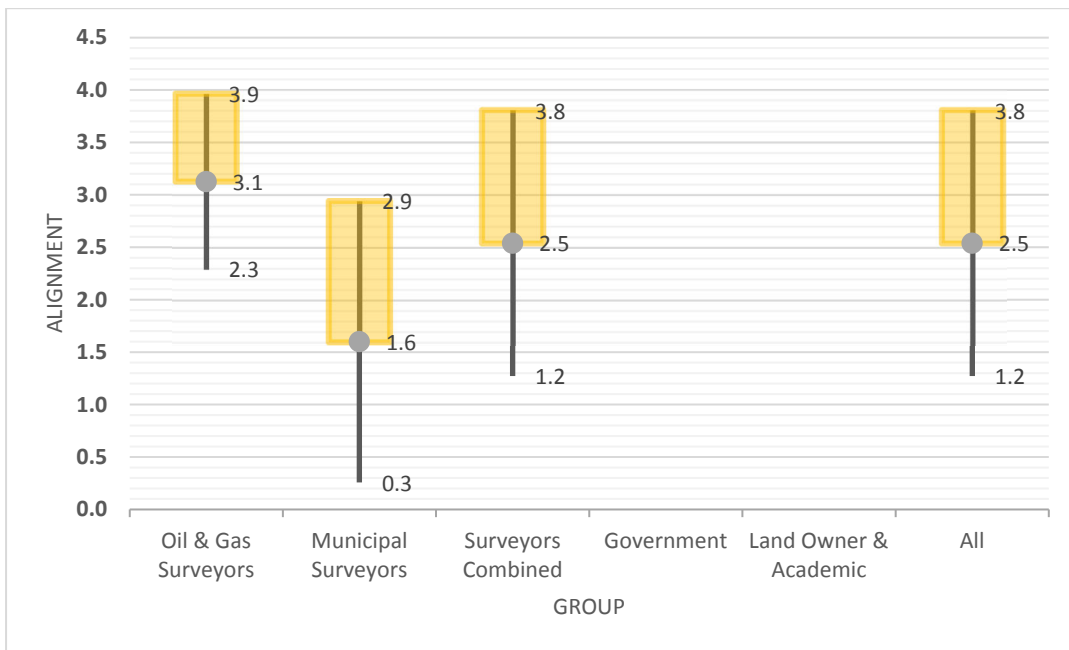


Figure 18 – Average Alignment of Respondent Groupings and Standard Deviation of the Alignments for the Effects on Daily Practice Theme

The average alignment of the Oil & Gas Surveyors respondent grouping ranks slightly above neutrally aligned (3.1) with a less than one ranking deviation in alignments (0.8). In contrast, the Municipal Surveyors respondent groupings average alignment is between strongly non-aligned and slightly aligned (1.6). It should be noted that the deviation in the alignment for this grouping is substantial and points to a large degree of variation in responses (1.3). The Surveyors Combined respondent grouping has an average alignment of between slightly non-aligned and neutral alignment for this theme (2.5), with a deviation great than one ranking (1.3).

Examples of minor impacts that stemmed from the respondent's interviews included office challenges, such as checking procedures for the new products and handling sequential point numbering through automation of processes. More severe issues that came to light proved to surround meeting client demands, timelines for submission, consistency of the application process and standards, and overall experience with the product generation based on the specifics on the location surveyed⁴⁵.

The results evidently point to a greater effect on practice with the Oil and Gas practitioners based on their alignment with the theme. This is contrasted with the Municipal grouping of respondents below average alignment with the theme. The Hybrid Cadastre is not able to be used on privately held lands in the province and is restricted to Crown land surveys under the Public Lands Act (Government of Alberta, R.S.A. 2000, P-40). There is some bias in this theme's comparison of alignments, as in most cases the Municipal respondents were unable to comment as they had no use for Hybrid Cadastre products in their sphere of practice. Often, the Municipal Surveyors respondents would relate it to Section 47 plans because these products are not a new initiative, and many of the initial adverse effects on practice have been mitigated.

For this theme, the Landowner & Academic and Government respondent groupings were not assigned an alignment since they are not involved in running a survey practice or performing the duties of a practitioner. The Government grouping is responsible for regulating the practice through requirements for Hybrid Cadastre products, and as such cannot comment on the effects of these initiatives on practitioners.

Oil & Gas Surveyors

The Oil & Gas Surveyors grouping is an average just above neutrally aligned (3.1) with a deviation (0.8) of below one rank. This points to a higher correlation of alignments between respondents and infers a greater degree of agreement across the respondent grouping as it relates to effects of the Hybrid Cadastre on daily survey practice.

⁴⁵ This stems from the possible hundreds of unique on the ground scenarios that can result from the land being modelled, some more complicated than others. These can influence respondents' perspective on feasibility as a tool in the tool set.

Of the participants, one was highly aligned, six were neutrally aligned, and one was slightly non-aligned with the theme. The one respondent who was highly aligned with the theme discussed the practical implications of the Hybrid Cadastre project on their practice. This respondent viewed the risks associated with Hybrid Cadastre products as a limiting factor in their use and noted that changes to the standards throughout the successive updates had affected some practitioner's timelines for clients. Further, the fairly new submission process produces a high degree of uncertainty for surveyors' projects.

Ultimately, this practitioner noted that some survey practices have put in place processes to work with the Hybrid Cadastre products, however these are few and far between as a result of a limited demand for these products. This practitioner noted a preference toward traditional survey products on public lands due to the consistency with their use and the submission process. The respondent noted that they had witnessed inconsistencies in the plan checking processes, in which some plans were rejected, and some practitioners were provided with a chance to remedy the situation instead⁴⁶.

The six respondents who were neutrally aligned with the theme overall saw limited impacts of the Hybrid Cadastre on their survey practice. Common discussion points included training of surveying staff on the standards of the Hybrid Cadastre for plans, as well as procedural office concerns surrounding checking and drafting the plans. Sequential numbering of coordinates⁴⁷ came up a few times, as did changes to the checking and drafting processes. All of these practitioners recognized the benefit of having the Hybrid Cadastre products in the toolbox as an option but did admit there were issues surrounding feasibility. This is not to say that Hybrid Cadastre products cannot be used in certain scenarios, but rather the limitations as provided by the standards and uncertainty in the submission process drove practitioners to products that have a more consistent submission process.

⁴⁶ Ideally this plan inspection portion of the standards should be made for consistency such to provide stability and confidence in job costing.

⁴⁷ As required by the Hybrid Cadastre Standards, the coordinate table on the plans must be sequentially numbered, and there is a prescribed order regarding what types of evidence should appear at first. This has been a point of contention throughout the adoption and successive versions of the Hybrid Cadastre standards and has forced industry to adapt to provide solutions to alleviate higher than normal drafting and plan checking time for these products.

Ultimately the practitioners agreed with the concept that with any new initiative there will be growing pains, and changes that must occur. However, a few did note that given the changing standards, many practitioners in their view steer away from Hybrid Cadastre products due to a lack of confidence in being able to produce a product that meets their client's costs and timelines.

It was a common discussion point that even though the Hybrid Cadastre is supposed to alleviate survey costs by not requiring as many monuments in the ground, rather it just defers these costs to the greater scrutiny that must be applied to office procedures in working with coordinates. A final concern that came up surrounded intersection requirements⁴⁸ making these products more labour intensive than standard products as a result of having to intersect disposition boundaries, which a practitioner would not have to do under a standard product.

The one respondent who was slightly non-aligned with the theme provided feedback that the advent of the Hybrid Cadastre had minimally affected the practice. Overall, the practitioner just viewed the Hybrid Cadastre as another tool in the surveyor's toolset and discussed minor administrative learnings throughout the first few plans surveyed.

Municipal Surveyors

The Municipal Surveyors respondent grouping is on average between highly and slightly non-aligned (1.6) with a large deviation (1.3) of greater than rank 1. Of the Municipal Surveyors, one was slightly aligned, and four were strongly non-aligned with the theme. One informant was not provided an alignment as they did not provide a response in regard to the effects on the Hybrid Cadastre on daily practice.

⁴⁸ These have been alleviated in the most recent version of the standards. Between the pilot and first full version it was required that all disposition boundaries had to be intersected and retraced. This added more work in the long run and was noted by some practitioners as driving them away from adopting Hybrid Products in their practice. This can be chalked up to learning pains with the management of the new framework, and a divergent focus between efficiency and sufficient integration of adjacent and existing interests in land.

The one respondent who was slightly aligned with the theme discussed some issues with the roll out of the Hybrid Cadastre. This was a result of a few instances in which the Hybrid Cadastre product was adopted to a situation. Being unfamiliar with the new requirements and process pushed projects over budget. The consistency of the submission process, standards, and timelines over the course of the initiative have provided uncertainty. The practitioner viewed the Hybrid Cadastre as being in constant change, and the complications of the grandfather period resulted in some issues for meeting client's timelines.

The four respondents who were highly non-aligned with the theme all work in the municipal field and not in a jurisdiction that is adjacent to crown lands. They have no experience with the initiative and have not used Hybrid Cadastre products. One of the respondents discussed this in regard to Section 47 plans and noted that in terms of practice it was simply a change in emphasis of when the monuments are placed in the ground.

The biggest concern in this instance is keeping track of when the monuments need to be posted, because a Section 47 plan is initially registered with the coordinates as governing and it is not until the monuments and subsequent monumentation certificate that the plan is finalized. Interestingly, this practitioner viewed Section 47 plans as almost dormant plans⁴⁹ in a way, except that the statutory requirements for Section 47 plans are followed.

Combined Surveyors

The Combined Surveyors' respondent group is an average between slightly non-aligned and neutrally aligned (2.5) with a large deviation (1.3) of greater than rank one. This is indicative of the Hybrid Cadastre initiative only having a limited or slight impact on practitioner's survey practice across the province and is somewhat biased by the Municipal Surveyors lack of practical use and experience with the Hybrid Cadastre products.

⁴⁹ This refers to a phenomenon that occurred in the 1980s onward, in which oil and gas infrastructure was built (i.e., a pipeline) but since the surveyor was not required to submit the plan, rather just provide it to the client often the plan was never registered. As such there is a large component of interests in the ground that were surveyed and had a plan of surveyed prepared for them, but the registration was never followed through on. This is being amended in current times with a workaround by the government that allows Land Surveyors to register their dormant plans today.

4.3.5 Hybrid Cadastre within Current Legislation

The fifth theme discusses the participants' views of the Hybrid Cadastre policy within the current legislative framework governing the surveying of legal boundaries. The Hybrid Cadastre operates as a policy within the Public Lands framework and is administered by the Director of Surveys office. It does not affect lands that are privately held, and its adoption without changes to the Surveys Act pertaining to what constitutes a monument is the key point of contention. The metric established for alignment with the theme is previously outlined in section 3.8.5. The average alignment of the respondent groupings to the theme is provided in Figure 19.

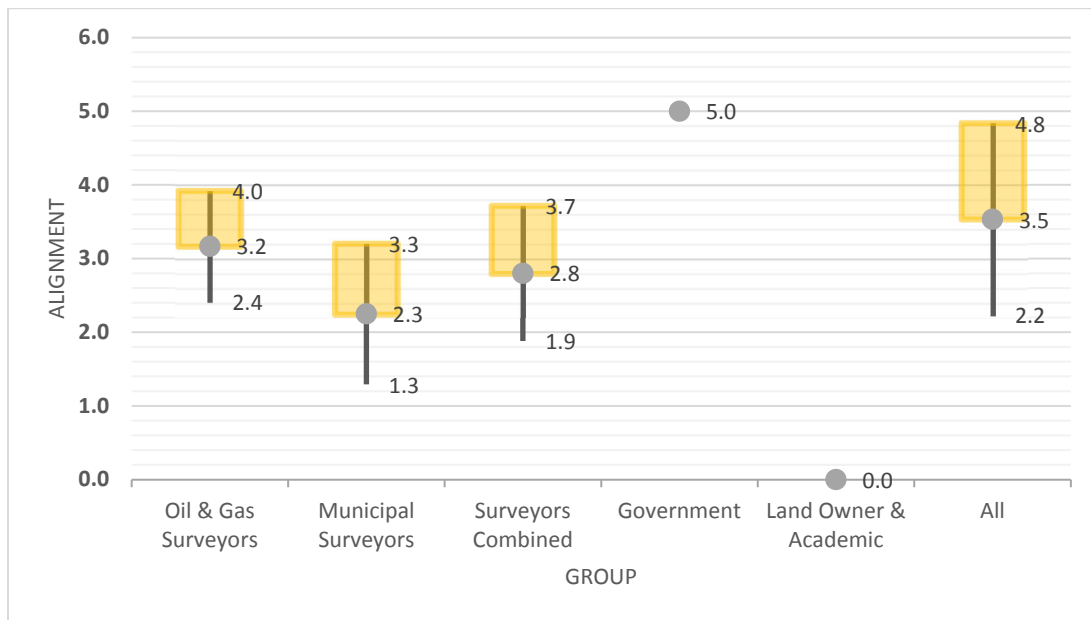


Figure 19– Average Alignment of Respondent Groupings and Standard Deviation of the Alignments for the Hybrid Cadastre within Current Legalisation Theme

The average alignment of the Oil & Gas Surveyors is just above neutrally aligned (3.2) with a deviation of less than a full ranking (0.8), while the average of the Municipal Surveyors is between slightly non-aligned and neutrally aligned (2.3) with a greater deviation in responses (1.0). The Surveyors' Combined grouping provided an average alignment just below neutrally aligned (2.8) with a deviation slightly below one ranking (0.9). The Government respondents grouping was assigned a high alignment with the theme. Overall, the alignment of the respondents was between neutrally and slightly aligned with the theme (3.5), with a deviation of greater than rank one (1.3).

The landowner and academic grouping were exempt from this question as it pertained to the Hybrid Cadastre within the current legislative framework. Since neither of these participants is an active practitioner or has worked with hybrid plans, they were unable able to inform this theme. A few instances of a potential misalignment were addressed throughout the respondent interviews, including the Pipeline Act, certain products under Directive 56, and as highlighted already in the research as a separate refined theme, the Surveys Act. These perspectives were provided at the time of the key informant interviews, and some of these documents may have been amended.

Oil & Gas Surveyors

The Oil & Gas Surveyors respondent grouping showed an average just above neutrally aligned (3.2) with a deviation (0.8) of less than rank one. Of the respondents, two were slightly aligned, three were neutrally aligned, and one was slightly non-aligned. Two participants were not assigned alignments as they did not provide responses to the topic of the Hybrid Cadastre within the current legislation.

The two respondents, who were slightly aligned with the theme viewed the Hybrid Cadastre as fitting within the current legislative framework for the most part, with the one respondent noting a few slight conflicts stemming from the intersection requirements and the Surveys Act⁵⁰. Overall, these respondents viewed the standards as fitting within their intended context, i.e., disposition surveys of public lands.

One of the practitioners noted that the Hybrid Cadastre initiative, and the whole concept of using coordinates as evidence worked under the current context because the Crown is the owner. They provided direction as it relates to the survey of their lands. Under this context the Hybrid Cadastre is feasible, but the practitioner highlighted that any move towards the adoption of coordinates as evidence in privately held lands will conflict with the current legislative framework.

⁵⁰ These have since been alleviated, and a less robust set of requirements for intersections is included in the more recent initiatives.

The three respondents who were neutrally aligned with the theme viewed the initiative as somewhat fitting within the current legislative framework but would benefit from some changes. One viewpoint was that the Hybrid Cadastre's adoption of coordinates as monuments is an interpretation only relevant under the initiative and done so by the Director of Surveys for public lands. The respondent discussed the issues stemming from the difference between the definition of a monument and the interpretation being held that it is a coordinate.

This relates to a *de jure* vs. *de facto* application of the legislation's definitions, in which the *de jure* case is as it is written in the act, and the *de facto* case is as it is interpreted on the ground. Another respondent viewed it as a workaround for the time being even given some of its conflicts with the existing legislation. Finally, of note is the feedback from this respondents grouping that there are further conflicts between the standards and the Pipelines Act of Alberta, and that for future adoption of private lands portions of the Land Titles framework would need to be revised⁵¹.

The one respondent who was slightly non-aligned with the theme accepts that coordinates can be used under the Hybrid Cadastre initiative but does not view them as fitting within the current legislation. Ideally, this respondent would like to see the surveys act amended to include guidance on practice with coordinates and pragmatic definitions of what a coordinate is and how they should be derived. This respondent views the Hybrid Cadastre initiative as a workaround for the specific context of public lands.

Municipal Surveyors

The Municipal Surveyors respondent grouping provided an average just above slightly non-aligned (2.3) with a close to rank one deviation (1.0). Of respondents in the Municipal Surveyors grouping three were neutrally aligned, one was slightly non-aligned, and one was highly non-aligned.

⁵¹ This will not be delved into in depth, seeing as this is outside the scope of the research and entering a legal review of changes required for coordinates to govern on private lands. The discussions relating to the Pipelines Act related to marking requirements set out by the legislation that may be not occurring under the Hybrid Cadastre initiative. The Land Titles framework was speculative and was the viewpoint of one of the respondents that there was an expectation of issues with the current version of this legislation.

Two of the participants were not assigned alignments as they did not respond to the topic of the Hybrid Cadastre within the current legislation. The two respondents, who were neutrally aligned with the theme, viewed calling a coordinate as a monument concerning. Ideally, the concept would be further defined to provide context moving forward for what constitutes a coordinate, and what constitutes a monument.

The one respondent views it as somewhat fitting since it is done under the Director of Surveys purview but is not amenable to the means by which it was implemented. The perspective provided that by not doing the Hybrid Cadastre initiative through legislation, it ultimately hinges the risks with the initiative on the backs of practitioners.

One respondent who was slightly non-aligned with the theme admits that the initiative is working but has concerns as it relates to the alignment with statute law. The practitioner views it as being feasible as a result of the Director of Surveys interpretation of how a monument can be inferred under the Surveys Act, but highlights the risks perceived by this. It is highlighted that the risks associated with new initiatives that move forward without prudent legislative underpinnings could provide further complexities in land management.

Furthermore, the practitioner views the risks of impromptu judicial purview as potentially having a negative effect on coordinates being able to be used as evidence, not based on the merits of this kind of evidence, but based on the means by which it was adopted, i.e., the means by which the Hybrid Cadastre initiative has adopted them.

One respondent who was highly non-aligned with the theme did not view the initiative as fitting within the current legislative framework, i.e., the Surveys Act. The practitioner was a proponent of revising the statute and instead of attempting to re-interpret long standing definitions of the statute. The premise of this feedback was that if the use of coordinates as evidence is the objective, then simply amend the framework to support this, instead of trying to do it through *de facto* interpretations and workarounds. This respondent also viewed any changes to the legislation as hopefully being pre-emptive and future thinking, such that this debate surrounding coordinates as evidence does not have to be re-hashed every decade.

Combined Surveyors'

The Combined Surveyors' respondent group is an average just below neutral alignment (2.8) and with a deviation (0.9) of slightly less than rank one. This points to a general acceptance of the Hybrid Cadastre within the current legislative context from all surveyors across the two respective fields of practice albeit that the initiative would benefit from some legislative tweaks in the future to streamline it.

Government

The Government respondent grouping is an average of a high alignment as it pertains to the theme of the Hybrid Cadastre fitting within the current legislation. This follows since it is a government's initiative, and it would be in their interests to advocate that the initiative fits within the current legislative framework.

4.3.6 Requirements of Hybrid Cadastre

This theme sought to inquire about the requirements for practice under the Hybrid Cadastre and whether the participants felt they were or were not sufficient. The metric established for alignment with the theme is previously outlined in section 3.8.6. The average alignment of the respondent groupings to the theme is provided in Figure 20 below.

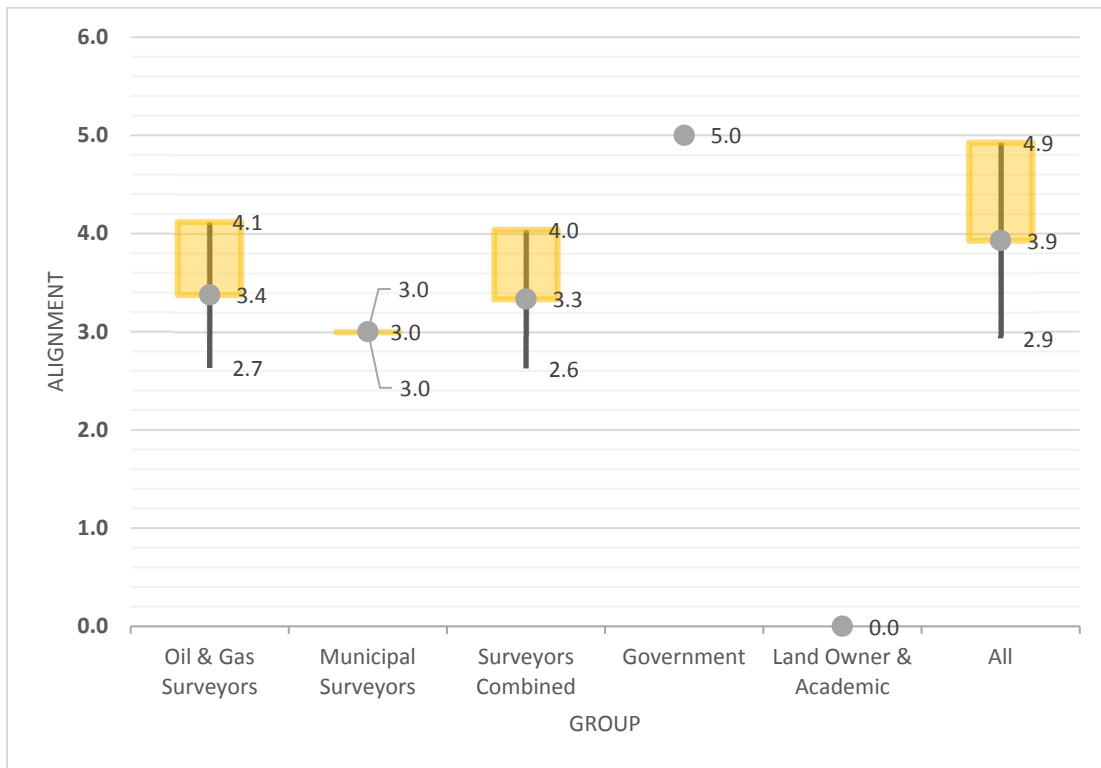


Figure 20 – Average Alignment of Respondent Groupings and Standard Deviation of the Alignments for the Requirements of Hybrid Cadastre Theme

The average alignment of the Oil & Gas Surveyors with the theme was slightly above neutrally aligned (3.4) with a deviation of roughly three quarters of a ranking (0.7). In contrast, the Municipal Surveyors average alignment was neutrally aligned (3), with no deviation. This points to the fact that either all participants are aligned in a similar fashion, or there are very few participants for this theme, or both. The Surveyors' Combined grouping average alignment is also slightly above the neutrally aligned (3.3) with a similar deviation to the Oil & Gas Surveyors (0.7). The Government respondents' grouping was highly aligned with the theme. The overall alignment of the respondents was just below slightly aligned (3.9) with a deviation of rank one.

This theme informs the context surrounding the requirements as set out under the Hybrid Cadastre policy and its subsequent revisions⁵². The focus is on how the changes in these requirements across the version (mostly from pilot to version 2.1) affect the ability of the project to gain widespread recognition and meet its goals of becoming an integral and useful tool for surveyors. Furthermore, a discussion surrounding the ramifications of some of the requirements on the practice, whether intended or not, is touched on by the respondents throughout.

The results provided from the ordinal analysis show a high overall alignment with the respondents towards the theme, which is indicative of their view that the requirements are sufficient for practice under the Hybrid Cadastre. As was the case before, there is a slight difference between the Oil & Gas Surveyors and Municipal Surveyors groupings.

Topics pertaining to the requirements that came up as challenges to practice included requirements to intersect boundaries on Hybrid Cadastre projects, and the resultant changes in this requirement as the policy has progressed. The grandfather period came up as a hindrance to practice, due to the fact that it is the client that submits the plan. In instances beyond the practitioner's control, the client submitted the plan after the grandfather period had expired, resulting in the plan being assessed on a different set of requirements than those in which it was prepared for.

Overall, most practitioners viewed the requirements as sufficient, but saw barriers to the widespread adoption of hybrid products in their practice as a result of uncertainties inherent to this product. Some respondents had a bad experience with a hybrid product and given the stability of registration for conventional products chose to avoid hybrid products.

The landowner and academic grouping were exempt from this question as it pertained to the requirements of the Hybrid Cadastre project. Neither of these participants had any experience working under the Hybrid Cadastre project, let alone within the context of the requirements thereof.

⁵² There have been a number of versions of the Hybrid Cadastre initiative over the past 7 years. These start with when it was a pilot project and progress through versions 1, 2, 2.1, up to the most recent version 2.2.

Oil & Gas Surveyors

The Oil & Gas Surveyors respondent grouping is an average of slightly above neutrally aligned (3.4) with a deviation (0.7) of less than rank one. Of the respondents in the Oil & Gas grouping, one was highly aligned, one was slightly aligned, and six were neutrally aligned with the theme.

The one respondent who was highly aligned with the theme viewed the requirements set out under the Hybrid Cadastre as sufficient and being above and beyond what is normally required in the survey profession. In the long term, the intersection requirements should be discussed once the level of integrations between Hybrid products and existing dispositions is sufficient.

The one respondent who was slightly aligned with the theme viewed the standards as overall sufficient, and only had a few issues stemming from practical instances. The one of note being the changes relating to intersection requirements between the pilot and full project, which caused inherent adoption problems for practitioners. Otherwise the respondent viewed the requirements as sufficient with practitioners becoming familiar with the nuisances with the Hybrid Cadastre products as they use them.

The remaining six respondents were neutrally aligned with the theme and viewed the standards as somewhat sufficient but could use a series of improvements. Most of these issues stem from the creation of a Hybrid Cadastre product as it relates to the generation of the plan. Issues that were identified commonly among this group of respondents included communication of standards, timelines for standards, and the application process. A common trend among the practitioners was the variability of the application process, and the inconsistent means of rejections that they had perceived.

When queried if the application process was similar to that of Land Titles, in which small clerical discrepancies are treated with a degree of forgiveness, it was provided that this is not the case. The practitioners found that often this human working component of the land checking / practitioner relationship was less pragmatic.

Given that these initiatives are new, some practitioners understood the need for a hard line in applying the standards, while others viewed the hard line as inappropriate, given the fact that both the government and practitioners were learning about this initiative as they went.

Municipal Surveyors

The Municipal Surveyors respondent grouping is an average of neutrally aligned (3) with no deviation. This lack of deviation is indicative of only one respondent providing feedback to this question, with the remainder opting to not discuss the requirements of the Hybrid Cadastre given they have never worked within in context.

The one respondent who provided sufficient responses to the key informant questions was neutrally aligned with the theme as it related to the requirements of the Hybrid Cadastre standards. This practitioner responded in the context or framing of their experiences, specifically the Section 47 requirements. In this context there was a concern regarding the requirements for the number of ground control points (GCPs) and the distance between these. Hybrid Standards only require two physical monuments to tie the mathematical evidence and they must be within 10 kilometers of each other, and the plan.

This viewpoint is understandable given the higher constraints put on Section 47 products that require a network with specific distances between monuments and network points depending on the setting⁵³. This feedback informs the discrepancy between the fields of practice in terms of what is expected for ground control when working with coordinates as evidence. It elucidates that even though the Hybrid Cadastre requirements are for public lands surveys, in the future the adoption of coordinates across more of the province may require a shift towards Section 47, i.e., as it relates to requirements for physical control in the ground to tie the mathematical plan to the earth. The requirements are also a result of the degree of risk in boundaries on public lands, often in un-surveyed territory, versus municipal subdivision with potentially many affected parties, i.e., landowners.

⁵³ That is, municipal vs rural. Marking requirements are noted under Section 47 Surveys Act (R.S.A. 2000, S-26), and practice specific requirements are discussed in the Manual of Standard Practice (Alberta Land Surveyors' Association, 2019).

Combined Surveyors

The Combined Surveyors respondent group is an average alignment of slightly above neutrally aligned (3.3) with a deviation (0.7) similar to the Oil & Gas Surveyors grouping. This is heavily weighed to the Oil & Gas Surveyors respondent grouping, seeing as all eight responded compared to the one Municipal Surveyor who provided feedback. Thus, a degree of bias must be inferred when reviewing these results, seeing as they do not really represent all the combined surveyors' perspectives.

Government

The Government respondent grouping was highly aligned with the theme that the requirements established under the Hybrid Cadastre were sufficient. This stems from their biases as having set up the project and having spent a great deal of time going through a pilot project feeling that they have covered all the main aspects well. As with all new initiatives, learning points and growing pains are the norm, and it is expected that minor and unforeseen issues will come to the front as more hybrid plans are produced. Since this research began, the requirements have gone through two revisions and has enabled feedback to be incorporated into the working requirements.

4.3.7 Monuments under the Surveys Act

The final theme attempts to narrow in how monuments are defined and viewed by the profession (practitioners) under the Alberta Surveys Act, in light on the Hybrid Cadastre. The Hybrid Cadastre has provided a *de facto* interpretation that coordinates can be considered as monuments for the purposes of the standards. The metric established for alignment with the theme is previously outlined in section 3.8.7. The average alignment of the respondent groupings to the theme is provided in Figure 21.

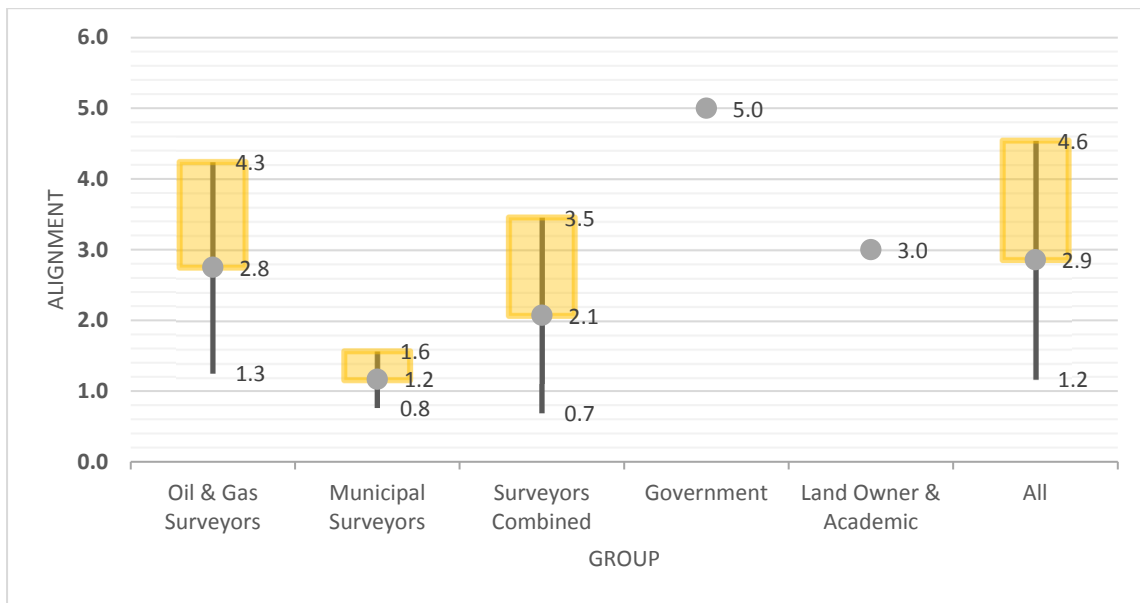


Figure 21 – Alignment of Respondent Groupings for the Monuments under the Surveys Act Theme

The average alignment across the Municipal Surveyors respondent grouping close to highly non-aligned (1.2) with a relatively small deviation (0.4). This is quite different than the Oil & Gas Surveyors respondents with an average alignment of just below neutrally aligned (2.8). This respondent set has a large deviation of above one rank (1.5) and highlights the diversity of responses as it pertains to this theme. The Combined Surveyors grouping has an average alignment of just above slightly non-aligned (2.1) and also has a large deviation in responses (1.4). The Government respondents are highly aligned with the theme (5), and the Landowner & Academic grouping is neutrally aligned (3). Overall, the respondents were slightly below neutrally aligned (2.9) with a substantial deviation (1.7). This further points to the discrepancy in alignment across the respondent groupings.

Oil & Gas Surveyors

The Oil & Gas Surveyors' respondent grouping is an average of slightly below the neutral alignment (2.8) with a large deviation of 1.5 ranks. Of the respondents in the grouping two were strongly aligned, one was neutrally aligned, four were slightly non-aligned, and one was strongly non-aligned with the theme. No respondents were slightly aligned with the theme.

The two respondents who were highly aligned with the theme viewed monuments as anything that is intended to mark or be used to define a boundary. The key for these respondents is the intent by a surveyor, in which they view coordinates as a form of monuments since surveyors create a coordinate with intent to define the boundary. This is a *de facto* interpretation of what can be considered a monument in present times based from on the ground perspectives. It provides this elevation of coordinates as a form of legal survey evidence based on the degree of repeatability and confidence in a coordinate derived position that is provided by modern survey technologies.

The respondent who was neutrally aligned with the theme provided that monuments are physical iron posts and did not view monuments and coordinates as the same thing. Specifically, this perspective provided that the respondent does not view that coordinates are what is meant by a monument as defined under the Surveys Act. It is noted that this was not the intent of the definition of a monument when the act was written and has concerns with subsequent *de facto* interpretations thereof. This respondent is amenable to the use of coordinates as evidence given their use of Hybrid Products in their practice. However, philosophically they do not view the two definitions as the same.

The four respondents who were slightly non-aligned with the theme view monuments as physical marks under the act and not the same as coordinates, however they are amenable to coordinates role as evidence in the current limited circumstances. These respondents are more circumspect of the concept of coordinates as monuments, but still amenable to their use as evidence.

Ideally, they would be described as taking a narrow view on the *de facto* interpretations of monuments under the Surveys Act in recent times. Emergent from this group was the realization that even though some of these practitioners use Hybrid Cadastre products, they are still trying to rationalize the *de facto* interpretations pertaining to coordinates as a form of monument.

The respondent who was highly non-aligned with the theme viewed monuments as something that was physical and went into a great deal of detail relating various kinds of monuments that can be found and subsequently interpreted by a surveyor. This respondent provided a positive view of defining in the legislation what a coordinate is, instead of arbitrarily assigning it under the definition of a monument.

A commonality across these alignment subsets was the acceptance that monuments are physical objects in the ground and tangible and can constitute more than just a statutory iron post. Often spikes, iron bars, drill holes, lead plugs, magnetic nails, and wood posts were discussed as other forms of monuments in the eyes of these practitioners.

Municipal Surveyors

The Municipal Surveyors' respondent grouping is on average close to highly non-aligned (1.2) with the relatively small deviation (0.4). Of the respondents in the grouping, one was slightly non-aligned and five were strongly non-aligned with the theme of monuments and coordinates being considered the same under the Surveys Act. No respondents in the municipal group were strongly, slightly, or neutrally aligned with the theme.

The respondent who was slightly non-aligned with the theme viewed monuments as physical marks on the ground but was amenable to the use of coordinates as evidence given that the concept was reframed. The respondent discussed the differences between coordinates defining boundaries from a control network such as in Section 47 plans, versus the polar plan coordinates of interior lots in Block Corner era subdivisions.

The five respondent who were non-aligned with the theme held that monuments were physical marks on the ground, and coordinates did not fit this definition under the Surveys Act. The viewpoint provided was that the *de jure* interpretation of the Surveys Act held, that required monuments to be physically placed on the ground and leave some mark. This follows with the three Ds as discussed in section 2.2.3 whereby monuments are a physical demarcation of a boundary location on the ground, and coordinates are a mathematical representation of a vertex of the delineation on the plan.

Stemming from this feedback is the perspective that it is the means by which modern coordinate initiatives are progressing that provides the concern from respondents, not the principle of using coordinates as evidence. Furthermore, it was a common discussion point that coordinates were seen as relative, while physical monuments were absolute. This relates to the fact that coordinates can move over time through datum changes and transformations between projections and coordinate frames while the monuments stay in the same position in the ground.

Combined Surveyors

The Combined Surveyors' respondent group is an average of just above slightly non-aligned (2.1) and also has a large deviation (1.4) in respondents' alignments. This low alignment stems from the Municipal respondents' narrow views of coordinates within the context of the legislation, and overall relates to a more *de jure* interpretation of monuments under the act.

Overall Oil & Gas practitioners were more amenable to coordinates being a form of monuments under the act as a *de facto* interpretation for the Hybrid Cadastre. However, even the alignment with this grouping was indicative of some amendments to the legislation and clarity pertaining to these forms of evidence being welcomed.

Landowner & Academic

The Landowner & Academic respondent grouping provides a neutral alignment with the theme of what a monument is classified as under the Surveys Act. In this instance, the neutral position is taken because the respondents are not overly familiar with the Surveys Act and are in principle open to the idea of coordinates holding an alternative monumentation status in the future. From the respondent's perspective, as it pertains to their property, they consider a monument to be a mark on the ground.

Government

The Government respondent grouping is an average of highly aligned with the theme. It is in the government's interest for the interpretation to be that a coordinate can be a monument, otherwise the predication of the Hybrid Cadastre is built upon tenuous footings. This is explicitly stated in the standards, and the entire initiative hinges on the ability to *de facto* interpret coordinates as monuments for the purposes of surveys under the Hybrid Cadastre.

4.4 Summary

This chapter presented the results and analysis of the ordinal ranking of the themes stemming from the qualitative analysis of the key respondent's dataset. The specifics of the sample of participants was discussed, and the ordinal 5-point method results were presented in tabular form. Analysis of these results in the context of each theme, and the degree of alignment between the respondents and the theme were analyzed, and key learnings from the respondents were used as a means to provide context as it relates to the initiative of coordinates as evidence in Alberta. A discussion of these inferences is provided in chapter five.

Chapter Five:

Synthesis and Discussion

5.1 Introduction

Throughout this research, the topic of focus has been the ability for mathematical coordinates to define legal survey boundaries. As interest in the adoption of coordinates as evidence has peaked in recent years, so have initiatives to adopt them. The Hybrid Cadastre is the most modern initiative in Alberta that incorporates coordinates and provides a unique purview into how the transition to the incorporation of coordinates as evidence can occur.

The literature review in Chapter Two provides perspective of mathematics as evidence governing in other jurisdictions in different periods of time. Ultimately, as shown throughout the historical review, coordinates can be used to define legal boundaries to land if they are provided the correct framing/context. This requires rigid guidelines and regulatory frameworks being enacted to ensure that there are checks and balances in the process of creating boundaries by coordinate. Depending on the jurisdiction, this could require statutory, regulatory, and practice-based changes, and in some instance's judicial purview and assessment.

The methodology for the research in chapter three highlights the use of qualitative data gleaned from participants during the field study. Themes are generated from this dataset that relate directly to the questions in the interview guide. A 5-point ordinal assessment is adopted to organize and present the data in a uniform manner. The respondents are then ranked against the themes, to provide a means of quantitatively aligning the responses. The results and analysis of the ordinal assessment presented in chapter four provide keen insights into the generalized view of the profession as it relates to coordinates as evidence in Alberta.

This chapter provides a discussion of the results and analysis and a synthesis of emergent theory stemming from the research. Considerations relating to coordinates as evidence in Alberta under the Hybrid Cadastre initiative are presented through responding to the initial research questions and hypothesis. In adopting coordinates as evidence, the practical requirements and work on the ground is much simpler to enact than getting the legal constraints framed correctly.

This is ultimately not the focus of the author, and since he is not a lawyer, he would not attempt to provide commentary on this. The author has considerable background in the study of law as it pertains to the field of surveying. With that being said, it would take some judicious legal minds to ensure that any future initiatives are securely established such that future legal challenges do not arise.

5.2 Initial Research Questions

The initial research questions are discussed in the context of the feedback from the respondents and the ordinal assessment provided in chapter four as informed by the literature review and the feedback from the key informants. The responses to these initial research questions provide insights about the Hybrid Cadastre and the topic of coordinates as evidence in the context of Alberta as informed by the data. The ordinal alignments of the informants with the themes is also discussed.

1. What is the current system for establishing property boundaries in Alberta?

The current system for establishing property boundaries in Alberta is a traditional cadastral model, as discussed in section 2.6. This stems from the monumentation requirements set out under Section 45 of the Surveys Act for the establishment of new boundaries (Government of Alberta, R.S.A. 2000, S-26). As discussed in section 2.6.2 of the literature review, the period prior to June 9, 1988 was colloquially known as the Block Corner era, and the interior lot lines along a block were not required to be posted (*Ibid*). These were established through mathematical proportioning of the delineated plan distance with respect to the true ground distance between the block monuments.

The period following June 9, 1988, all newly established boundaries were required to be monumented at the beginning and end of all curves, at all deflections, and at any affected intersecting boundaries. Simply put, the current system for establishing property boundaries in Alberta is through physical demarcation with statutory iron posts. This is colloquially known as “monuments govern” and incorporates the Hierarchy of Evidence in assessing survey evidence.

This description of the current framework as “monuments govern” was a common viewpoint among the respondents who are practitioners in the field of land surveying. Section 47 plans are incorporated into this current model, however, since coordinated positions under these products must be monumented within a finite timeline, they are not considered governing evidence over the long term, albeit just during the construction phase of development (Government of Alberta, R.S.A. 2000, S-26).

This has been the status quo for the past three decades, until the recent advent of the Hybrid Cadastre, which enables coordinates to indefinitely define boundary positions that delineate between legal interests in land. It should be noted that these are not able to be used on traditional property boundaries, rather only on lands under the purview of the Public Lands Act, i.e., Crown lands (Government of Alberta, R.S.A. 2000, P-40).

2. How would you place or re-establish a monument in the traditional Alberta cadastre?

This question is intended to discern the differences between re-establishments in the traditional monument driven cadastre, and that of more recent blended cadastral initiatives. In scenarios pertaining to traditional cadastres, the retracement and subsequent re-establishment of lost monuments is done with respect to adjacent monuments that are along the boundary of the lost monument, and ideally on the same plan of survey⁵⁴. In more complex scenarios, such as Mount Royal⁵⁵ area of Calgary, the search of adjacent monuments along boundary lines can be an exercise in diminishing returns, bordering on futility. In some instances, a resurvey under the acts is simply the only path forward⁵⁶.

⁵⁴ It is possible to do re-establishment that have to cross plans of surveys. A plan of survey that has been registered is checked for congruency with itself, not necessarily with monuments shown in adjacent plans. Thus, by crossing plans a practitioner is incorporating the errors incumbent in both plans of survey, i.e., the survey plan has to close within a tolerance. It then follows that working across plans incorporates the errors incumbent in both plans, in theory. Crossing plans and re-establishments with evidence that is further and further away from the lost position is ultimately an exercise in diminishing returns. However, this is not to say that this isn't the best evidence to inform a most probable position of the original monument.

⁵⁵ The Mount Royal area is known for having a lack of evidence. This perspective stems from both the informant's responses and the researcher's personal experience in performing resurveys in these neighbourhood.

⁵⁶ A respondent discusses this in the context of Fort McMurray after the 2016 wildfire that decimated the evidence in the ground. Natural events, and force majeure instances lend themselves more toward coordinate defined positions in that the coordinate cannot be destroyed by one of these types of scenarios.

In contrast, the more recent initiatives with coordinates as governing evidence means that a practitioner is not looking for a monument on the ground at many of these positions. It has been maintained that the use of a Re-establishment Coordinate (RC) under the Hybrid Cadastre is performed by a practitioner in the same way as if re-establishing a monument. The difference being that on a Hybrid Cadastre product there are only two Reference Points (RPs) that hinge the product to the ground. This results in less monuments and physical checks on the ground for practitioners to find in Hybrid Cadastre instances.

3. What are the allowable changes to permissible boundary evidence in Alberta under the Hybrid Cadastre? How do these changes affect Alberta?

The Hybrid Cadastre allows the use of mathematical coordinates to define boundary positions in lieu of monuments indefinitely. This is a substantive change in terms of practice, as all previous initiatives with coordinates as evidence in the province, i.e., Section 47 plans, are much more limited in their scope. These are enacted through legislation.

The initiative allows for the use of Establishment Coordinates (ECs) to *de facto* act as monuments and define the theoretical position of legal boundaries on the earth. The reason a theoretical description is used is that since there are no marks left, the exactitude of the position is defined by the delineation the coordinate provides on the plan. Furthermore, since the coordinate is established within a tolerance (in this case a confidence interval), it can be said that the theoretical position ranges within the bounds of this. With no mark to indicate the original observations position, the coordinates can only be accepted as a position with a relative ellipse of confidence. There is not an exactitude to the coordinates even though they are shown as such on plans.

Thus, since nothing is tangible on the ground, i.e., monuments, to compare between the time of original survey, and subsequent surveys, it is inferred that this position is theoretical until such a point as it is attempted to be retraced. This hinges on the principle that coordinates observed in the field can be adjusted and shifted to fit adjacent hybrid products, and since these coordinates are not often re-checked in the field after these adjustments, the validation of the alignment of the theoretical coordinate and the intended position will not occur until successive retracements.

There are some constraints to this in terms of the number of physical monuments required for a Hybrid Cadastre plan (two monuments, within 10 kilometers of each other) and specifications relating to confidence of coordinates used. However, the technical specifications are not the focus of this, it is the fact that coordinates now define the position of legal survey boundaries on public lands. This does not relate to lands held privately by Alberta citizens, but those on Crown land whose survey is intended for the exploration of resources and public infrastructure. Since Crown lands are dealt with through dispositions under the Public Lands Act, and these relate to leases and licenses, these coordinates in effect govern the extent of legal interests in the land, but not necessarily rights to ownership.

4. How does this compare in relation to the international instances/ experience?

As discussed in the literature review in chapter two, the international instances of working with coordinates as evidence are varied. The only instance that has given a legally governing status to mathematical evidence and by default coordinates is South Africa in 1962. This was done through a regulation to the 1927 Land Surveys Act 9 and allowed for the office of the Surveyor General to provide an official coordinate for a specific monument. Barry (2004), notes that this may have been done unintentionally and was rarely applied in practice due to the confliction between assigned governing coordinates and original monuments.

Prior to this, there were instances in the South African context in the 19th century before it was a single nation state and still a collection of colonial interests. During this time, mathematical plan data was held as superior to monuments in the ground. This is previously discussed in section 2.4.1 in detail, but these instances across the Cape of Good Hope and Transvaal commonly highlight complexities that can arise from elevating mathematical evidence over monuments in the ground.

Recent initiatives in the Australian Northern Territory have provided for coordinates to be used as evidence but under constrained scenarios. As previously discussed in section 2.4.3 of the literature review, this is a progressive step towards coordinates being granted widespread legal acceptance.

5. How will the prevailing theories on the establishment and security of legal boundaries be affected considering the evidentiary changes of the Hybrid Cadastre?

The concern as it relates to security of boundaries is not with the idea of using coordinates as governing evidence or legal boundary positions, but rather the manner of implementation and legislative supports. Currently, there is a gap in the perceived status afforded to mathematical coordinates as evidence under the Hierarchy of Evidence. As informed by the analysis of the respondents' ordinal alignments with the themes in section 4.3, there is a wide discrepancy in terms of how these are viewed. Some practitioners view them as *de facto* original monuments under the hierarchy, while others treat them with a lower evidentiary weight akin to mathematical plan data.

The recent arguments for the elevation of coordinates as evidence under the hierarchy is that given the advancements in position technologies, and the ability to perform consistent and repeatable measurements with confidence they should be afforded a higher weight.

Interpretations of coordinates under the Hierarchy of Evidence is not definitive at this stage, and it most likely will not be until the veracity of this kind of survey evidence is put before judicial purview. Alternatively, legislative and regulatory changes could alleviate some of these concerns.

6. How do indicatory monuments relate to the changes in evidence proposed by the Hybrid Cadastre?

The focus of this question is to determine if witness and indicatory monuments that have existed in the Alberta cadastre since the early Dominion surveys are similar to coordinates referenced to monuments. Basically, the principle of an indicatory or witness monument has held since the Dominion Surveys of the Alberta Township Framework and have allowed for a monument with a planar distance along a bearing to witness a position.

In essence, it is the witness monument to the position that is held as highest, or in essence governing the position through witnessing it. Thus, the adoption of boundary locations that are governed by mathematical relationship to adjacent monuments on the ground is founded and is akin to the use of coordinates historically.

The key difference is that one is represented in a polar system of bearings and distances from a monument, while the other is a Cartesian representation of this with respect to a specific reference origin.

5.3 Alignment with Hypothesis

The alignment of the hypothesis with the information gleaned from the themes, and the respective perspectives of the profession provide the ability to comment on each of the hypothesis critically. The context of this commentary is informed by the material discussed in the literature review. This provides insights in regard to the respondents' feedback, the case law, legislative law, and practical implications coalesce under each of these.

Hypothesis 1:

Formalization of the Hybrid Cadastre in Alberta and the changes to evidence, specifically regarding coordinates, requires a change to the hierarchy to incorporate coordinates.

This relates to respondents who view coordinates the same as plan distances, as mathematics, and just because there is more advanced technology that provides better confidences in coordinates does not mean that the hierarchy can be arbitrarily set aside. The respondents that aligned with this hypothesis were more vested towards the municipal field of practice.

This can partly be attributed to the perspectives of the Section 47 plans that these practitioners incorporate into their practice. These plans allow for coordinates to be used under the Surveys Act for a finite period of time, a year, and boundary locations are simply being held by the coordinate while construction occurs. Subsequent to construction, these positions are monumented as per the requirements. When discussing coordinates throughout the data collection, it was common for practitioners who identified as the municipal area of practice to discuss the concept in the context of these products.

Hypothesis 2:

Formalization of the Hybrid Cadastre in Alberta does not require formal change to the hierarchy, but rather a change in the emphasis on how coordinates are handled.

This relates to the respondents who view coordinates as assisting in work with monuments, given their limited scope that is akin to the Section 47 plan. Since these plans are legislated to allow coordinates for a short period of time to assist in construction, they are a change of emphasis, but not a modification of the hierarchy. Furthermore, these instances are supported by proper legislative and legal underpinnings. This view aligns with most of the Municipal respondents in the study and provides a practical use of coordinates founded in the *de jure* provisions pursuant to their use.

Hypothesis 3:

Formalization of the Hybrid Cadastre in Alberta does not require formal change or a change of emphasis from the perspective of the Hierarchy of Evidence in order to adopt the use of coordinates.

This relates to the respondents who view coordinates as interchangeable with monuments under the hierarchy, in light of the original intent of the surveyor placing the monument and registering a statutory declaration. This does incorporate both a *de facto* interpretation of monuments under the Surveys Act, as well as inferences that it is the intent of placing an original monument that provides its weight under the hierarchy, and since a coordinate can be placed on a plan with intent it represents the same. This is a modern viewpoint, emergent in-situ with the Hybrid Cadastre initiative, and further is validated by its continued use. The validity of this viewpoint is based on interpretation of legal statute and is implicitly biased by the general economic ramifications of having to place less monuments.

5.4 Emergent Theory

The emergent theory stemming from the inductive research in this thesis is that mathematical evidence in the form of coordinates can govern legal survey boundary positions given that the initiatives are provided for special scenarios that have lower thresholds for risks associated with tenure security, and are enacted in a manner that fits within the current legislative context.

The use of mathematical coordinates as legally governing evidence in boundary surveys is a feasible application under the Hybrid Cadastre given the *de facto* interpretation of coordinates as monuments under the Surveys Act. Under this context it can be said that coordinates are a *Sui Generis*⁵⁷ form of boundary evidence. This is explicitly provided by the wording in the Hybrid Cadastre Standards, where,

“A coordinate is deemed to be a monument for the purposes of determining disposition boundaries on public lands” (Government of Alberta, 2020).

Although this statement does not mention the Surveys Act, it fits within it by interpreting a coordinate as a monument within the intended scope of Hybrid Cadastre plans. This initiative is adopted within the current Alberta legislative framework with its scope being reserved to public lands held under the ownership of Her Majesty the Queen in Right of Alberta⁵⁸.

These propositions are emergent from the hypotheses, which are informed by the thematic analysis of the key informant responses and the 5-point ordinal assessment. These align with the emergent continuum for framing coordinates as evidence in practice which is presented in the next section. The learnings from the Hybrid Cadastre context are transmutable to other jurisdictions, however the specific form of the initiative, i.e., a policy under the legislative framework unique to Alberta, is not. This stems from the variability in how societal initiatives are enacted through legislation and subsequent regulation, and where the emphasis is placed, i.e., in the law or the regulations meant to interpret the law.

⁵⁷ As defined in the glossary, Latin for “*of its own unique properties, distinct*”. The *de facto* interpretation of allowing coordinates to act in a similar manner (legally speaking) as monuments provides that they are in practice being considered a unique form of evidence for establishing legal survey boundaries.

⁵⁸ This is the official title for the government on Crown lands.

5.5 Emergent Continuum

An emergent continuum is proposed in Figure 22 as a means of describing how much weight is placed on coordinates as evidence, what that means in context, and the associated risks and benefits assigned to this application. The basic premise is how coordinates are treated, as absolute or relative. Currently monuments are considered absolute⁵⁹, while plan data is considered relative as is discussed in the Block Corner era. This continuum represents the divergent approaches to coordinates as evidence, and under each are the key topics that define the approach.

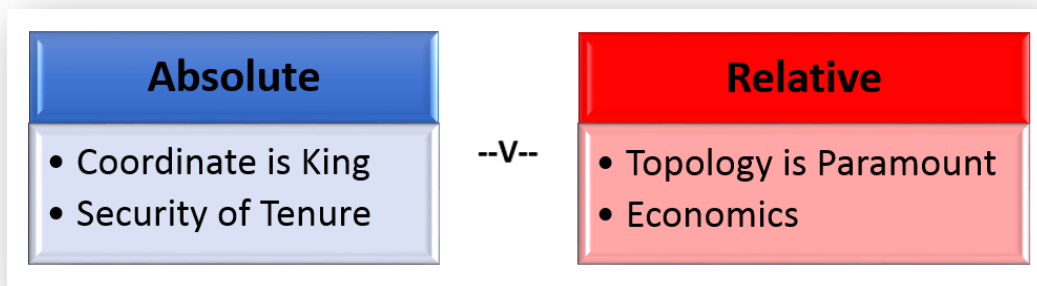


Figure 22 – Emergent Continuum for Coordinates as Evidence and Effects on Land
The ramifications of treating coordinates as absolute provides for greater security of tenure, however strictly sticking to this concept that coordinates must be exactly the same can produce practical problems in managing a coordinated dataset. This was provided as contextual feedback throughout the research as it related to the Hybrid Cadastre in that previously adopted Establishment Coordinates (EC) are considered absolute, and future hybrid products must adjust to this realization. This could prove to pose problems on a longer management timeline, in which adjustments to the dataset may result in coordinated positions that are not relevant with real world solutions decades later.

⁵⁹ Under the assumption they are found in good condition and constitute the original monument.

This can become complex when working in an area with intersections of multiple different hybrid products of different eras, with it being impossible to shift and adjust to all coordinates, but just one realization⁶⁰. Thus, the discrepancy between the observations taken during the survey and the published coordinates would be a result of propagation of errors in measurements across products. This is informed by the viewpoint that no two Precise Point Positioning (PPP) solutions are necessarily exactly repeatable, and often times there is a discrepancy of a few centimetres, up to a decimetre with previous coordinates⁶¹.

In the context that coordinates are treated as relative position, as is similar to the Block Corner era of interior lots, coordinates can be assessed in terms of relative position. This means that coordinates are not taken quite literally as being either exactly the same or not and assessed based on a most probable position. In these instances, as long as coordinates are statistically within a high enough confidence or within the acceptable error ellipse for the type of coordinate, they are considered acceptable. Under this scenario, the topology of the plan data is paramount, and the coordinates are a function of this topology. This means that the relationships between coordinates should stay consistent and be adjusted across the data set.

This has a great potential to cause security of tenure issues as is exemplified in the easements in the Block Corner era, however from a pragmatic working stance provides for an easier practical framework. Less time has to be taken in terms of alignment between coordinates which are better from an economical point of view in managing the land framework. Albeit as with all instances of security of tenure versus economics, this could be a short-term benefit, as any long-term confusions that arise through the use of coordinates could cost more to fix after widespread adoption, i.e., legal remedies to systemic issues across blocks.

⁶⁰ An example of this could be a pipeline that is affected by its relative proximity to other previously registered Hybrid Cadastre products. In instances of longer pipelines this poses the question of which Hybrid Cadastre realization to adjust to, given that there could be a variety of Hybrid plans intersected that are from different epochs.

⁶¹ This is a direct function of the time of observation when performing a PPP static survey. The longer the observations, the greater the confidence in the reliability of the coordinate provided. If the original published coordinate is to be considered true, which also has an ellipse of error in its generation, then future observations using PPP would have a higher degree of accuracy as a direct relation to observation time. There is an upper limit in what repeatability is achievable, and sub-millimetre approximations require refined geodetic solutions.

These scenarios stem from the continuum above and act as a means of framing the coordinates in terms of how to assess their position, as either absolute or relative. A third scenario is included and commented on, in which the centrist viewpoint allows for some blend of absolute and relative perspectives of practice with coordinates. These have been brought into the practice and academic review by Barry in recent writings and discussions and provide various contexts by how coordinates should be viewed (Barry, 2019).

Scenario 1 – Coordinates are Absolute

In the first scenario, mathematical coordinates are treated as absolute to the position on the ground. They reference a fixed position on the ground. In this instance, the coordinate governs the position as has been discussed by Barry (*ibid*). The ‘Coordinate is King’, which elevates coordinates to a similar status as physical monuments. The coordinates are treated as exact, and management of the coordinate dataset requires the coordinates to be matched exactly on future plans. This ignores the stochastic nature of these coordinates as within a statistical ellipse of a specified confidence⁶².

These instances require a greater degree of diligence in practice, as well as being more costly in their survey endeavours. Stemming from the requirement for coordinates to be considered absolute is a higher degree of security in tenure requiring greater GNSS static observation times and confidence in these measurements. This means a greater degree of field work is required to achieve higher quality solutions. Albeit the efficiency of streamlined practice is more wanting in this scenario, but it comes down to the balance between efficiency of practice as it relates to economics, versus a higher degree of security in boundaries which has other inherent economic impacts. Less conflict in boundaries provides less costs for the general public stemming from disputes that may arise and require legal intervention.

⁶² Requirements for the accuracy of coordinates is provided in Section 4.2 of the Hybrid Cadastre Standards Version 2.2 (Government of Alberta, 2020). This requires that coordinates be generated with respect of a reference frame to five centimeters relative and ten centimeters absolute, both at a 95% confidence. This relates to the confidence of the coordinates prepared in the survey to be registered, and not with respect to interpreting previous establishment coordinates.

Scenario 2 – Coordinates are Relative

In the second scenario, coordinates are not given absolute status and are rather a piece of evidence used in the assessment. In these instances, coordinates can be invaluable in assisting with boundary re-establishment but are not to be treated as governing. Instead, they are treated probabilistically, i.e., the most probable position of a boundary can be the coordinate, but the coordinate must be assessed in a similar manner to a monument. This means that a perspective is given to the degree of error in generating the coordinate resulting in expected confidence of this position. Thus, in this instance, when a coordinate is an observation of a monument, the degree of misalignment of the coordinate with the monument in subsequent surveys accounts for this error in the coordinate's generation⁶³.

It is key here to take the coordinates in perspective and realize that they are a topology of vectors between points on the ground, just represented differently, i.e., as Cartesian instead of polar. In this instance it is the polar data, and polar relations between objects in the plan that must be maintained, i.e., the plan must conform to itself, and stay consistent relative over time. If the coordinate does not match the plan, then there becomes a conflicting discussion surrounding the coordinate governing even though it has been possibly misplaced.

This is similar to instances when a post is placed in error and has to be amended, however, with no tangible evidence on the ground it may be difficult to discern some of these issues. Thus, the maintenance of topology and the geometry of the product (plan of survey) and ensuring harmony with the cadastral fabric is key. This instance is similar to the Block Corner surveys of 1912-1988 where the entire plan can move relatively as long as it is equitable. These coordinated positions will shift over time as successive datum updates are realized. They are not a fixed absolute coordinate in time, and collective shifts as a function of the control that hinges them to the real world.

⁶³ Basically, if the coordinate matches the monument to within the accuracy standards for the generation of coordinates it can be considered acceptable. The coordinate value does not have to match up exactly given that perturbations in successive coordinate observations over time can be attributed to the propagation of random errors.

This view of coordinates as evidence vests towards the pragmatism of a streamlined practice, where chasing exactitude in coordinates can be a task of futility. This stems from the primary concern when dealing with people's boundaries and interests in land, in that no substantive changes should occur that can upset the peaceful occupation of land. Thus, this perspective realizes it is most important to keep everyone's interests equivalent in a relative manner. As highlighted by the Landowner & Academic grouping in Chapter Four this perspective could have assisted in preventing the lots of encroachment in these respondent's scenario. Taking coordinates as absolute in the face of long-standing possessory evidence of occupation can produce pursuant legal concerns that may never be settled.

This relative perspective also assists in the economics of practice, because technology and geomatics methodologies have advanced to a point where precise coordinates can be observed within a relatively short amount of time. Chasing absolute interpretations of coordinate values can cause surveyors to spend a greater deal of time attempting to provide conformity between products to ensure continued public faith in the cadastral framework.

A better approach stems from giving surveyors the ability to adopt the coordinates as provided on a previous plan given that their new field data confirms this position within an acceptable accuracy tolerance. Basically, arguments in the exact nature of coordinates at their extremes are a disagreement in the propagation of random errors in measurement techniques. This assists in making the practice more effective in providing a service to the public in a consistent manner as well as keeping the costs associated with surveying within reason of the intended use.

Scenario 3 – A Mix of Relative and Absolute

This third instance is indicative of a combination of the first two scenarios. In this framework, the use of coordinates as evidence has progressed to a point, in which there are different kinds of coordinates for different purposes in the cadastre. Essentially, it comes down to the principle of a hierarchy of coordinates as evidence, in which there are different confidences applied to different coordinate products.

Thus, in this scenario, it is possible to have certain coordinates that are treated as absolute, and some that are treated as relative. In this instance, some coordinates could be provided a status of having to be absolute, as is the case currently for traditional surveys with ASCMs and integration. These ASCMs are the cadastral framework that the subsequent survey products are fit within and referenced to.

An abridgement of this viewpoint could be provided in the context of the 1912-1988 Block Corner era, in which the monuments are held as absolute versus the plan distances for the interior lot lines between the block monuments. Basically, the relative positions are those that are mathematical, i.e., the lot boundaries, and the positions treated as absolute are the monuments⁶⁴. The weight that these coordinates hold is respective of the confidence of them and their purpose.

This is highlighted in the Hybrid Cadastre Standards, in which there are a variety of types of coordinates in practice (Government of Alberta, 2020). These include Establishment Coordinates (ECs) which are treated as governing and absolute, Re-establishment Coordinates (RCs) which are treated similarly to a re-established monument under traditional times, and Observed Coordinates (OCs) which do not govern but can provide evidentiary context as related to a boundary⁶⁵.

There has been a further discussion in describing coordinates as ‘Authoritative Coordinates (ACs) in recent publications (Janes, et al., 2020). This perspective was even emergent from the key informants’ feedback, in that there needs to be a further type of coordinate for those governing Establishment Coordinates (ECs) that have been subsequently verified with further survey work and provide a higher degree of confidence in their validity.

⁶⁴ This assumes the monuments are found in good condition and assessed by a practitioner as being original. Subsequent monuments in lieu of an original is considered as re-established as per the opinion of that practitioner and are not given the same legal weight as a true original monument.

⁶⁵ In the most recent version of the Hybrid Cadastre Standards (version 2.2), Observed Coordinates (OC) are noted as being surveyed to the same accuracy standards as the other coordinates. This is noted in Section 6 Georeferencing, and means that an OC can now be used as one of the two georeference points. This still requires that one be a physical Reference Point (RP) (Government of Alberta, 2020).

5.6 Triangulation of Data

This study triangulated the case law, documentary data, and key informant interviews as it pertains to the topic of coordinates as evidence under the Hybrid Cadastre. The feedback and assessment of the informant data informed of the viewpoints of practitioners as it related to the documentary data and case law. In the case of the documentary data, this meant perspectives on mathematics as evidence under the current legislation and Hybrid Cadastre standards. The themes for the requirements of the Hybrid Cadastre relate directly to the standards as written, and the current legislation is relevant for framing the context under which the initiative fits.

The literature review of the pertinent case law also came up in the key informant interviews as it related to the Hierarchy of Evidence. Of note, *McPherson v. Cameron* (1868) came up in relation to one practitioner identifying the key principle of viewing evidence from the lenses of providing the most confidence to the things in which humankind is least likely to mistake.

This was used as a validation for why mathematics is so far down on the hierarchy, and how just because coordinates can be more readily and precisely obtained, does not change their position on this hierarchy. Ultimately, the triangulation of the data provided that the learnings from the study were informed by practitioners' perspectives, legislative framings, and current viewpoints on case law.

5.7 Towards a Blended Cadastre

Ideally, a blended cadastre is one in which some monuments still exists to assist in hinging the mathematical data on the ground. The most pragmatic way forward is to explicitly define where coordinates as evidence can and cannot be used to define boundaries. Thus, as provided from the analysis of the key informant interview data, in which respondents generally perceived issues with the confliction in definition between coordinate and monuments, the need for further legislative initiatives in firming up the concept of coordinates as governing evidence is pressing.

Currently the *de facto* versus *de jure* interpretations of statute law cause philosophical conflicts for those well-versed in the topic and the practice of surveying. This highlights the issue of the public's ability to grasp and get behind the concept of monuments no longer being placed to define boundaries if there are philosophical misunderstanding surrounding the definitions. The current trend of trying to assign the concept of coordinate as a monument is fraught to fail, given that it is an attempt to assign definitions to things which they are not.

Definitions and writings, both in statutory and case law have provided over and over that a monument is something that is physically represented on the ground. Thus, it would be more prudent to move towards defining coordinates as evidence in the hierarchy, for example as a modified monument, or an ancillary monument. This stems from the achievable accuracy limits of GNSS solutions when attempting to retrace coordinates on the ground.

At the present time, in Canadian case law based on historical precedents relating to the Hierarchy of Evidence, mathematical evidence and coordinates would not be held as an original monument. This stems from the successive interpretations prior to this that highlight the marking on the ground as providing greater confidence in the position and thus a higher evidentiary weight in subsequent retracement. In order to avoid issues with legal interpretations of coordinates as evidence from judicial perspectives, it would be prudent for elected officials to amend legislative initiatives to align with this type of evidence.

5.8 Summary

This chapter provides a synthesis of the research by revisiting the initial research questions in context of the thematic analysis and respondents feedback. The alignments between the respondent's viewpoints and the three hypothesis is provided. An emergent theory of coordinates as evidence is presented, which informs a proposed continuum for assessing cadastral initiatives that incorporate coordinates. Finally, discussion surrounding the key learning towards achieving a pragmatic blended cadastral framework is presented.

Chapter Six:

Conclusions

6.1 Introduction

This chapter discusses the key learning stemming from the synthesis and discussion. The contributions the research provides to the understanding of coordinates as evidence in legal and practical terms are provided, as well. The relevant limitations and sources of error in the study are provided to validate the context of the research. Finally, future avenues of inquiry stemming from the learnings of the research are commented on.

6.2 Limiting Factors

This research is limited in its applicability to be cross applied to other jurisdictions due to the unique scope of the Hybrid Cadastre occurring on public lands in Alberta. Even now the Hybrid Cadastre could not be straight out applied to privately held freehold lands in Alberta without legislative intervention.

Furthermore, there is the variability in the legislative framework between Alberta and different provinces, Canada Lands, and international scenarios. It would be a task in itself trying to assess how each different region's legislative framework would have to be amended to adopting coordinates⁶⁶. This is outside the scope of this thesis and would be an excellent avenue for another inquiry hinged between the engineering and legal realms of academia.

Each jurisdiction generally has a survey act, but how these are written and what they include may vary significantly across the jurisdictions. Definitions are different across these pieces of legislation, as is the emphasis placed on their format.

⁶⁶ An example of the level of inquiry required for each jurisdiction, and the type of beholder required to achieve this is evidenced by Izaak de Rijcke's paper discussing the issues with coordinates as evidence in the Ontario instance (de Rijcke, 2016).

An example of this is the difference in the scope of legislation versus the regulations subsequent to the legislation in the various examples reviewed. In some jurisdictions, the act is simply meant to provide the general format of the constraints to surveying, while in others the bulk of the practical requirements are included in the act.

6.3 Sources of Error

The sources of error stem from the biases of the researcher, specifically his profession and educational background. The researcher is an engineering major and views the world in terms of a post-positivist viewpoint. This means the researcher views the world as recognizing biases in the taking of observations, and the need to discuss the biases present from the perspective of the beholder. This impacts the confidence that can be applied in inferences stemming from these observations.

Further to this, the researcher is also a surveyor and could be seen to have a biased viewpoint as it relates to initiatives that directly affect his profession. This stems from the means by which practice is taught, and the inherent impressions left throughout the researcher's articling/candidate time. Thus, the biases of the researcher lean towards the perspectives of the engineering and survey professions and are informed by firsthand experience.

A concerning bias presented from this research is that the sample vests towards practicing surveyors who are either directly or indirectly affected by the changes to practice with coordinates as evidence. This is a result of the highly specific scope of the Hybrid Cadastre initiative, and the public perspective being limited in its understanding of this initiative. It is important to note that this does not invalidate the need for further public perspective, rather is a result of the framework that is currently established for the management of publicly owned interests in land under this model of government⁶⁷.

⁶⁷ This relates to consultation for changes to how public resources are surveyed, and a pragmatic assumption is made that for the scope of the Hybrid Cadastre the public is less than concerned with slight changes to how wellsites on public lands are surveyed and defined. There is a lack of incentive for the public to be overly interested as a result of no direct impacts of this initiative on their position. In the event that coordinates as evidence are adopted widespread on privately held lands, this would not be the case.

6.4 Significance of the Research

The significance of the research hinges on the recent changes to what is considered permissible governing evidence as it pertains to legal survey boundaries in Alberta. Traditionally it has been physical monuments tied to legal plans, however with the Hybrid Cadastre the tangible monument is no longer required in all circumstances. This represents a substantive shift regarding how cadastral boundaries are tied to the land and provides a variety of potential problems and dilemmas that have not yet been addressed in the Alberta cadastre.

6.5 Contributions to Knowledge

This research contributes to the understanding of how coordinates as evidence can be applied in practice to govern legal survey boundary locations under the Hybrid Cadastre. It highlights the legislative and case law underpinning of the topic as it relates to survey requirements and the assessment of legal survey evidence under the Hierarchy of Evidence. Furthermore, it highlights the perspectives of the various parties involved pertaining to the use of mathematical coordinates as evidence. This included municipal and oil & gas practitioners, landowners, academics, and government officials.

Gaps and areas of concerns in the Hybrid framework and a future and further adoption of coordinates towards a blended cadastre with a higher emphasis on mathematics, is emergent from the qualitative analysis and is informative for future initiatives with coordinates. Given any instance of working with mathematics in modern surveying, there are unique scenarios that are applicable to understanding coordinates and their use. The scenarios discussed in this thesis can be cross applied in other similarly governed jurisdictions. They are specific to the Alberta scenario, and the history of both statute law and practice related to this jurisdiction. Finally, this research acts as a starting point for further work in the topic of coordinates as being legally governing evidence as informed by the Hybrid Cadastre and progresses the discussion following the previous academic work of Stephen Fediow (1995).

6.6 Future Work

This is a current and pressing topic in society as the drive for lower costs in surveying and greater efficiency are common. The updates to the land framework in the coming decades as it relates to the adoption of coordinates as evidence will allow for further avenues of inquiry and the ability for the researcher to respond to these changes within the context of the emergent theory and continuum.

To further this research upcoming inquiry would be related to reviewing further jurisdictions that incorporate coordinates internationally, and beyond the current scope of this thesis, i.e., commonwealth nations with similar legal structures. This work could be promoted to a hybridized multi-disciplinary study between the realms of technical GNSS engineering, and GIS and land tenure. Ideally, this would require a higher-level inquiry, by incorporating the survey and case law considerations of coordinates as evidence with further GNSS technologies and future geodesy initiatives.

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Appendices

Appendix A – Ordinal Assessment Raw Data

Grouping	Coordinates as Governing Evidence	Coordinates and Tenure Security	Coordinates as Monuments	Effect on Daily Practice	Hybrid Cadastre within Current Legislation	Hybrid Cadastre Requirements	Monuments under the Surveys Act
Land Surveyor	3	2	1	NR	NR	NR	1
Land Surveyor	3	3	1	3	3	3	2
Government	5	5	5	NR	5	5	5
Land Surveyor	3	4	2	4	3	NR	2
Academic	2	1	1	NR	NR	NR	3
Government	5	5	5	NR	5	5	5
Government	5	5	5	NR	5	5	5
Land Surveyor	4	4	3	1	NR	NR	1
Land Owner	2	1	1	NR	NR	NR	3
Land Surveyor	3	1	2	1	2	3	1
Land Surveyor	5	3	3	3	3	4	2
Land Surveyor	5	2	4	5	4	3	2
Land Surveyor	5	4	5	3	3	3	3
Government	5	5	5	NR	5	5	5
Land Surveyor	5	5	5	3	NR	3	5
Land Surveyor	4	1	3	2	4	5	1
Land Surveyor	3	3	2	1	1	NR	1
Government	5	5	5	NR	5	5	5
Land Surveyor	3	3	4	1	3	NR	1
Land Surveyor	5	5	5	3	NR	3	5
Land Surveyor	4	3	2	3	2	3	2

Appendix B – Certification of Institutional Ethics Review

The Ethics Confirmation page has been withheld as per the University of Calgary Faculty of Graduate Studies Thesis Formatting Guidelines.

Appendix C – Recruitment Email

2018-01-29
M.M.S.

Hello **NAME**,

My name is Matthew Sakatch. I am a Master's of Science (M.Sc.) student in the Geomatics Engineering department at the University of Calgary. I am doing my master's thesis study on mathematical evidence as it pertains to defining legal survey boundaries considering the recently initiated Alberta Hybrid Cadastre (HC). The University of Calgary Conjoint Faculties Research Ethics Board has approved this study.

I am contacting you to invite you to participate as a key informant in this study because you are a land professional who has knowledge on the theory of defining boundaries through mathematical evidence and have practical experience with the Alberta Hybrid Cadastre (HC).

There are some general questions that I would like to explore through this research, which include:

- 1) Please describe your experience as a professional land surveyor.
- 2) What is your experience with the Alberta Hybrid Cadastre?
- 3) How has the Alberta Hybrid Cadastre impacted you and your practice?

Please contact me directly should you wish to participate in this study. Upon receiving notification of your desire to participate, you will be provided a consent form to review. Participation in this study will include interviews between the participants and the researcher.

Should you have any questions or concerns in regards to the study, please do not hesitate to contact me.

I look forward to a positive discussion in the future and hope you will choose to participate in this study.

Thank you.
Matthew Sakatch, E.I.T., C.L.S., B.Sc.
ALSA Pupil
Geomatics Department
Schulich School of Engineering
Faculty of Graduate Studies, University of Calgary

Appendix D – Interview Guide

Oral Survey Questions

1 Boundary Theories

- 1) Describe your professional experience with land surveying for the establishment and maintenance of legal survey boundaries.
- 2) What jurisdiction do you practice in?
- 3) How are boundaries defined and maintained in your jurisdiction? Has this changed since you started?
- 4) In the jurisdiction of your practice, how is legal survey evidence assessed? How is mathematical evidence I.E. coordinates, interpreted in this evidentiary assessment?
- 5) For tenure security, do you believe that co-ordinates are equivalent, more than, or less secure than physical Monumentation?
- 6) Where do you view mathematical evidence or coordinates in the hierarchy of evidence in the current system?
- 7) Do you foresee any risks or benefits in terms of tenure security and legal status of survey boundaries in a transition to coordinate defined boundaries?

2 Alberta Hybrid Cadastre

- 8) Have you prepared and submitted Hybrid Cadastre plans under the Alberta Hybrid Cadastre?
- 9) Describe your experiences with the plan requirements and submission process.
- 10) What are your thoughts on the survey requirements as set out by the Directory of Surveys for the Alberta Hybrid Cadastre policy? Are these sufficient? What might improve these standards?
- 11) Were the practical requirements that came out of the pilot project sufficiently informed and implemented in the resulting policy?
- 12) How has the initiation of the Alberta Hybrid Cadastre affected the management and operation of your survey practice?
- 13) What are your thoughts on the legal ramifications of the Hybrid Cadastre in the context of current statutory legislation?
- 14) In your opinion, what do you interpret monuments as under the Surveys Act?
- 15) Do you feel that case policy informed practice, or practice informed policy?