




Developing a Quasi-Temporal GIS for Archival Map Data

2003 ESRI User Conference
San Diego, CA

Stefan Freelan, MS
GIS Specialist
Huxley College of the Environment
Western Washington University, Bellingham WA



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*Combining old maps with new technology
(GIS) for historical research*

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Outline

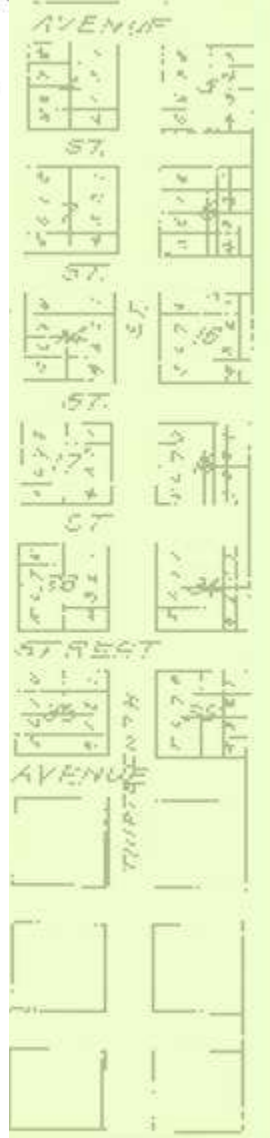
- Archival Maps
- GIS (& Historical Analysis):
 - Time
 - TGIS
 - tGIS Extension
- Case Study (Fairhaven, WA: 1880-1930)
- Conclusions & Recommendations

Archival Maps



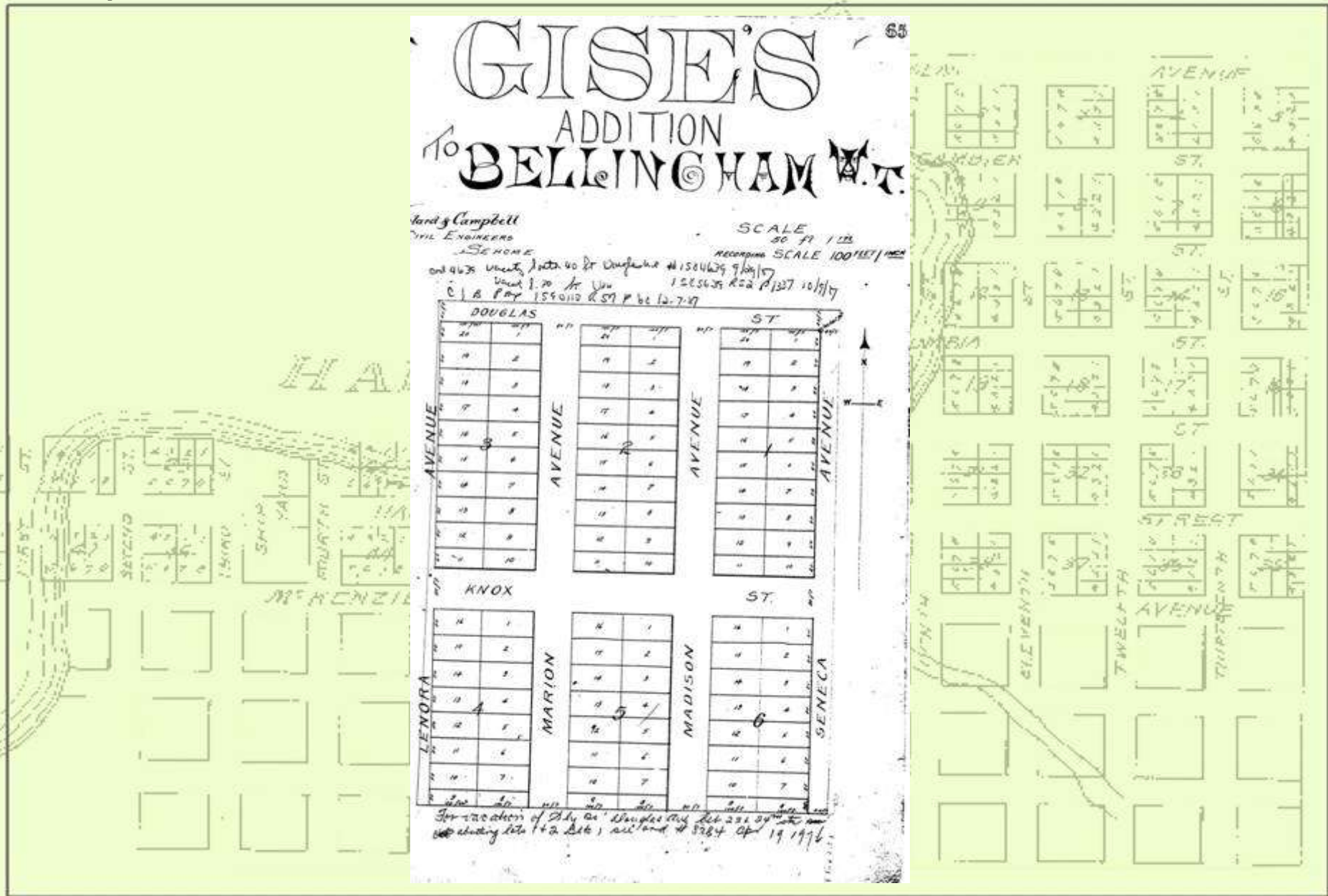
Reconnaissance of Bellingham Bay- U.S.C.S, 1855 - J. Alden

Hydrographic Survey



Reconnaissance of Bellingham Bay- U.S.C.S, 1855 - J. Alden

Plat Map



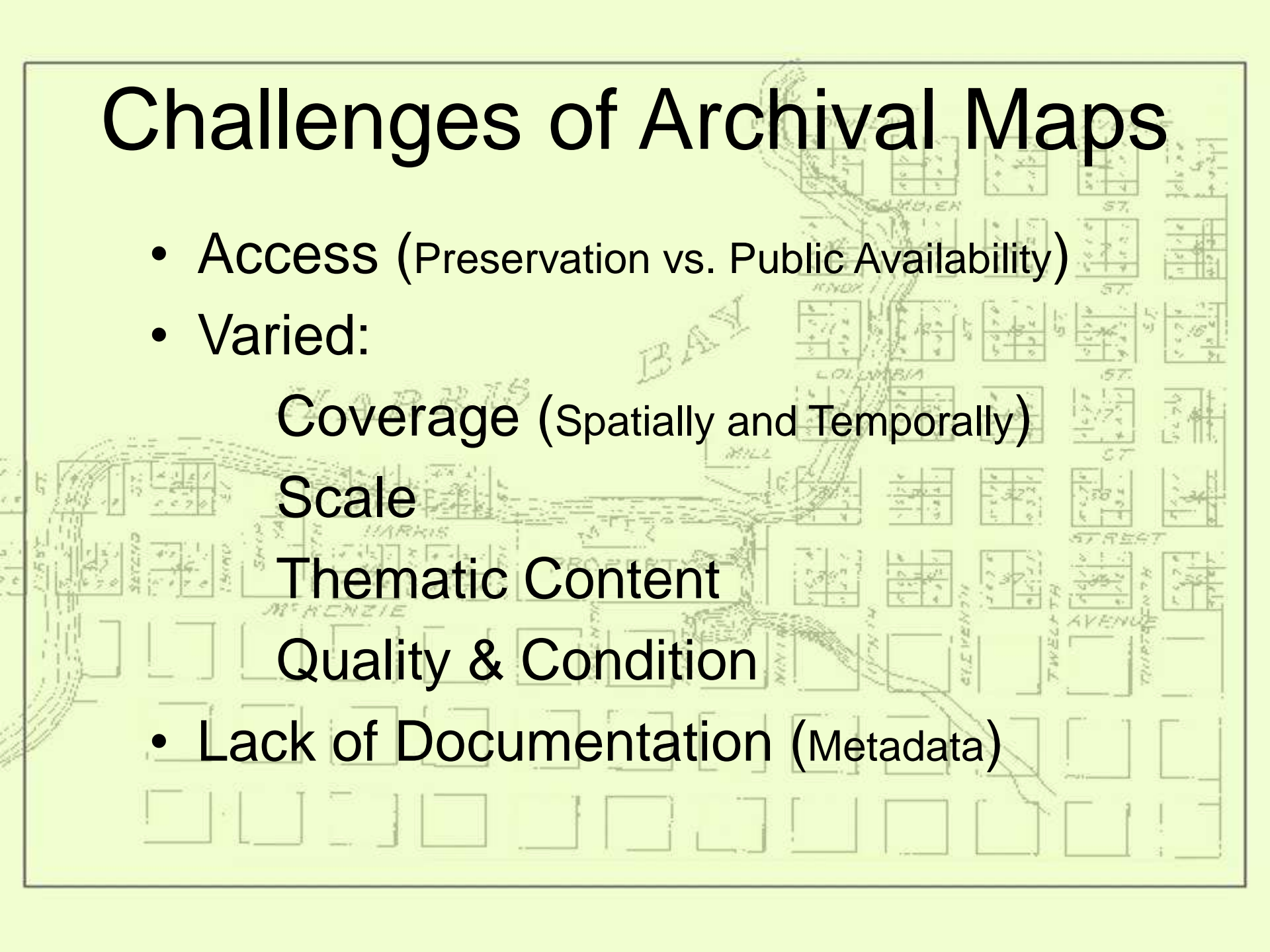
Plat of Gise's Addition to Bellingham, W.T. - 1889 - Woolard & Campbell.

'Bird's Eye View' Map



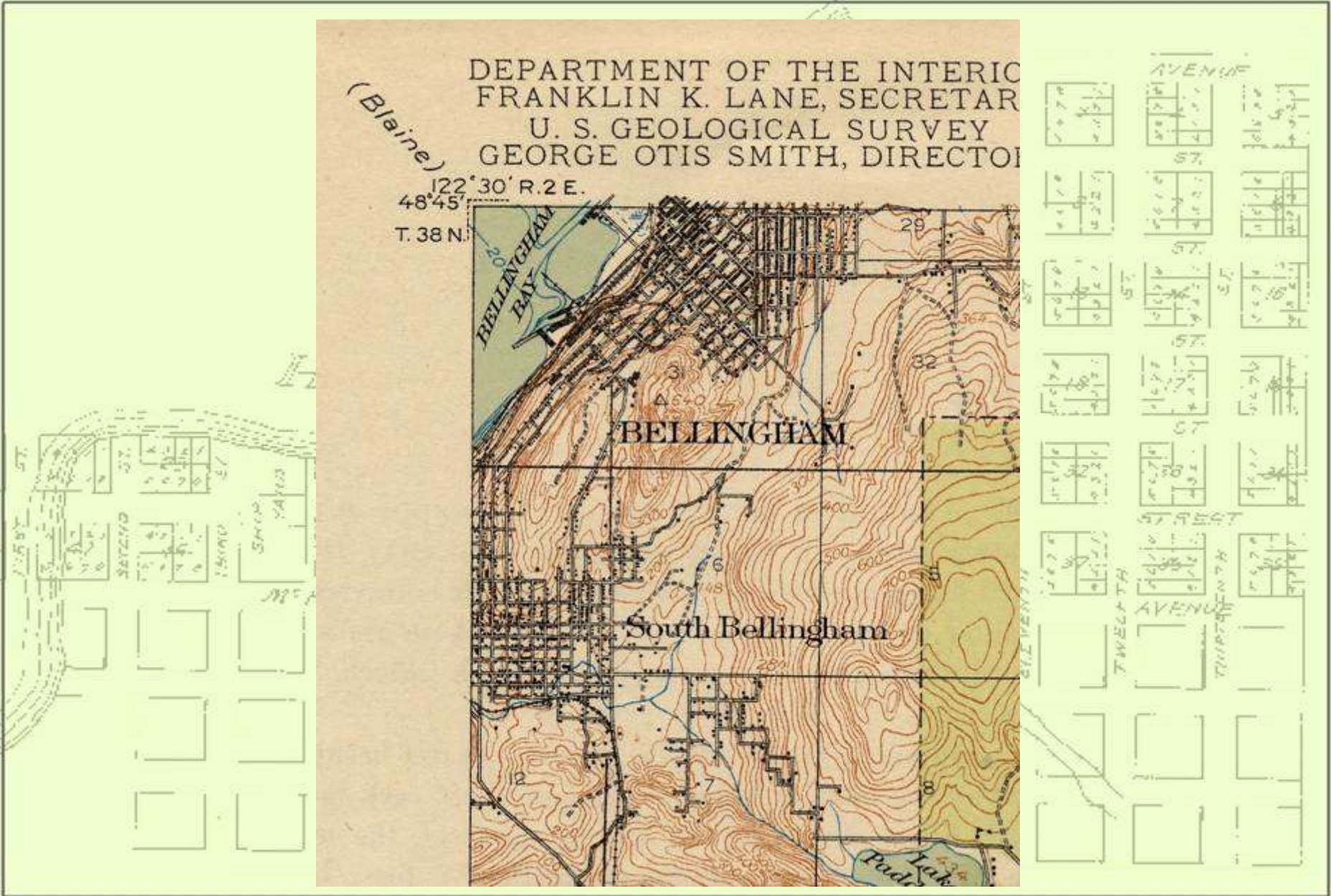
Fairhaven: A Birds Eye View - 1890 - Cartographer Unknown

Challenges of Archival Maps



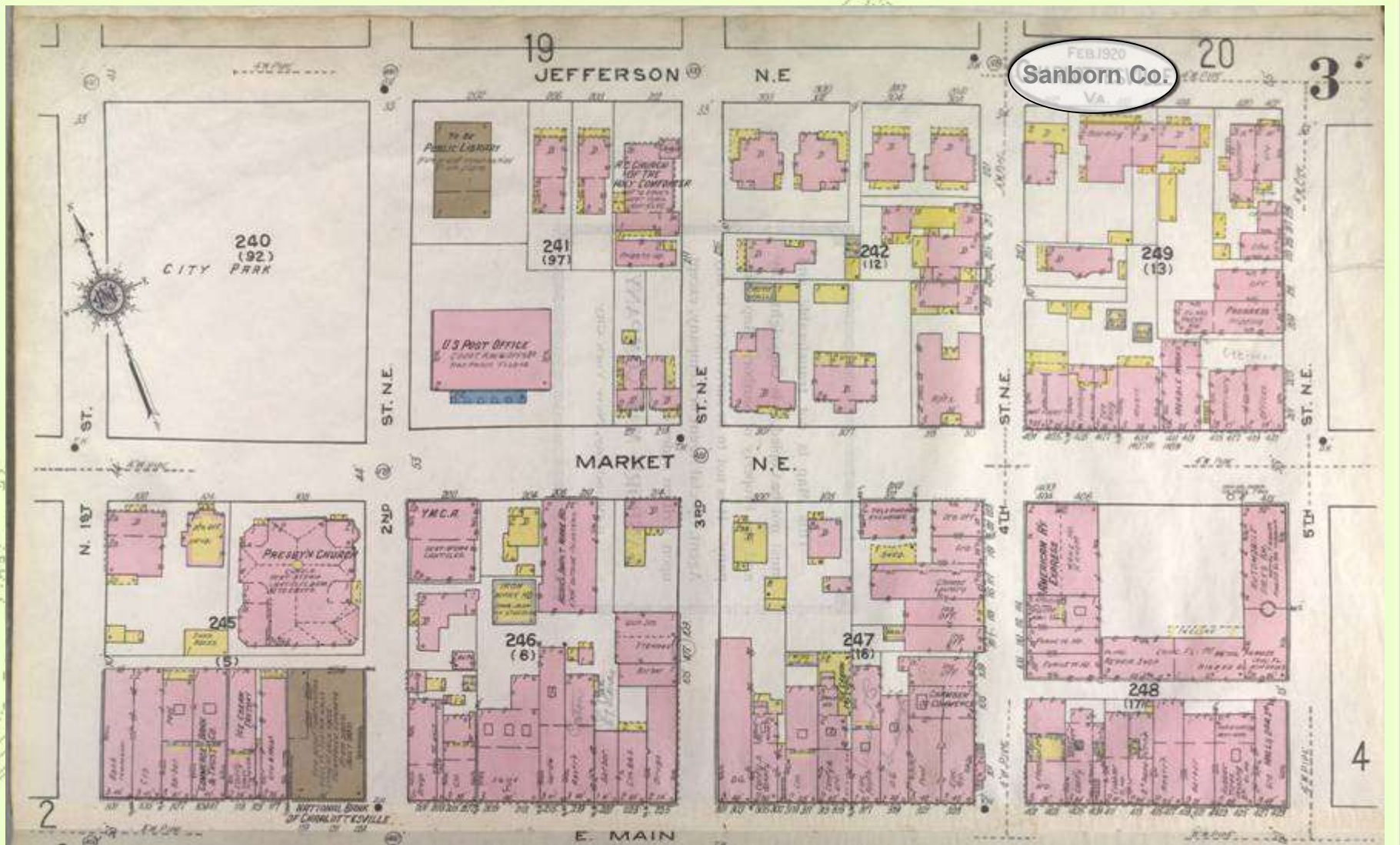
- Access (Preservation vs. Public Availability)
- Varied:
 - Coverage (Spatially and Temporally)
 - Scale
 - Thematic Content
 - Quality & Condition
- Lack of Documentation (Metadata)

USGS Topographic Quadrangle



Samish Lake Quadrangle - U.S.G.S., 1917

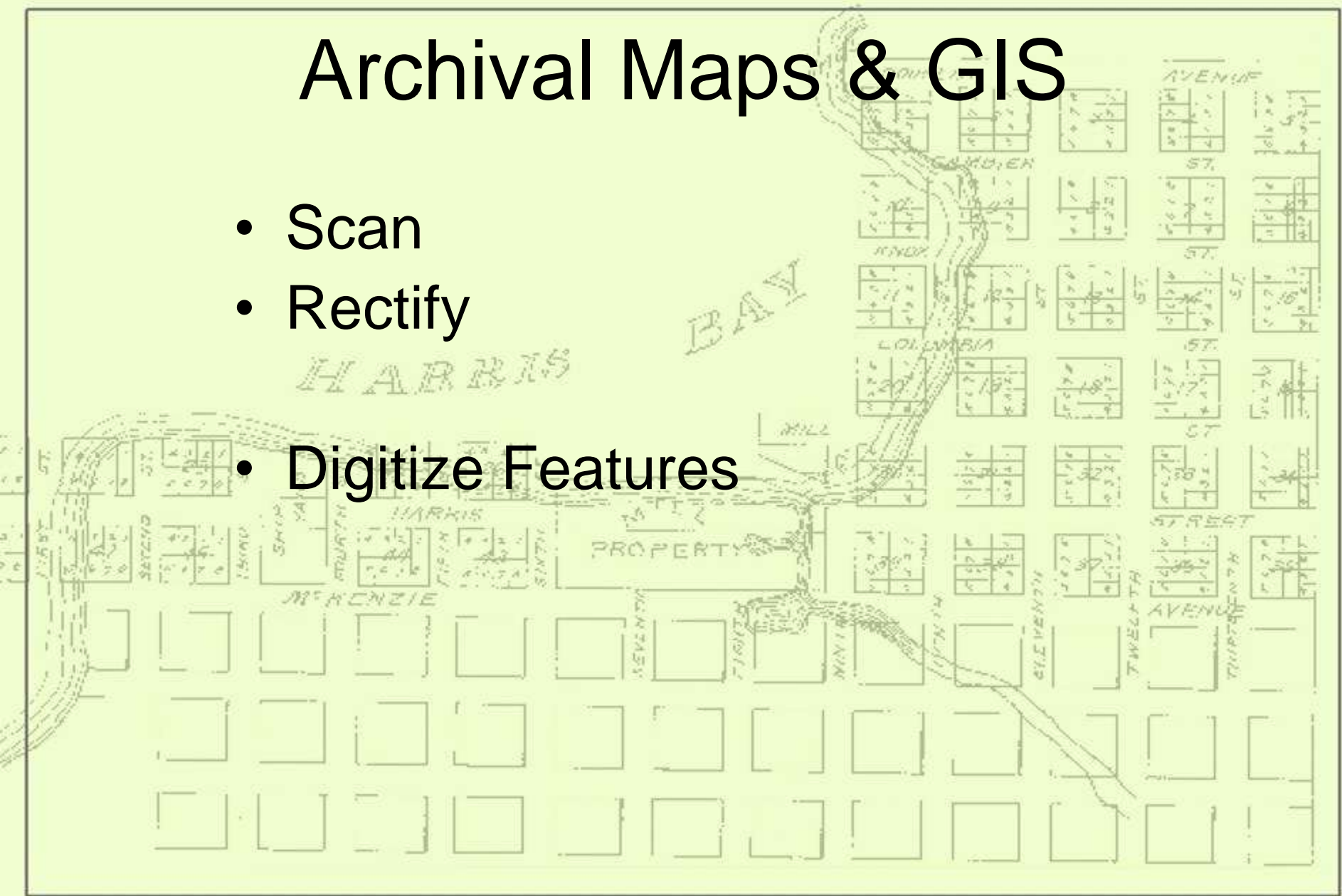
Sanborn Fire Atlas



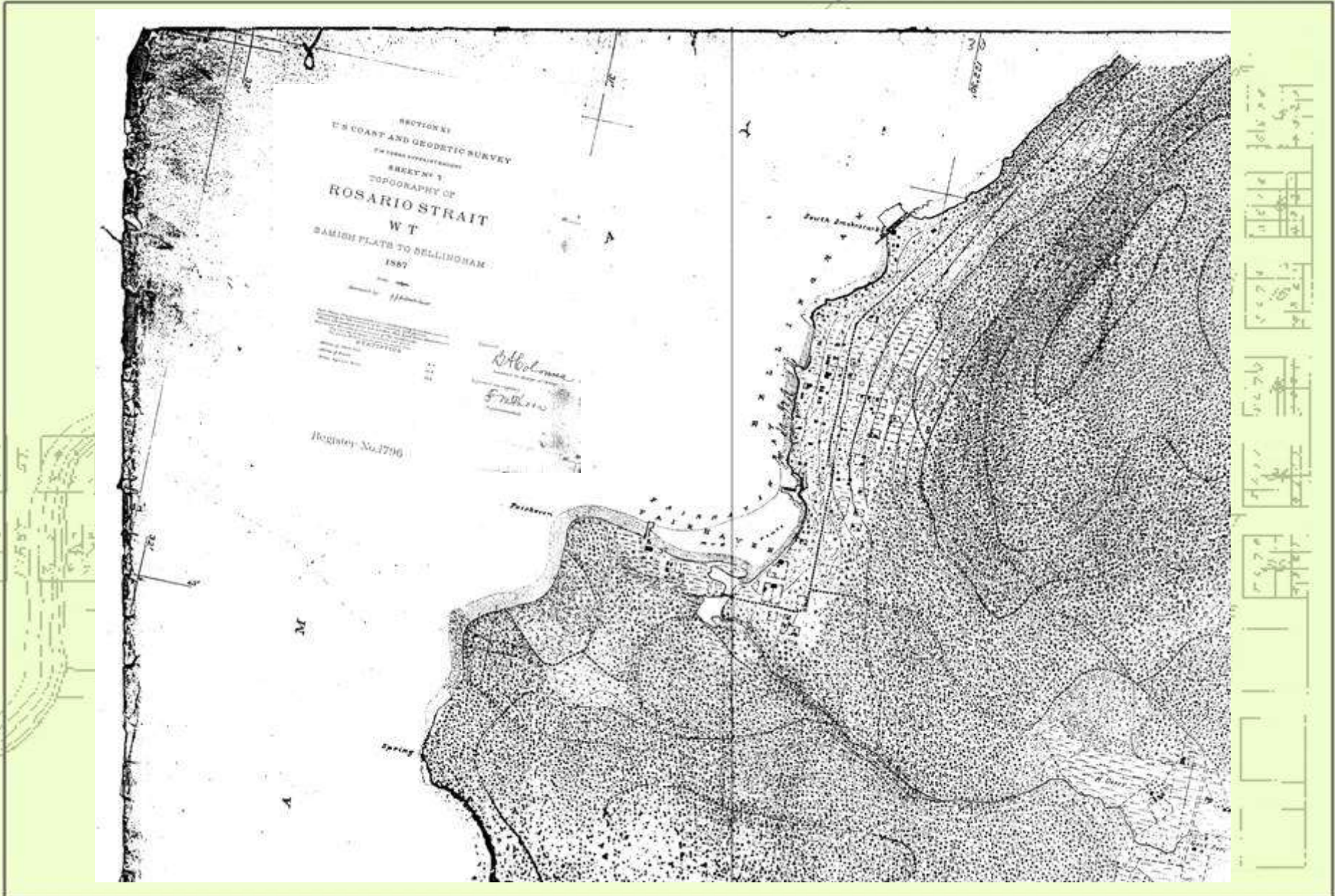
Sanborn Fire Insurance Atlas – 1920 - Sanborn Map Co. Inc

Archival Maps & GIS

- Scan
- Rectify
- Digitize Features

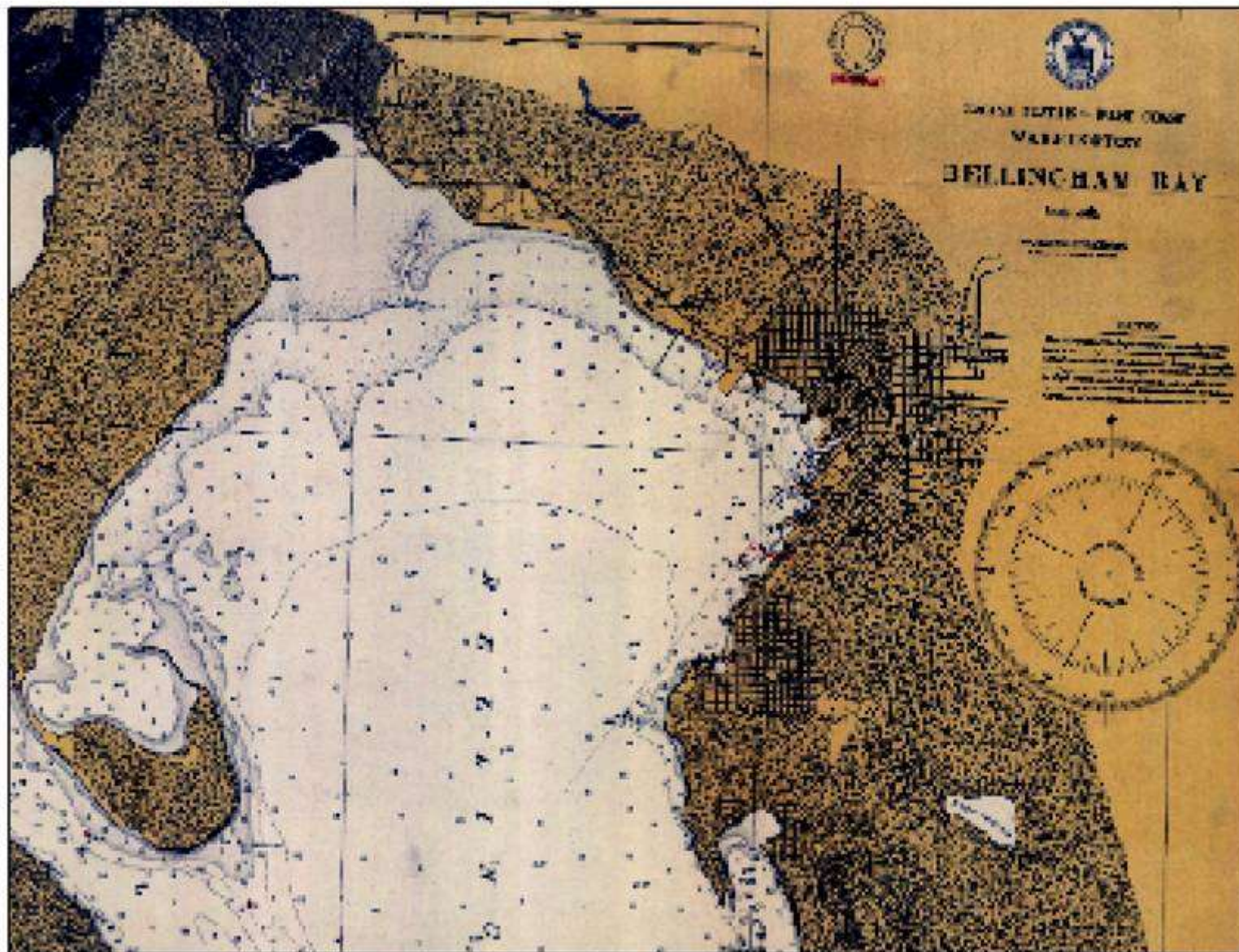


Scanned Map



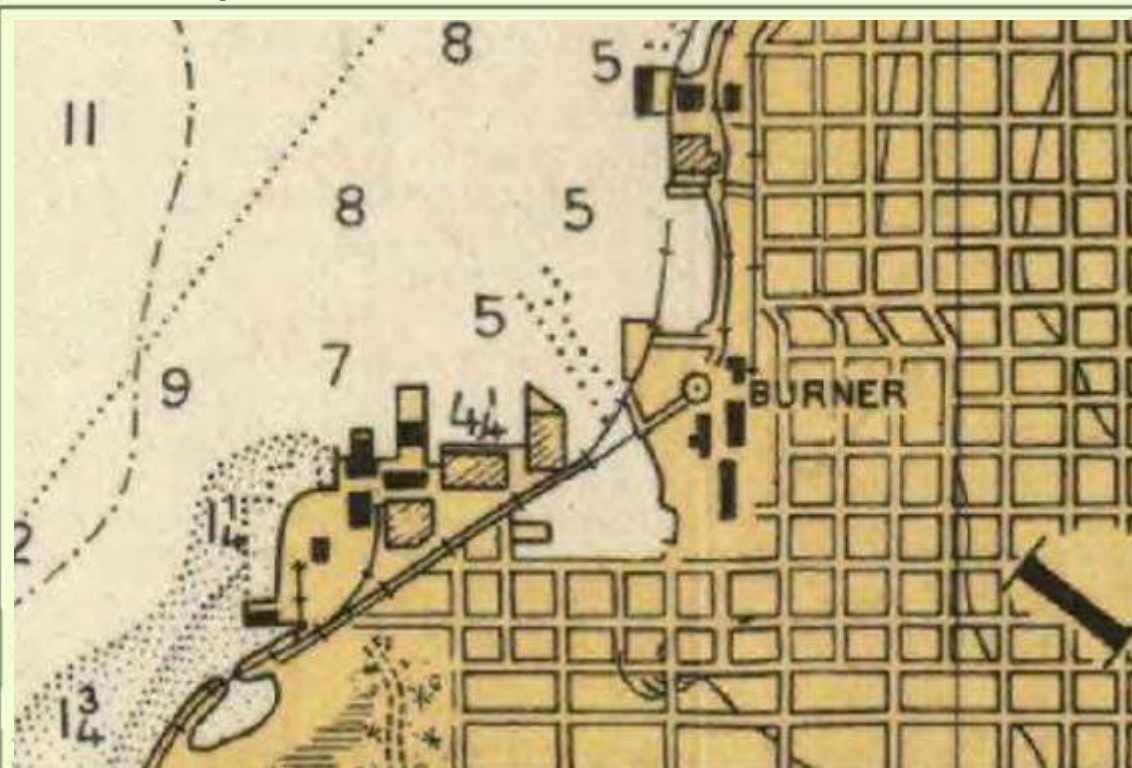
Topography of Rosario Strait, W.T.: Samish Flats to Bellingham - U.S.C. & G.S., 1887 – J.J. Gilbert

Scanned Map

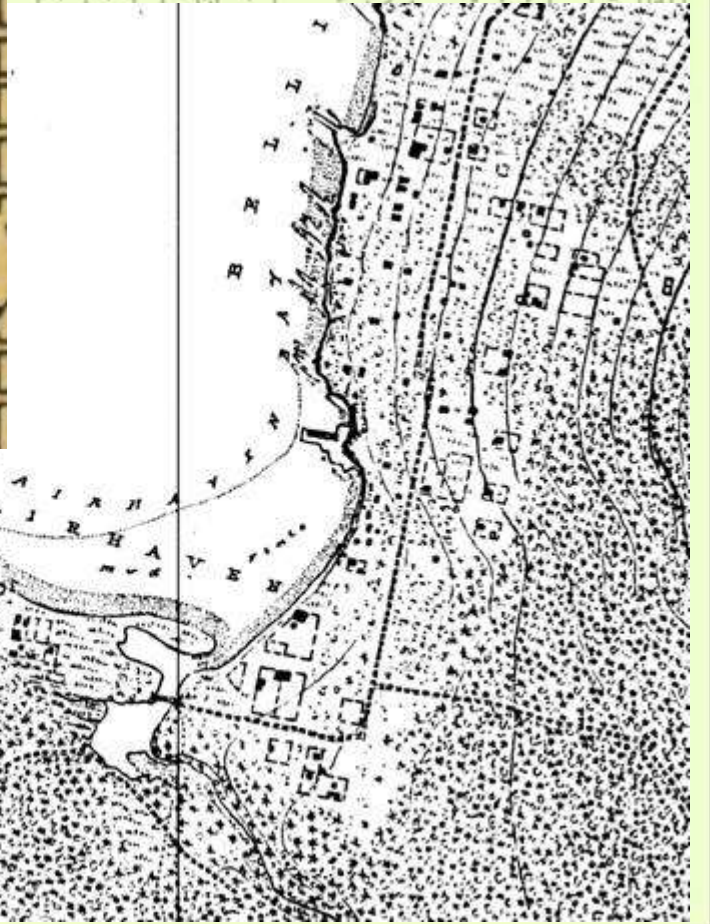
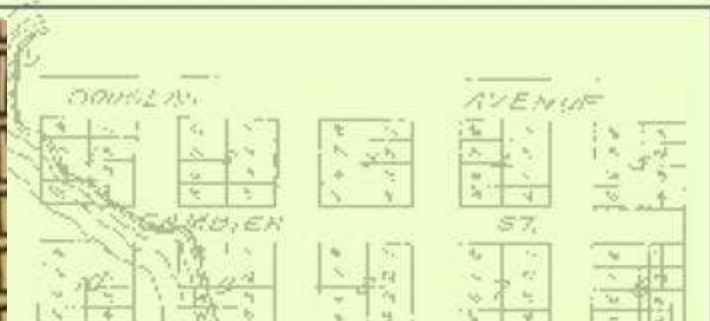


Bellingham Bay – U.S.C. & G.S - 1928

Scanned Maps

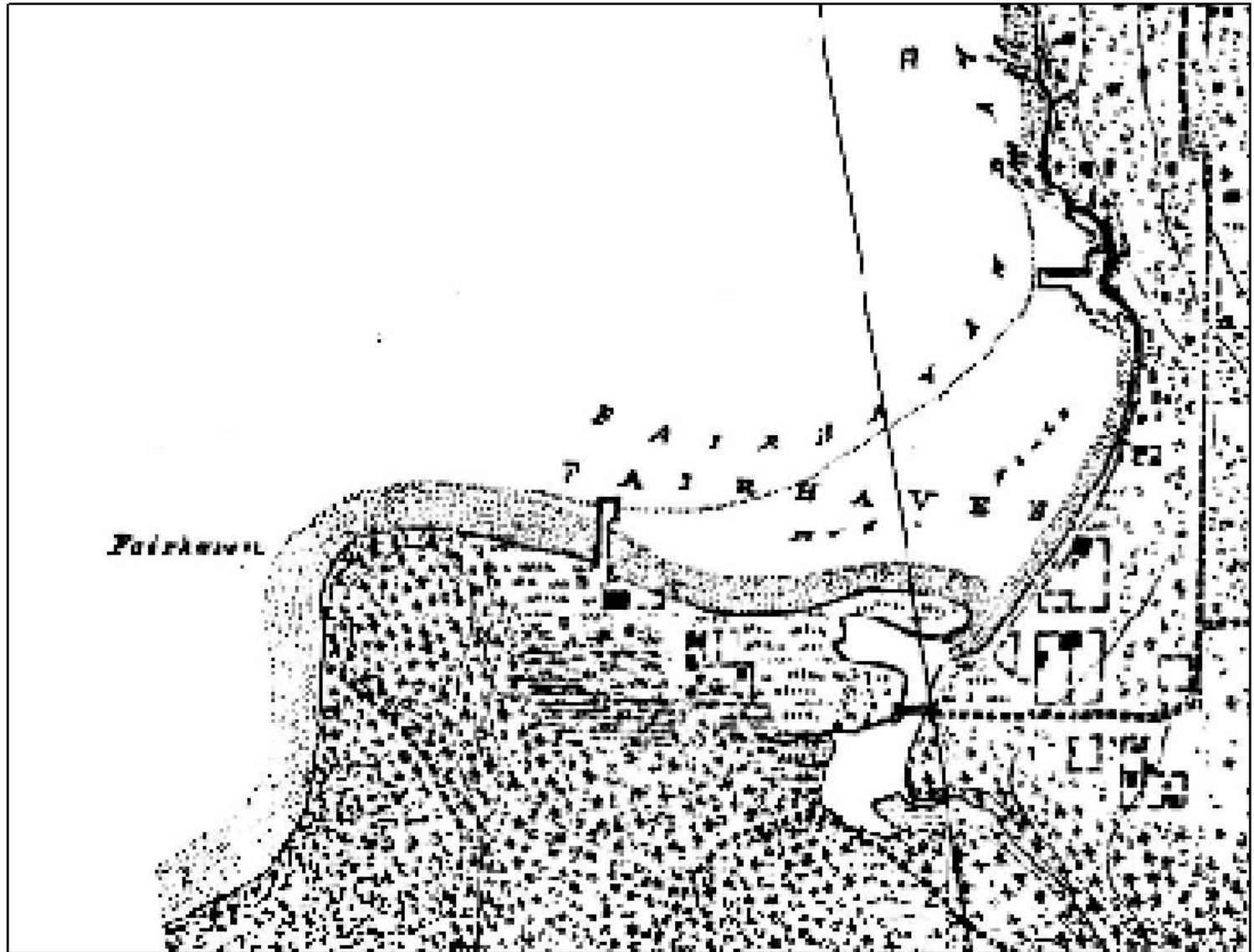


Bellingham Bay – U.S.C. & G.S. - 1928



Topography of Rosario Strait, W.T.: Samish Flats to Bellingham - U.S.C. & G.S., 1887 – J.J. Gilbert

Rectified Map



Topography of Rosario Strait, W.T.: Samish Flats to Bellingham - U.S.C. & G.S., 1887 – J.J. Gilbert

Rectified Map



Bellingham Bay – U.S.C. & G.S. - 1928

Semi-Transparent Overlay



1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50

51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
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91	92	93	94	95	96	97	98	99	100

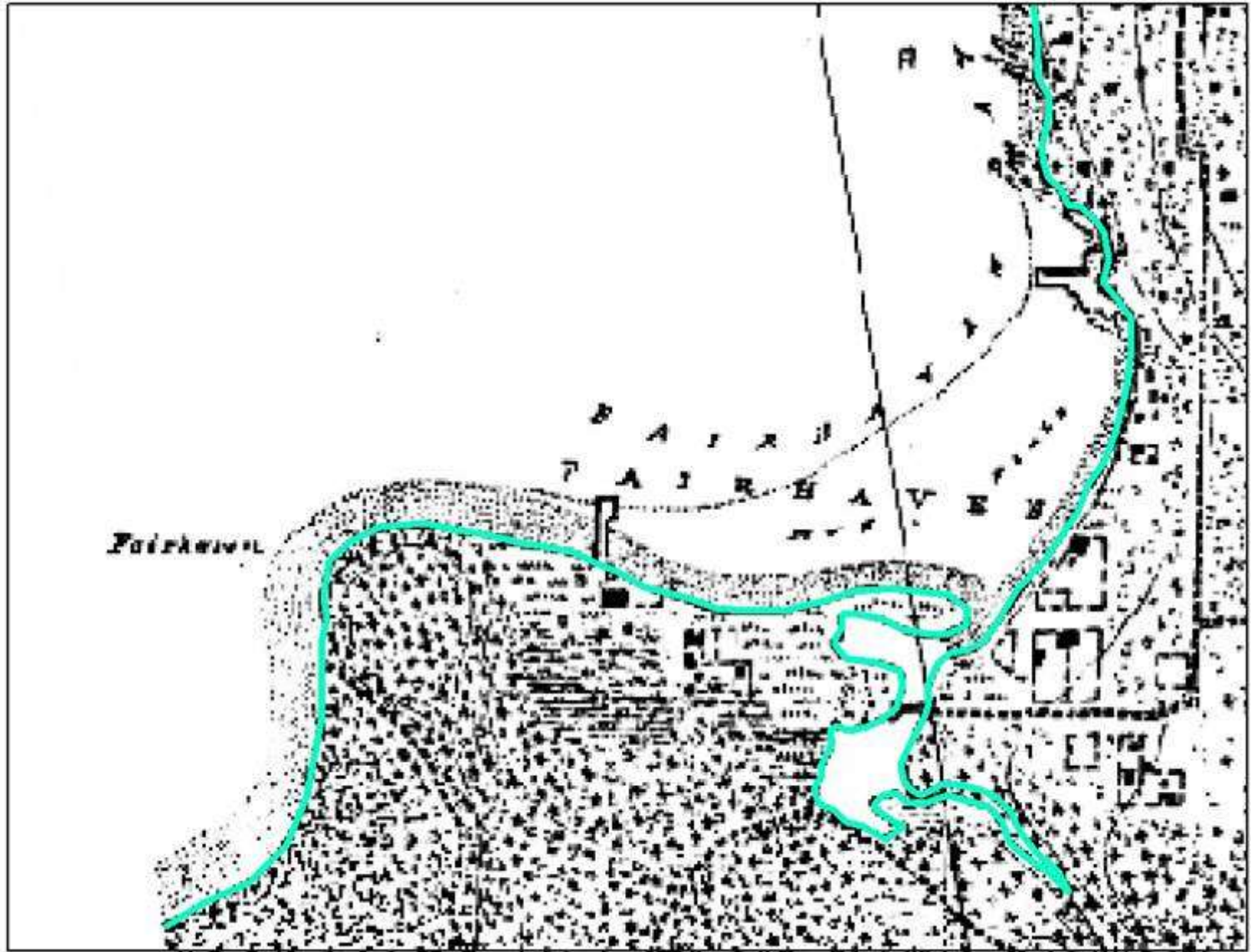
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111	112	113	114	115	116	117	118	119	120
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131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150

151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170
171	172	173	174	175	176	177	178	179	180
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191	192	193	194	195	196	197	198	199	200

201	202	203	204	205	206	207	208	209	210
211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230
231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250

251	252	253	254	255	256	257	258	259	260
261	262	263	264	265	266	267	268	269	270
271	272	273	274	275	276	277	278	279	280
281	282	283	284	285	286	287	288	289	290
291	292	293	294	295	296	297	298	299	300

Digitization of Features



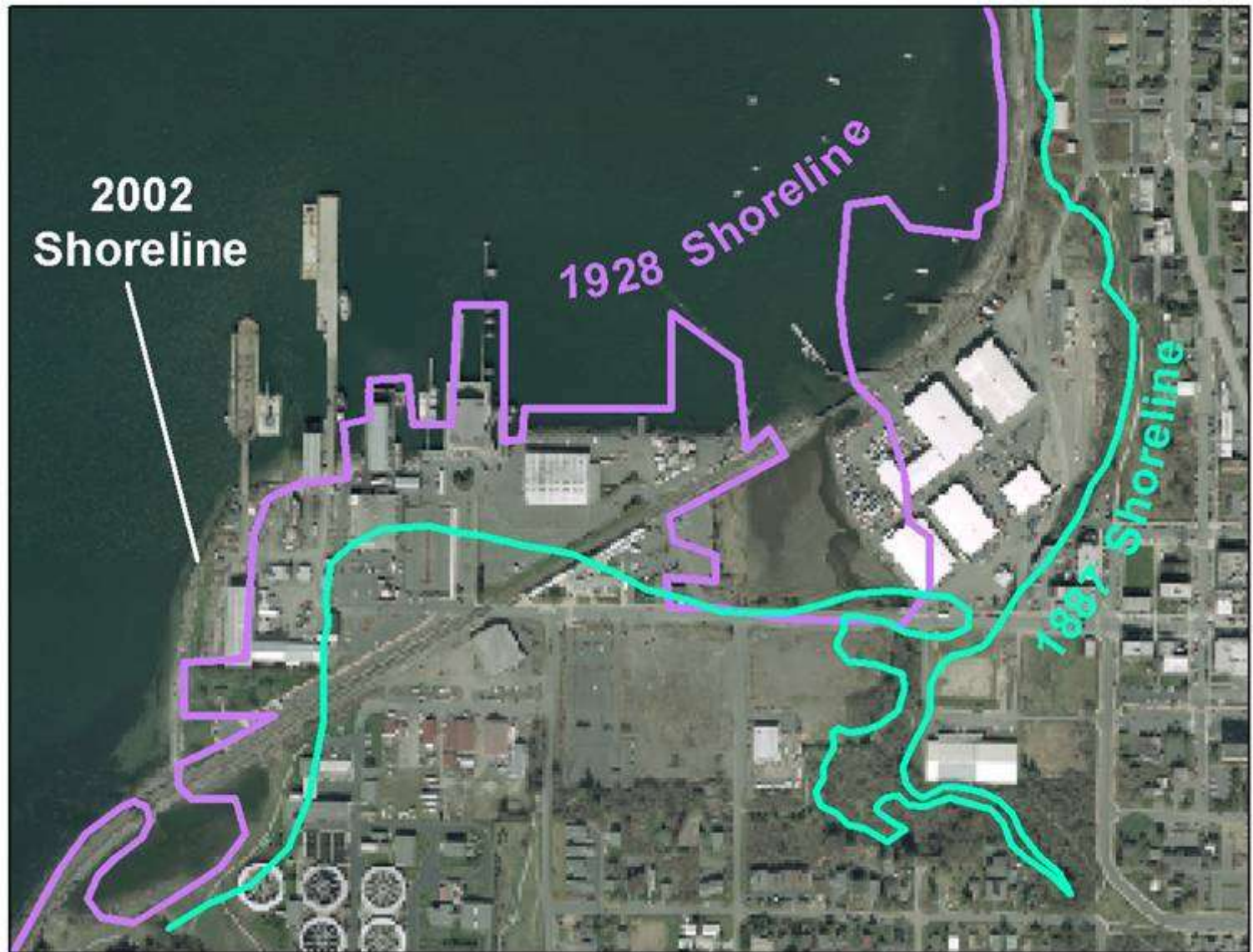
Topography of Rosario Strait, W.T.: Samish Flats to Bellingham - U.S.C. & G.S., 1887 – J.J. Gilbert

Digitization of Features



Bellingham Bay – U.S.C. & G.S. - 1928

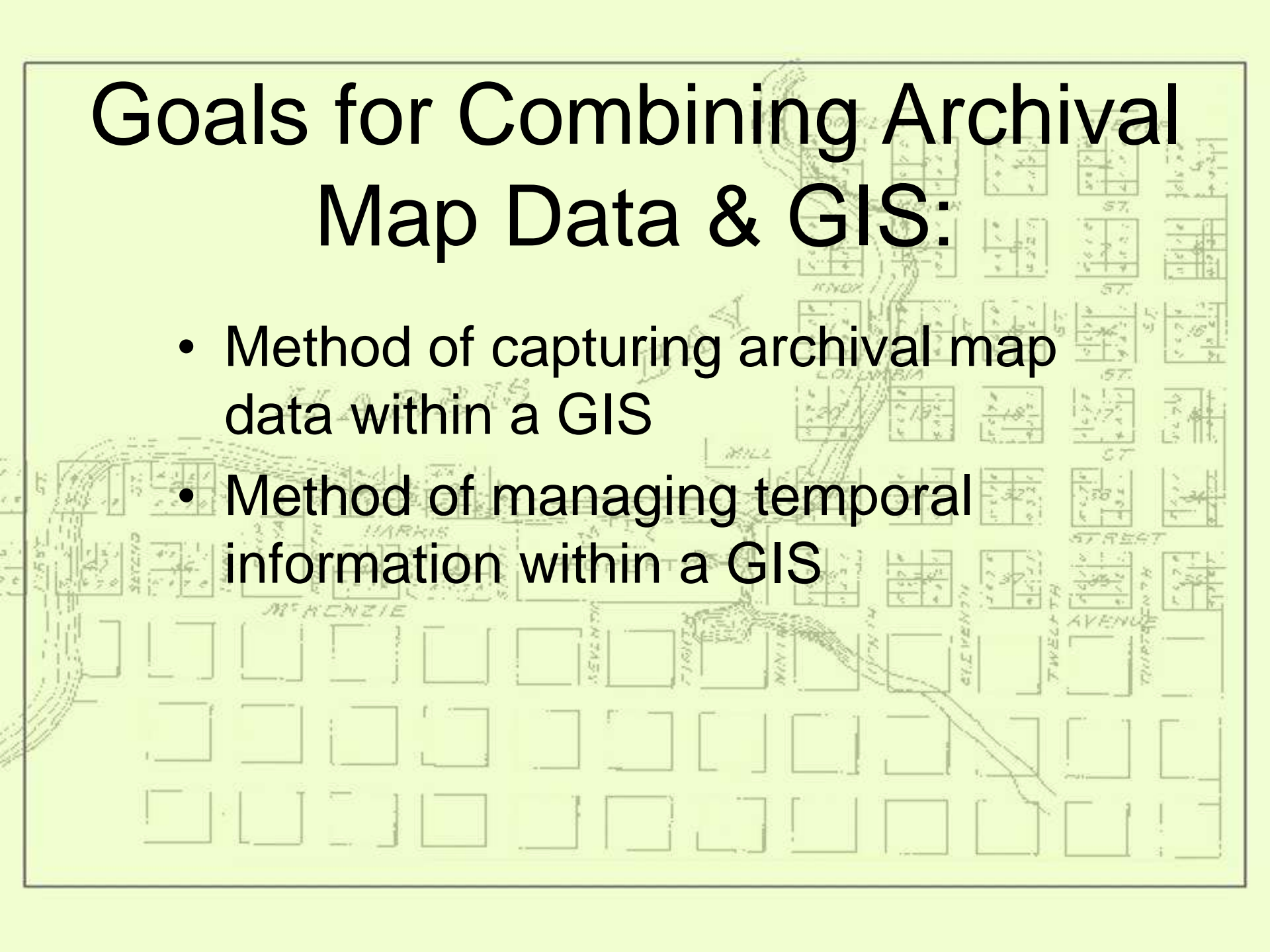
Feature Overlay



City of Bellingham Air Photo - 2002

Goals for Combining Archival Map Data & GIS:

- Method of capturing archival map data within a GIS
- Method of managing temporal information within a GIS



TGIS

(Temporal GIS)

Basic Functionality:

- Incorporate temporal dimension
- Temporal data entry, analysis & recall
- Filiation tracking (lineage of features)

TGIS



Advanced Functionality:

- Multiple 'Types' of Time (World, Measurement, Database)
- Multiple Temporal Metaphors
(Linear, Cyclical, Branching, Multi-dimensional time)
- Temporal Relationships
(before, after, during, i.e. *Ordinal* rather than *Interval* time)
- Modeling (Past or Future)
- Temporal Interpolation
- Temporal Zooming
- Real-time Temporal Data/Analysis

TGIS



Applications:

- Historical Research
- Land Records (Assessors Offices)
- Planning
- Archeology
- Geology
- Modeling (Urban or Environmental)

TGIS vs. tGIS

1. Entirely new software (3 or 4 dimensions)

Specifically designed for spatio-temporal analysis

Features located by coordinates of space-time

(Current GIS is 2 {or 2½} Dimensional...)

Objected-Oriented software?

2. Add-on “extension” to existing software

“Quasi-Temporal” functionality

Capturing Time

- Dated Layers (Snapshots) **(GIS)**
- Coordinate of Space-Time **(TGIS)**
- Attribute of Spatial Features **(tGIS)**
- Problem of Topology (Changing over time...)
 - Variable length fields
 - Related files
 - Archives and/or amendment layers
 - Composite model
 - If topological challenges can be solved...

Composite Model

Working within current GIS (RDBMS model)

Gail Langran (*Time in Geographic Information Systems*, 1992), concluded that the Composite Model held the greatest potential for TGIS.

However, there were two problems:

1. Inefficient database design
2. Topology
3. Amount of work required for building temporal databases...

Composite Model tGIS Extension

is currently feasible because:

1. Availability of bigger, faster computers
2. Availability of non-topological data model
3. Methodology of using archival maps in conjunction with existing GIS data for temporal attributes only (presence/absence for a given date, not spatial location). *Eliminates steps of scanning, rectification and digitization*

Goal: Simple temporal GIS functionality for use with archival map data.

tGIS Extension



- Extension to existing software

ArcView 3.x & Avenue

User interface for temporal data entry & recall

- Standard data model (Shapefile)
- Time as an attribute of spatial features
As opposed to a coordinate of space-time
- Composite Model (Tuple/feature level)
Minimal use of complex tabular relationships
- Temporal Filters
- Filiation Tracking (Lineage)
- Feature-Level Metadata

tGIS Extension

Pre-Defined Fields:

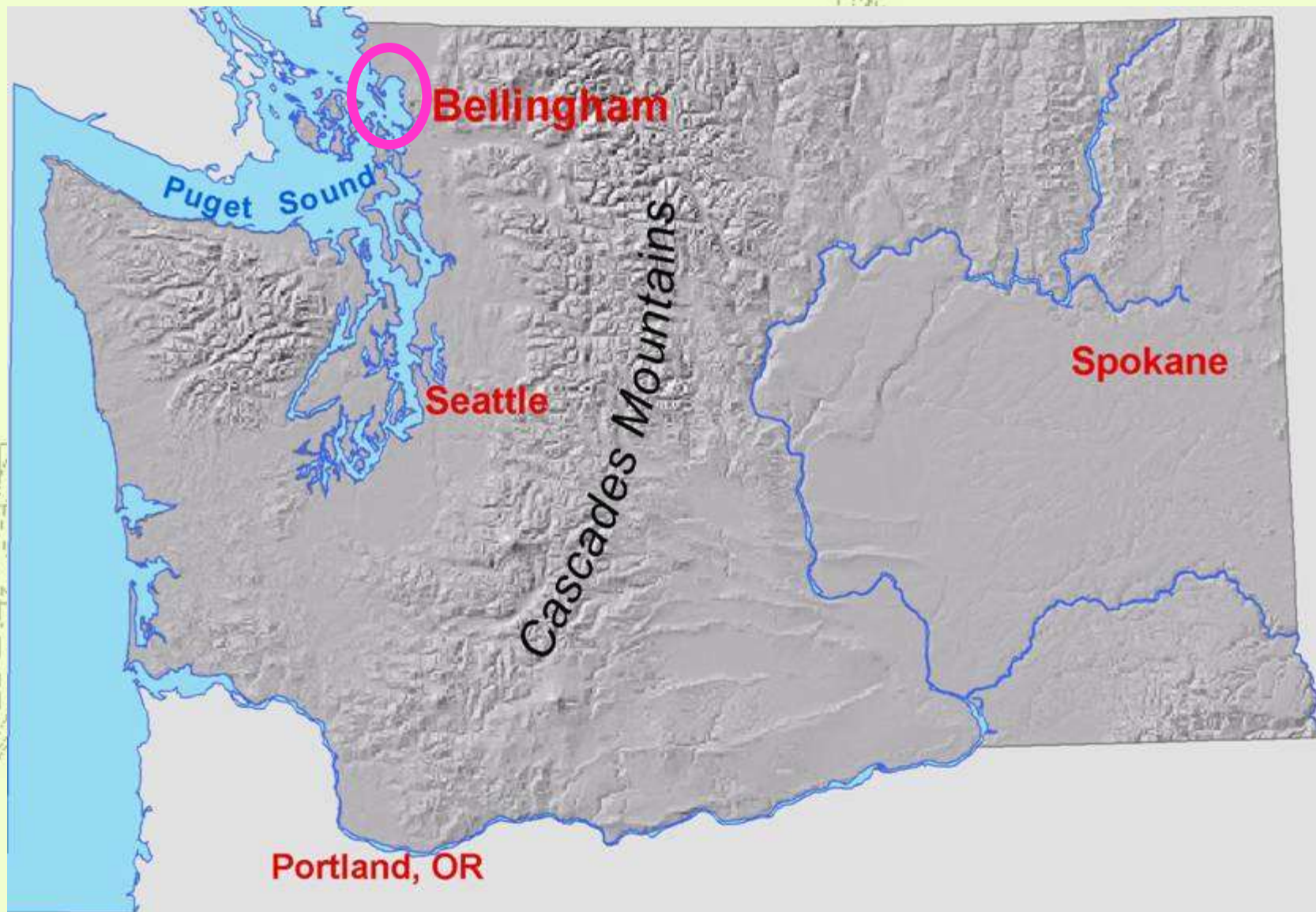
- EID (Entity ID number)
- PID (EID of Previous {parent} feature)
- FID (EID of Future {child} feature)
- Start Date (Year of beginning of feature)
- End Date (Year of end/modification of feature)
- Edit Date (Database entry/modification date)
- FMD (Feature-Level Metadata ID number)

Fairhaven Case Study

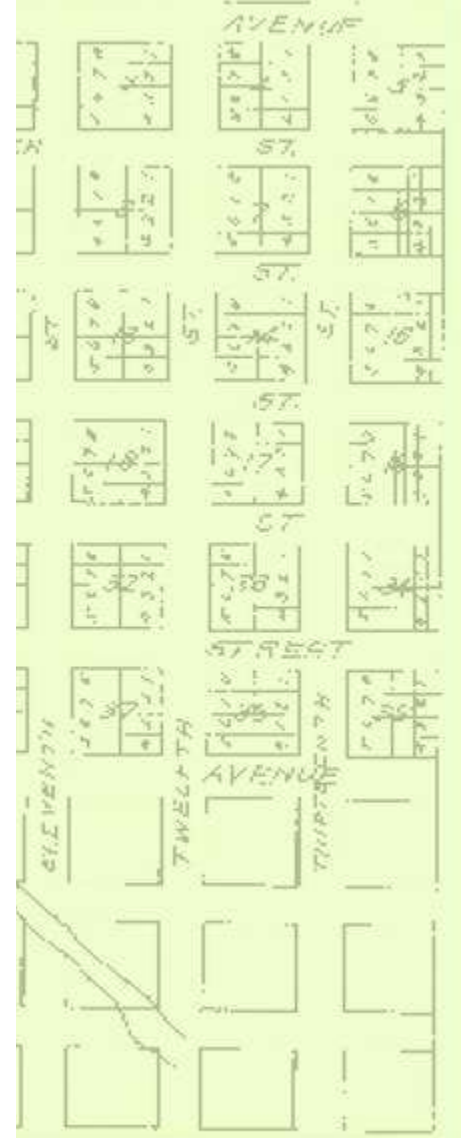
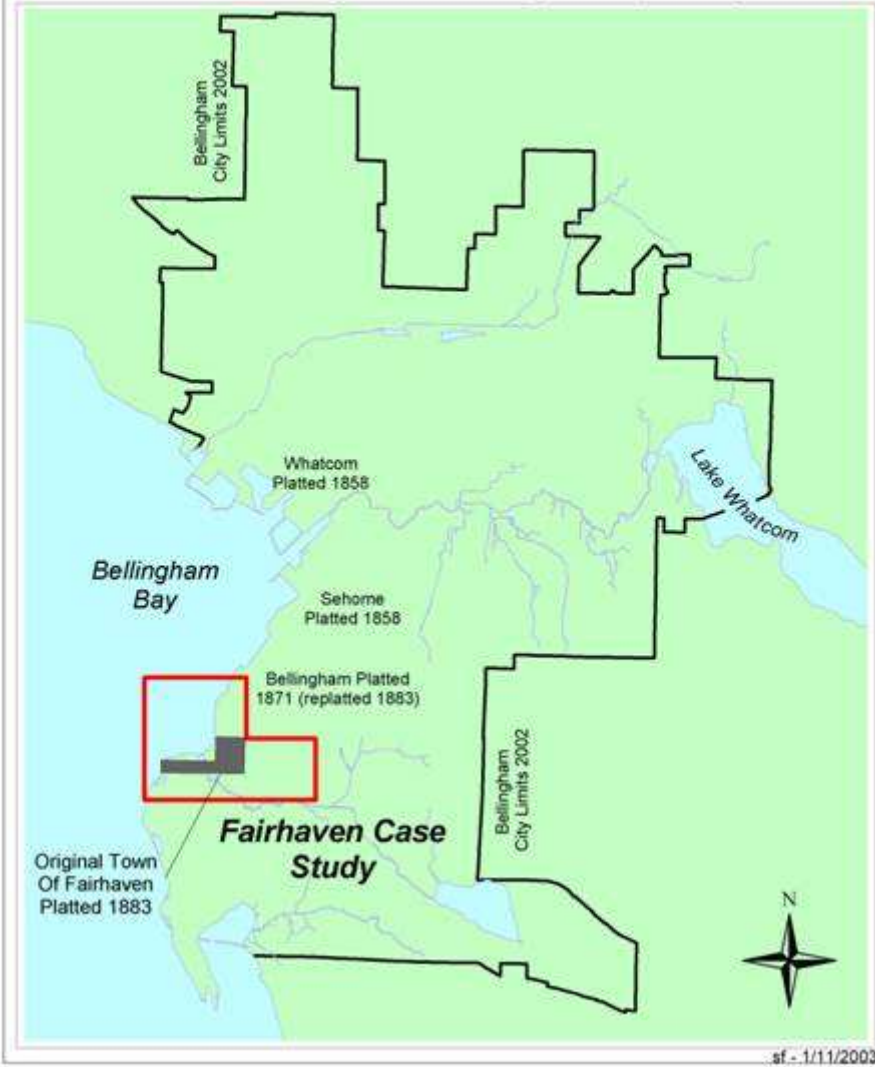
The background of the slide is a faded, light-colored map of Fairhaven, Massachusetts. It shows a grid of streets, a railroad line, and various property boundaries. Labels like 'VENUE', 'ST.', 'AVENUE', and 'PROPERTY' are visible on the map.

- 1880-1930
- Original Town of Fairhaven (Platted 1883)
- Features common to archival maps & GIS
 - Streets, Railroads, Electric Streetcars
 - Land Subdivisions (DLC's, Plats, Parcels)
 - Buildings
 - Government Jurisdictions (Context layer)
- Archival maps as primary data source

Washington State



Fairhaven Case Study Location & the City of Bellingham (2002)



Original Plat of Fairhaven

MAP OF FAIRHAVEN ON HARRIS BAY

SCALE 400 FT = 1 IN

This Town is located on lots 3, 4, 5 & 6 of Sec 1 and lot 1 and N.W. 1/4 of N.W. 1/4 of Sec 12 Town 37 N. Range 2 East and the initials 40 feet south of the N.W. cor of lot 1 in Sec. 1 which is the N.W. cor of Block 1.

Filed for Record in the Auditor's office of Whatcom County W.T. on the 2nd day of January A.D. 1883 at 9 O'clock A.M. and Recorded in Record of Town Plats Book 'A' on pages 32 & 33 of Records of Town Plats of said County and Territory at the request of D.J. Harris.

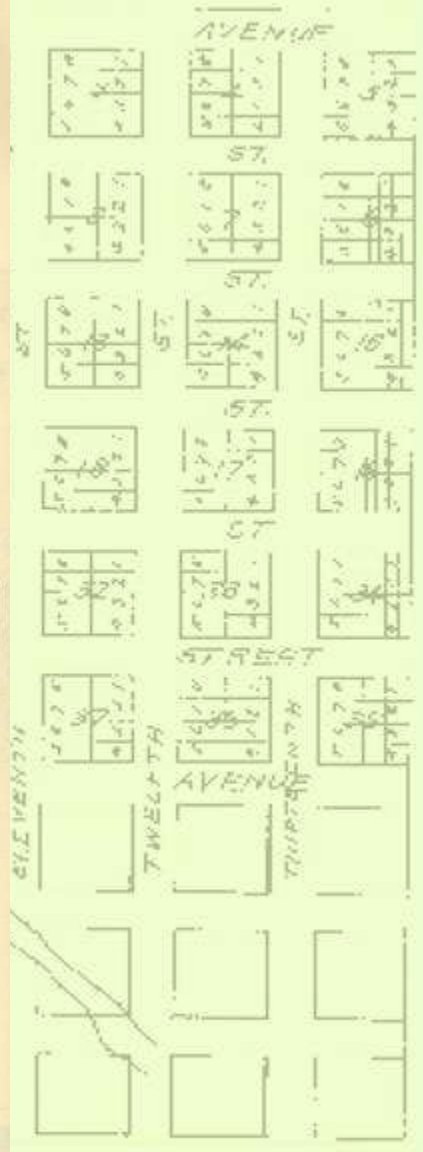
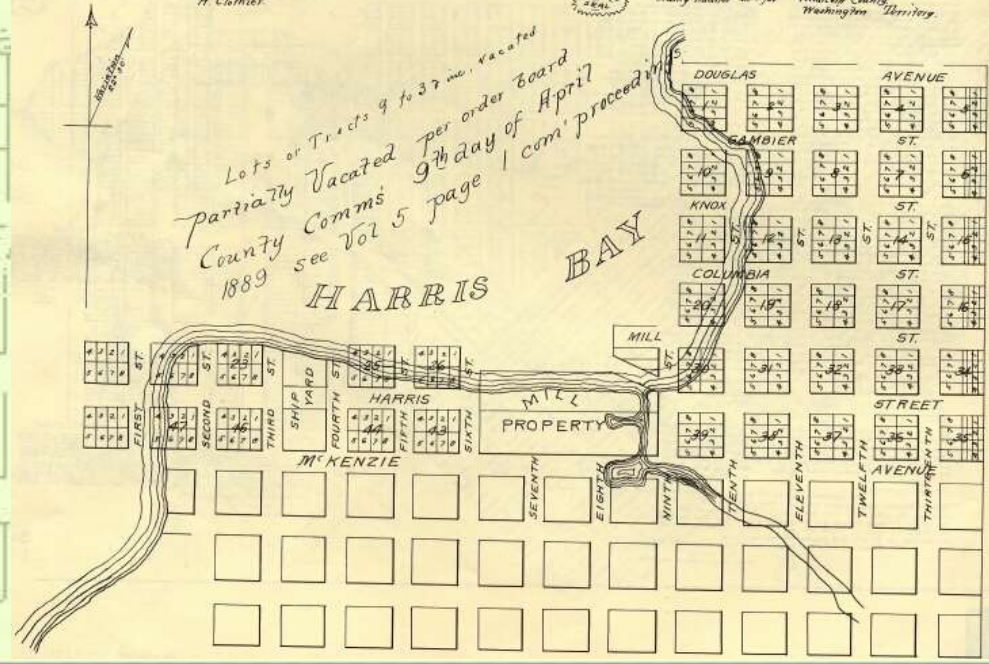
SCALE 200 FT = 1 IN
 EXPLANATION
 All lots 40x100 ft. All Blocks except 5, 6, 15, 16, 34, 35 200x200 ft.
 Blocks 5, 6, 15, 16, 34 & 35 50x200 ft.
 All Streets except M'Kenzie Avenue 80 ft.
 M'Kenzie Avenue 100 ft.

C. Donovan
 Auditor and Recorder of
 Whatcom County Washington Territory

I, Daniel J. Harris of Whatcom County Washington Territory hereby dedicate the Streets to the public use forever.
 Witness my hand and seal this 2nd day of January A.D. 1883.
 J.W. Law
 H. Clabner
 Daniel J. Harris (Seal)

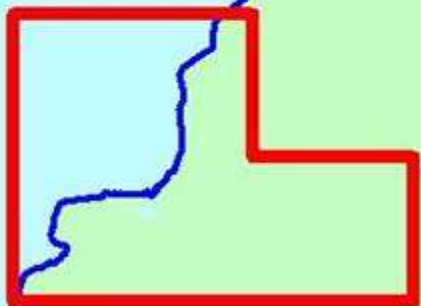
TERRITORY OF WASHINGTON } s.s.
 COUNTY OF WHATCOM }
 On this 2nd day of January A.D. 1883 before me the undersigned a County Auditor personally came Daniel J. Harris personally known to me and in my presence executed this Plat and acknowledged that he executed the same freely and voluntarily and for the uses and purposes therein indicated. In Witness Whereof I have hereunto set my hand and affixed my official seal the day and year first above written.
 C. Donovan,
 County Auditor in & for Whatcom County Washington Territory

Lots on Tracts 9 to 37 inc. vacated
 partially vacated per order Board
 County Comms 9th day of April
 1889 see Vol 5 page 1 com' proceed



Plat Map of Fairhaven on Harris Bay - 1883 - Daniel Harris

Study Area



GIS Street Layer



MAP OF FAIRHAVEN ON HARRIS BAY

SCALE 400 FT = 1 IN

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Filed for Record in the Auditor's office of Whatcom County W.T. on the 2nd day of January A.D. 1883 at 9 O'clock A.M. and Recorded in Record of Town Plats Book 'A' on pages 32 & 33 of Records of Town Plats of said County and Territory at the request of D.J. Harris.

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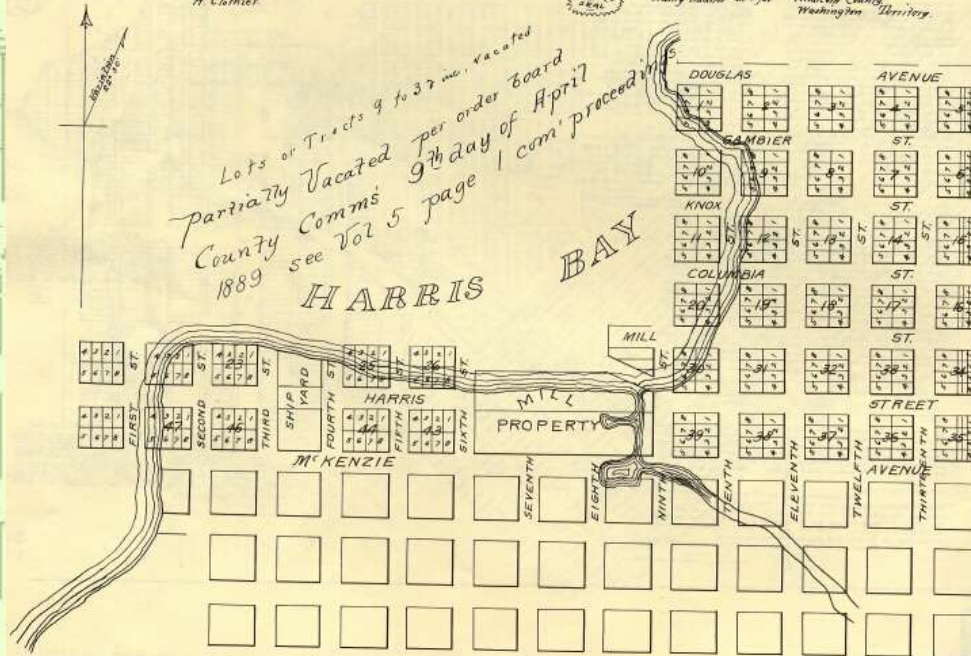
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County Auditor in & for Whatcom County,
Washington Territory.

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H. Clabner.

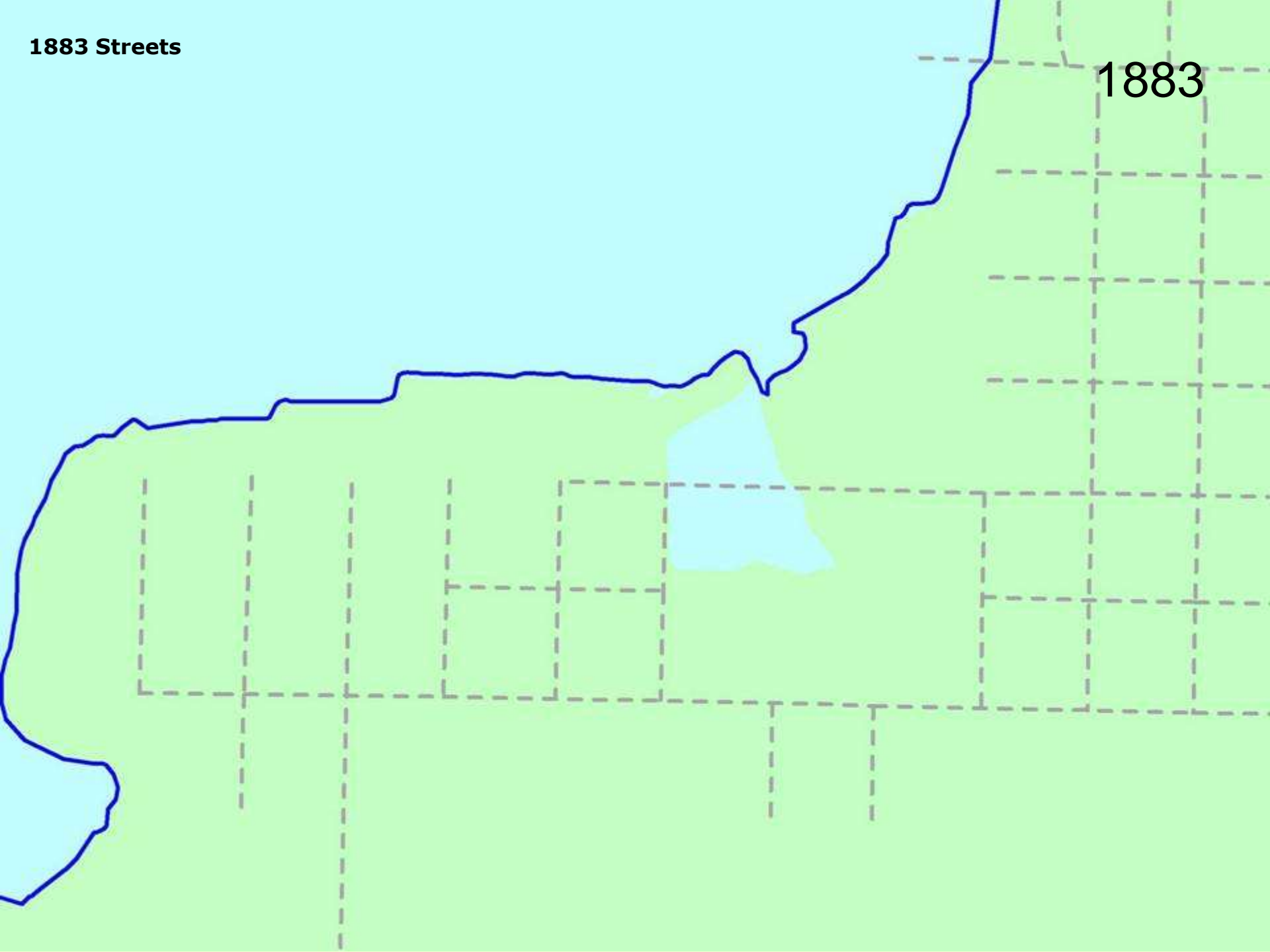
Lots or Tracts 9 to 37 inc. vacated
partially vacated per order Board
County Comms 9th day of April
1889 see Vol 5 page 1 com' proceed



Plat Map of Fairhaven on Harris Bay - 1883 - Daniel Harris

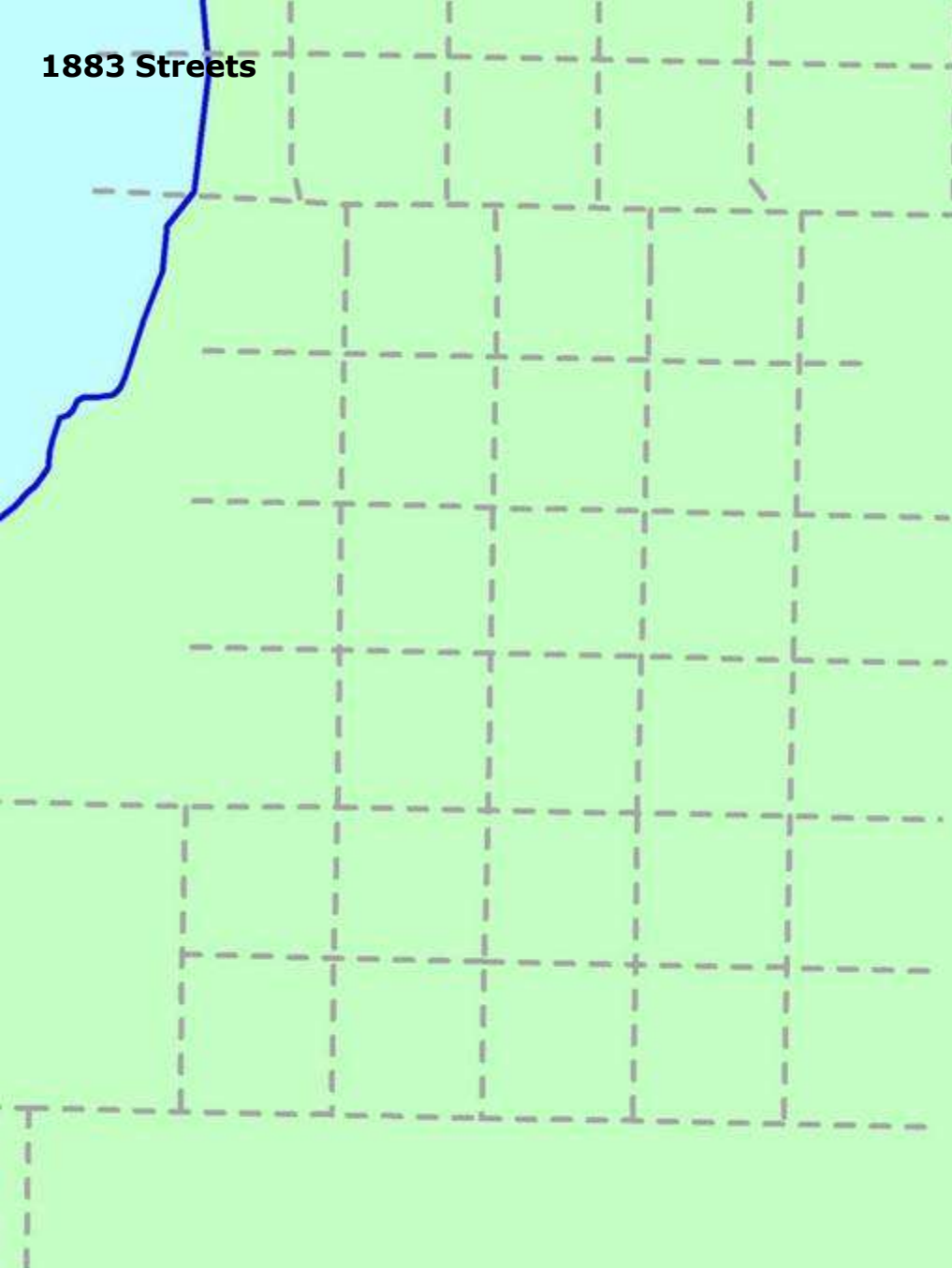
1883 Streets

1883



1883 Streets

1883

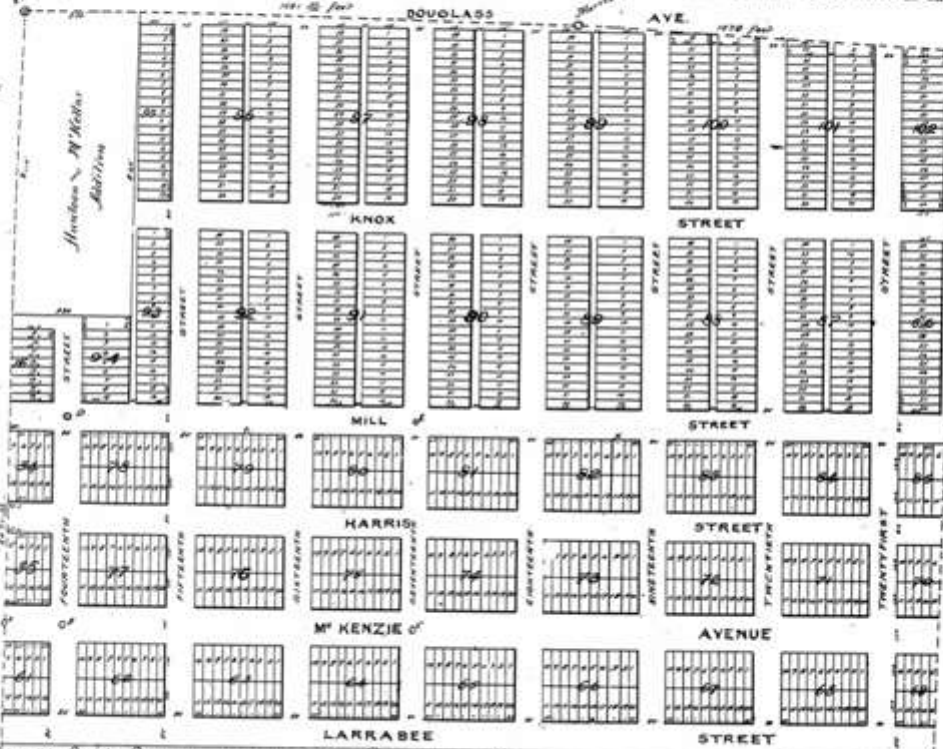


PLAT OF
 THE FAIRHAVEN LAND COMPANY'S
FIRST ADDITION TO FAIRHAVEN
 Washington
 SCALE 100' = 1" INCH
 RECORDING SCALE 200 FEET 1 INCH

Description
 This Addition consists of the 20 Corner Donation Claim in Sec 1 and 2, Twp 2 N R 2 E, excepting the M'Kellar and Hanton Addition and the Reserve. The Initial Point is the South west corner of the claim where a cedar stake four inches in diameter is set from which a line connecting with the northwest corner bears N 85° 56' E using a variation of 28° 15' E 381 1/2 feet northward along this line it intersects the centre line of M'Kenzie Avenue where a stone monument with cross bolt as center is set, marked A on plat 88' 26' east from the point where the center line of M'Kenzie Avenue is marked by similar monuments, B and C at 20' intersection with 10' and 10' Chalk. This is the base line of the survey. Monuments B and C are also set at the intersection of 300 ft wide by 10' and 275 ft wide. Corner stakes in right square are set at all the corners of the claim. M'Kenzie Avenue is 100 feet wide. All other streets are marked at all right angles thereto and except Douglas Avenue are 50 feet wide. Dimensions of lots and blocks are marked thereon.

See Ordinance # 7623 see file # 1183792 Jan 10 1968 vacation alley width 7' 2"
 1112 " " " " 1183792
 1152 " " " " 1183792
 1183156 - 25 ft. between Mill Lane + Main

DEDICATION
 We do hereby dedicate to the public for use as streets and alleys within the limits of the above described land the streets and alleys hereinafter named and we do hereby dedicate to the public for use as streets and alleys within the limits of the above described land the streets and alleys hereinafter named and we do hereby dedicate to the public for use as streets and alleys within the limits of the above described land the streets and alleys hereinafter named.



See Ordinance # 1379408 4-1-87
 C/O P # 1560542 R 115 P 591 8-22-87
 C/O P # 1648380 R 115 P 591 8-22-87
 C/O P # 1648380 R 115 P 591 8-22-87
 C/O P # 1648380 R 115 P 591 8-22-87

C to Bond (Cmp # 1560542 R 115 P 591 8-22-87
 C/O P # 1648380 R 115 P 591 8-22-87
 C/O P # 1648380 R 115 P 591 8-22-87
 C/O P # 1648380 R 115 P 591 8-22-87
 RESERVED
 C/O P # 1648380 R 115 P 591 8-22-87

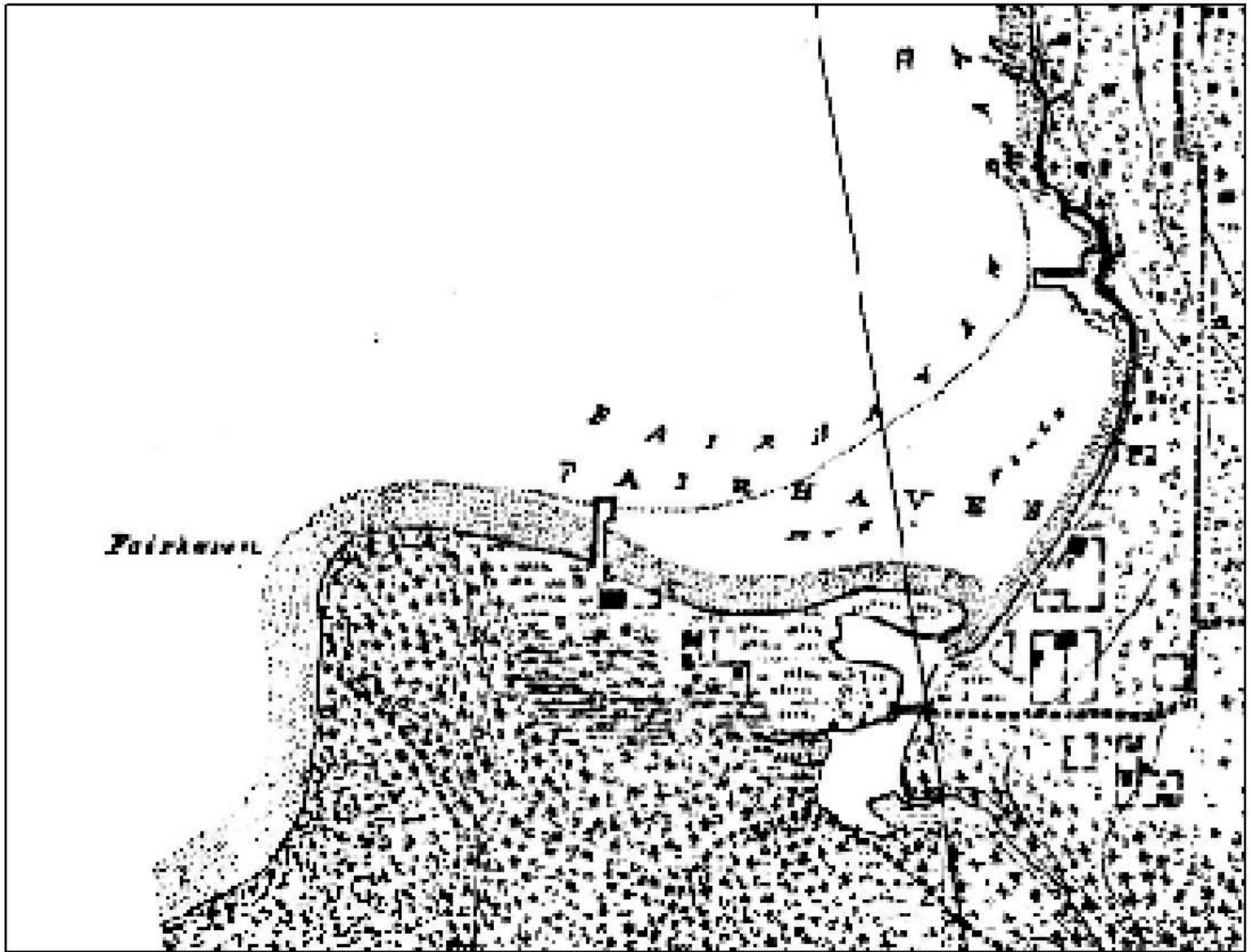
Plat Map of Fairhaven Land Co.'s First Addition to Fairhaven, WA - 1889

**1889 Streets:
Built vs. Platted**

1889



1887 Survey

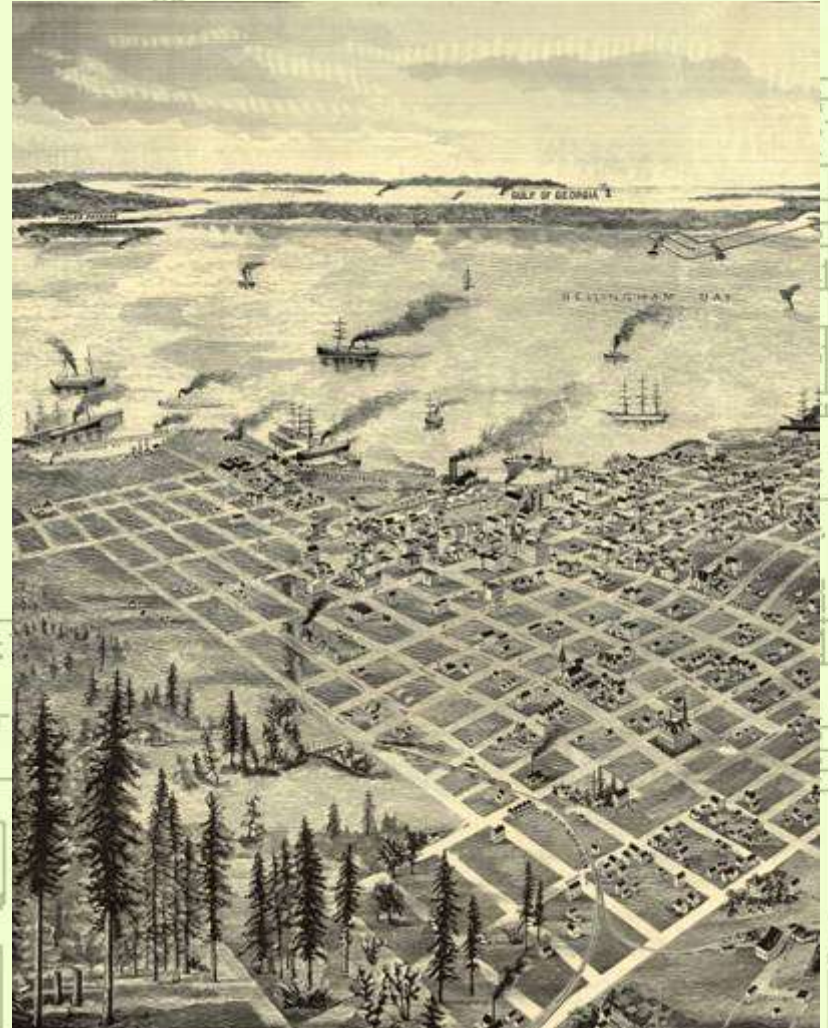


Topography of Rosario Strait, W.T.: Samish Flats to Bellingham - U.S.C. & G.S., 1887 – J.J. Gilbert

Reconciliation of Maps

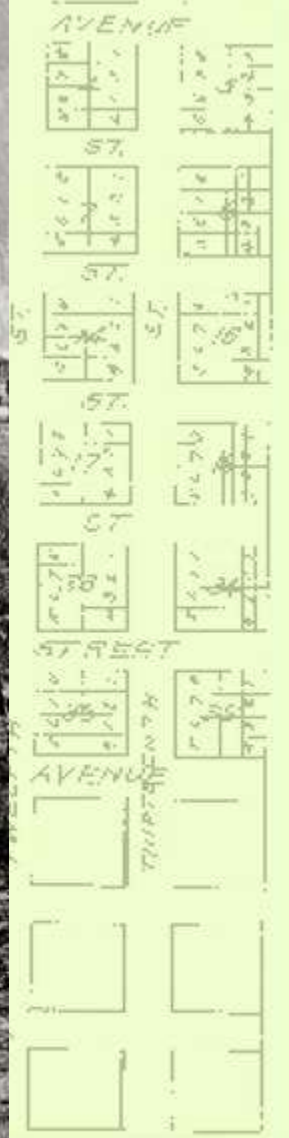


*Juan de Fuca Strait to Strait of George –
1889 - British Admiralty Chart by G.H. Richards*



*Fairhaven: A Birds Eye View – 1890
- Cartographer Unknown*

Oblique Photo

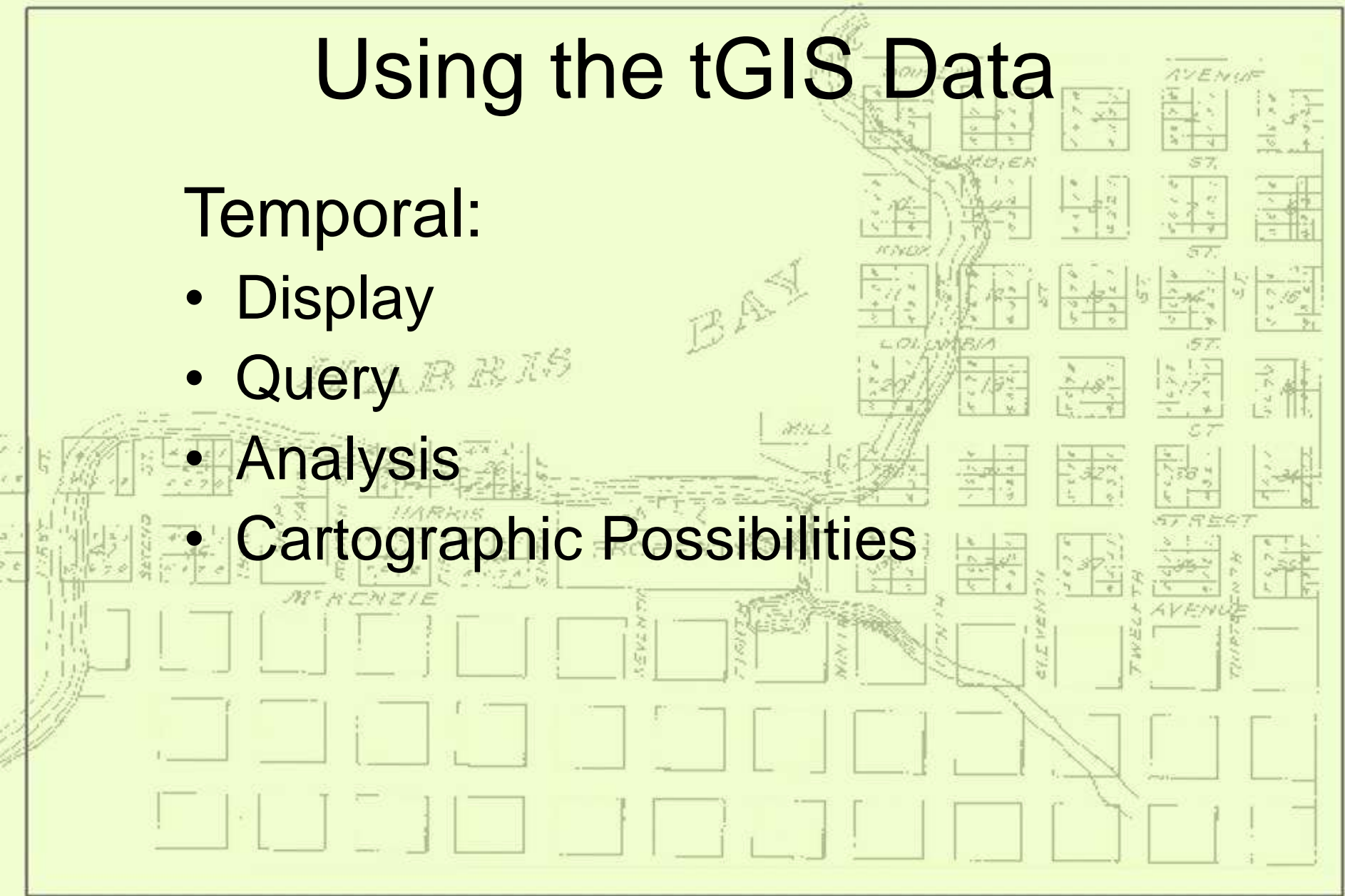


South Fairhaven – circa 1908 - Photographer Unknown, Whatcom Museum of History & Art (Biery Collection)

Using the tGIS Data

Temporal:

- Display
- Query
- Analysis
- Cartographic Possibilities




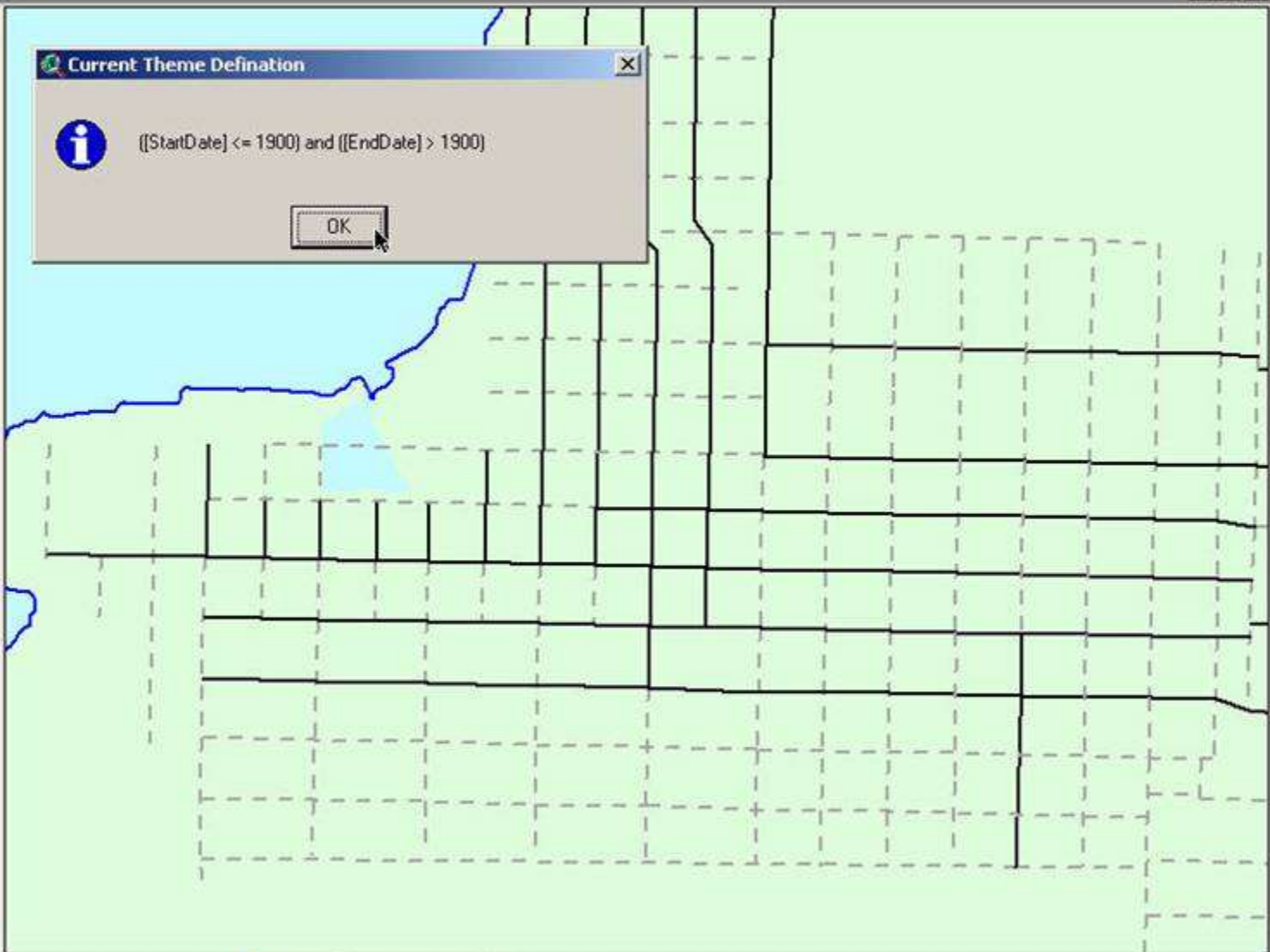


av TGIS Example

- 1 view-extent
- Study Area
- Buildings Layer
- Streets Layer
 - Plat
 - Street
- Plats Layer
- Metadata Layer
- COB Streets - 2002
- COB Shoreline
- Land

Current Theme Definition

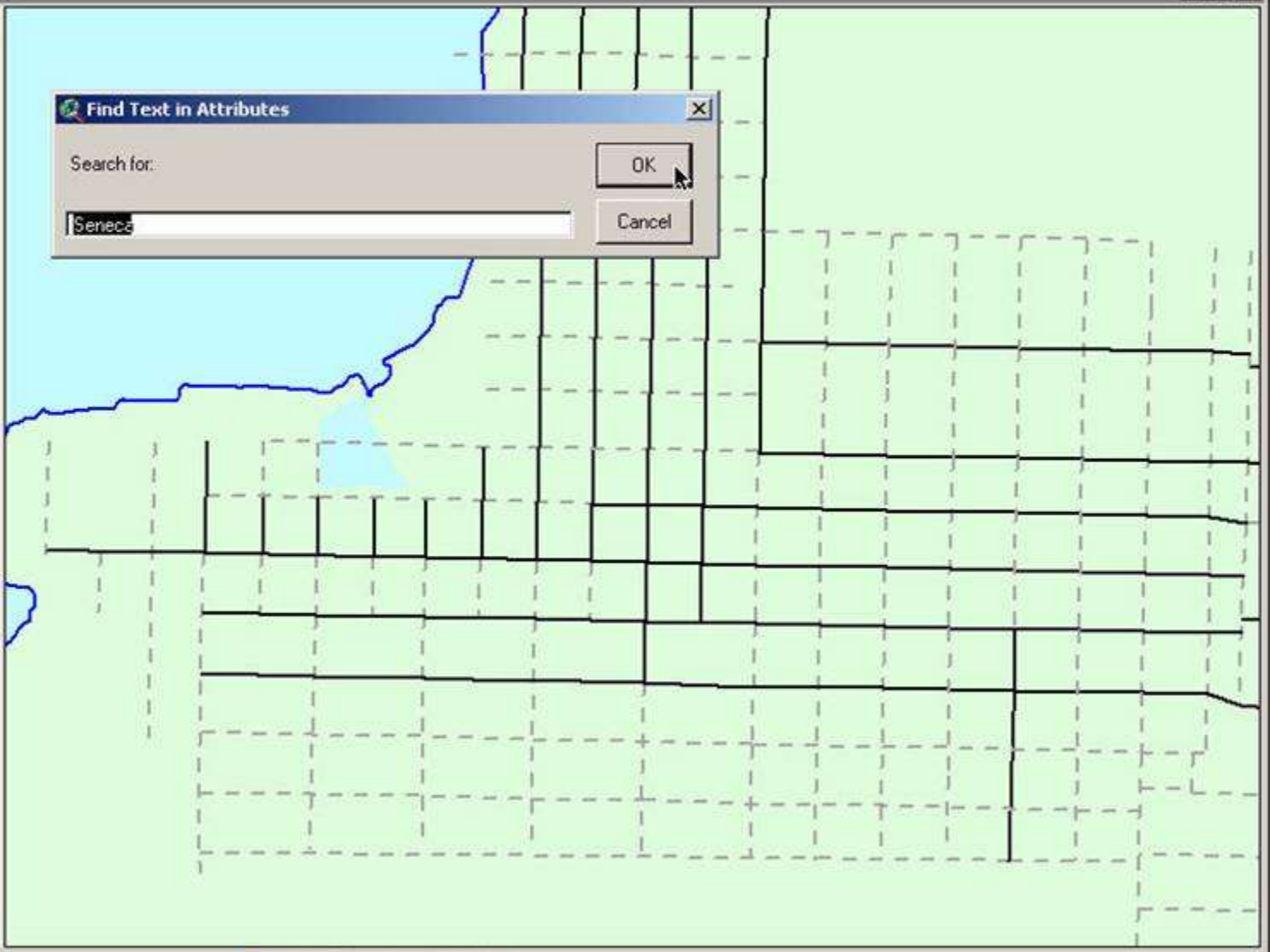
 `[(StartDate) <= 1900] and [(EndDate) > 1900]`





av tGIS Example

- 1 view-extent
- Study Area
- Buildings Layer
- Streets Layer
 - Plat
 - Street
- Plats Layer
- Metadata Layer
- COB Streets - 2002
- COB Shoreline
- Land





Scale 1:9,430

1,601,424.73
631,561.11

ay tGIS Example

- 1 view extent
- Study Area
- Buildings Layer
- Streets Layer
 - Plat
 - Street
- Plats Layer
- Metadata Layer
- COB Streets - 2002
- COB Shoreline
- Land





av tGIS Example

New

- 1 view-extent
- Study Area
- Buildings Layer
- Streets Layer
 - Plat
 - Street
- Plats Layer
- Metadata Layer
- COB Streets - 2002
- COB Shoreline
- Land

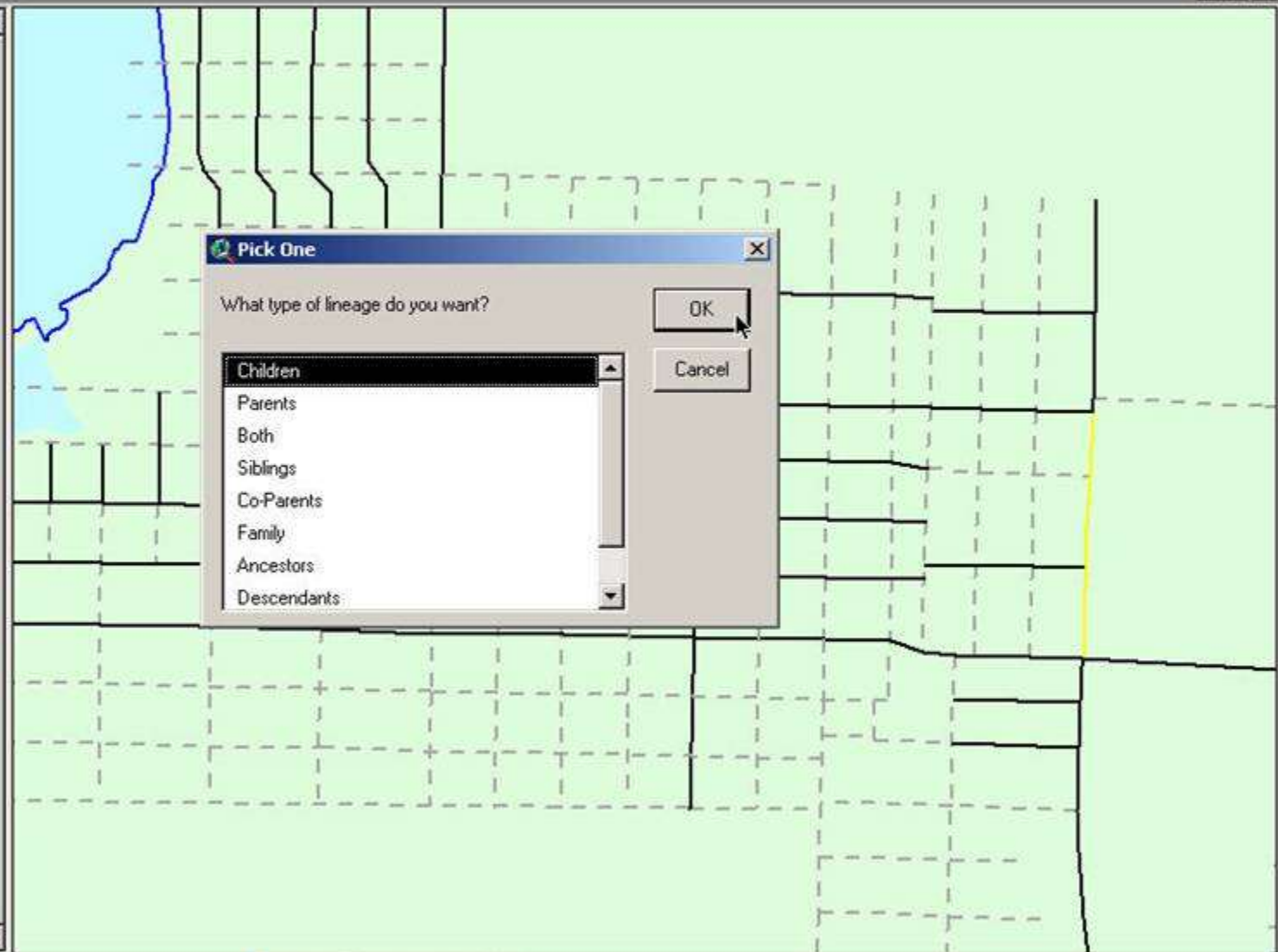
Views

Tables

Charts

Layout

Scripts





2 of 1208 selected



av tGIS Example

1 view extent

Study A

Building

Streets

Pl

St

Plats La

Metadat

COB St

COB Sh

Land

Attributes of Streets Layer

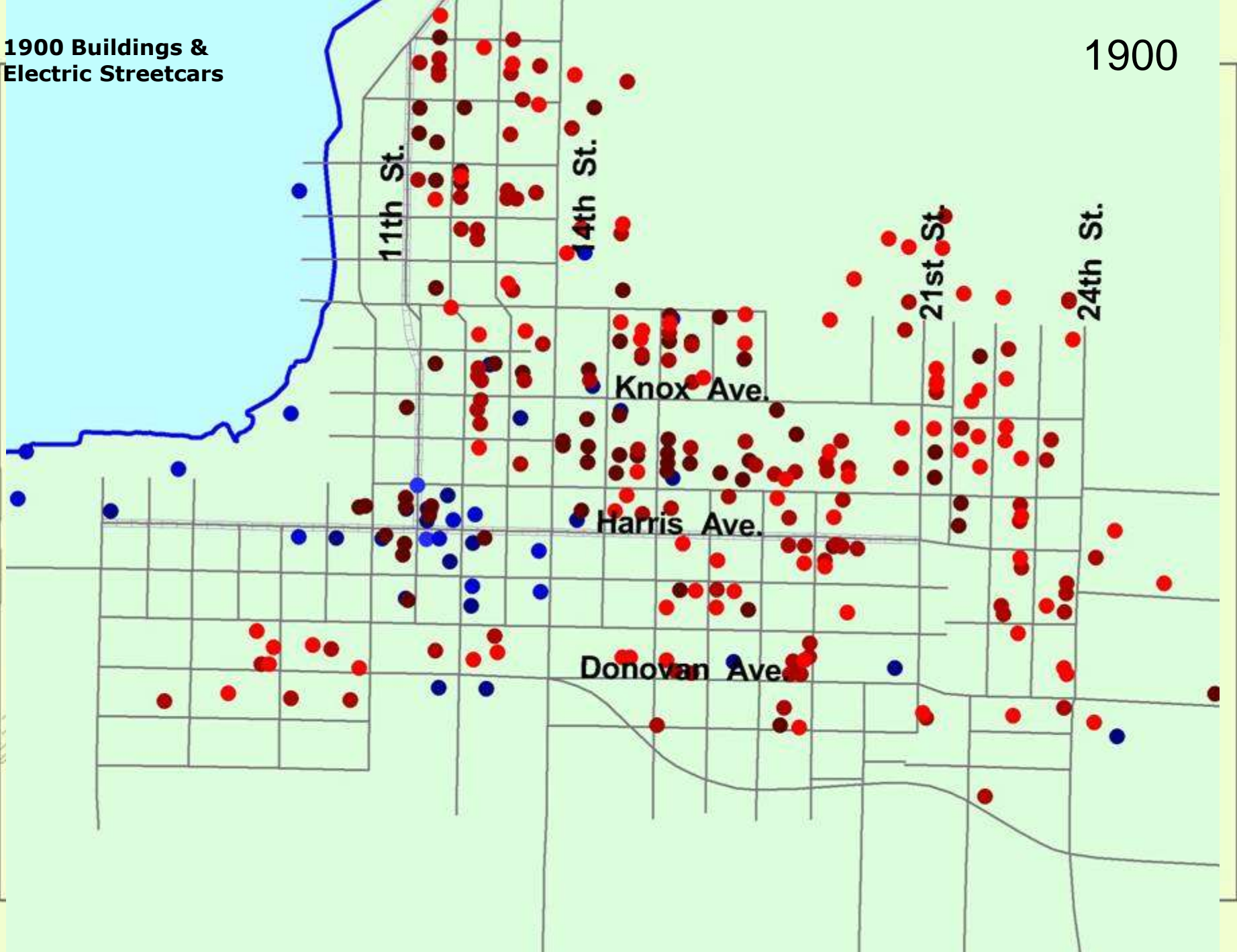
<i>Startdate</i>	<i>Enddate</i>	<i>Fid</i>	<i>Eid</i>	<i>Fid</i>	<i>Femeda</i>	<i>Tname</i>	<i>Type</i>	<i>Editdate</i>
1900	1905	51	271	232	48	Seneca Ave.	Street	20021227
1905	99999	271	232	99999	43	24th St.	Street	20181218
1883	1900	-1	258	259	1	McKenzie Ave.	Plat	20021227
1883	1900	-1	257	261	1	McKenzie Ave.	Plat	20021227
1883	1905	-1	34	304	3	Madison	Plat	20021227
1883	1887	-1	35	199	3	Front St.	Plat	20021218
1883	1905	-1	21	98888	1	Knox St.	Plat	20021227
1883	1891	-1	186	191	1	5th St.	Plat	20021218
1883	1891	-1	185	192	1	6th St.	Plat	20021218
1883	1903	24	182	183	1	Harris St.	Plat	20021218
1883	1902	-1	23	167	1	Mill St.	Plat	20021218
1900	1907	-1	100	101	1	11th St.	Plat	20021218

Streetcar

Street Offsets

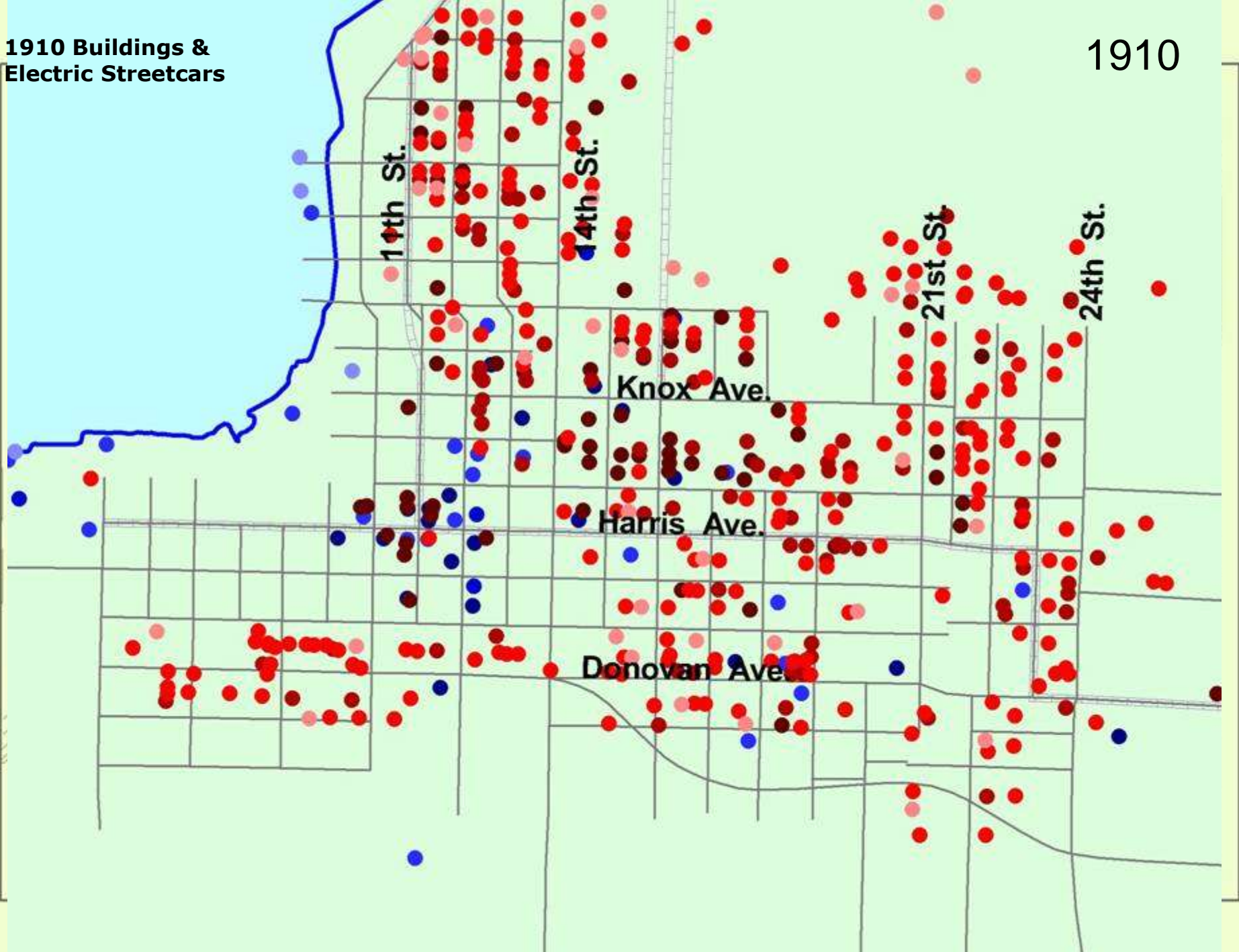
**1900 Buildings &
Electric Streetcars**

1900



**1910 Buildings &
Electric Streetcars**

1910



Cartographic Possibilities



- **Maps by Date**

Enhanced abilities for 'standard' cartography

- **Interactive Maps**

Ad-hoc, user-initiated map generation

- **Animation**

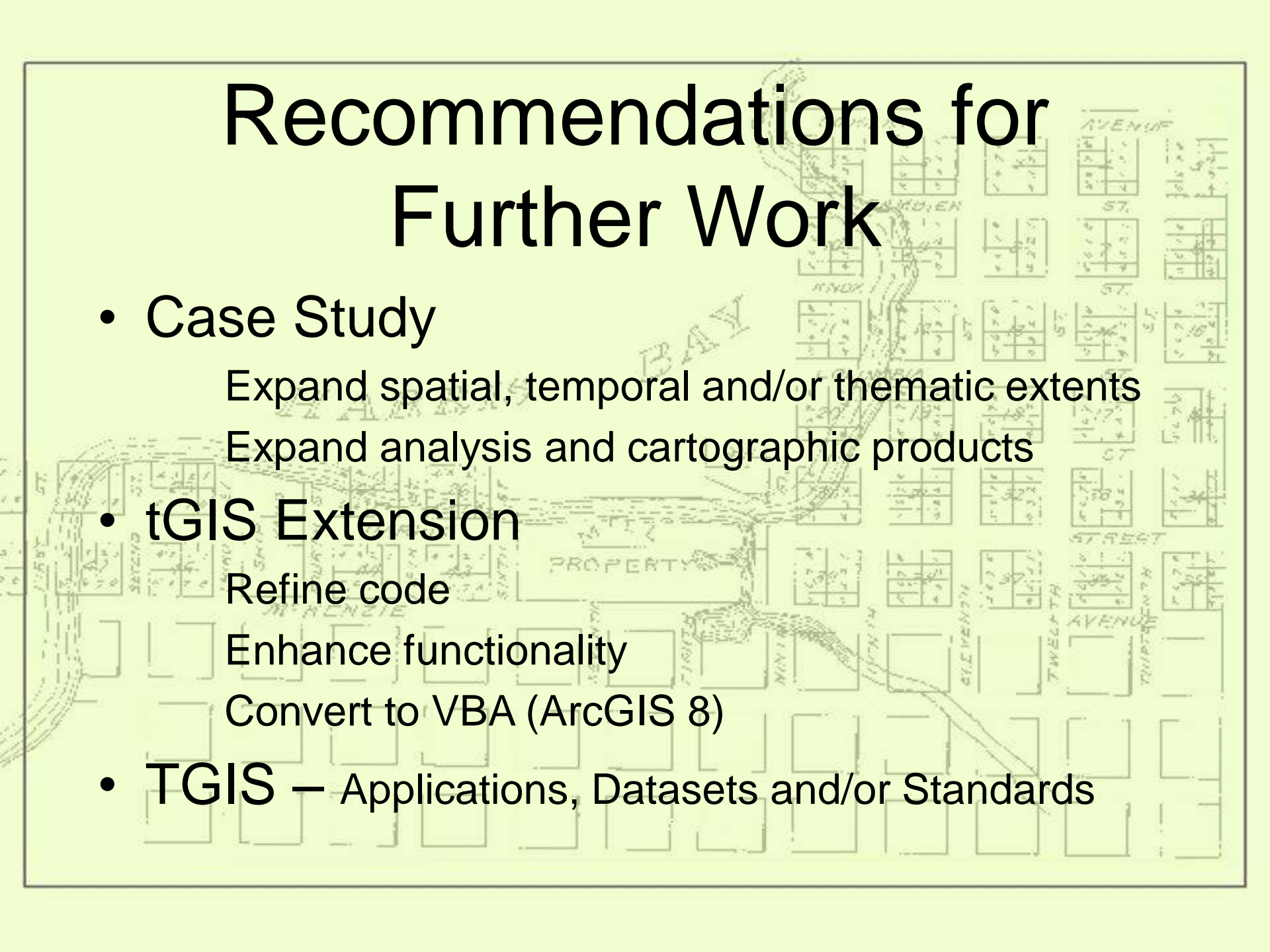
Using time to depict time

- **Temporally linked graphics**

Conclusions

- Yes, its possible...
 - (Technology isn't the limiting factor)
- tGIS extension greatly facilitates process
 - Reduces errors and time for data entry
 - Benefits of a composite database
 - Better able to identify patterns
 - Increased cartographic potential
 - Use as a spatial catalog of archival data
- And, it's still a lot of work...
 - Even with tGIS extension and methodology
 - Inherent problems of archival maps persist
- Need for TGIS (Database standards)

Recommendations for Further Work



- **Case Study**

 - Expand spatial, temporal and/or thematic extents

 - Expand analysis and cartographic products

- **tGIS Extension**

 - Refine code

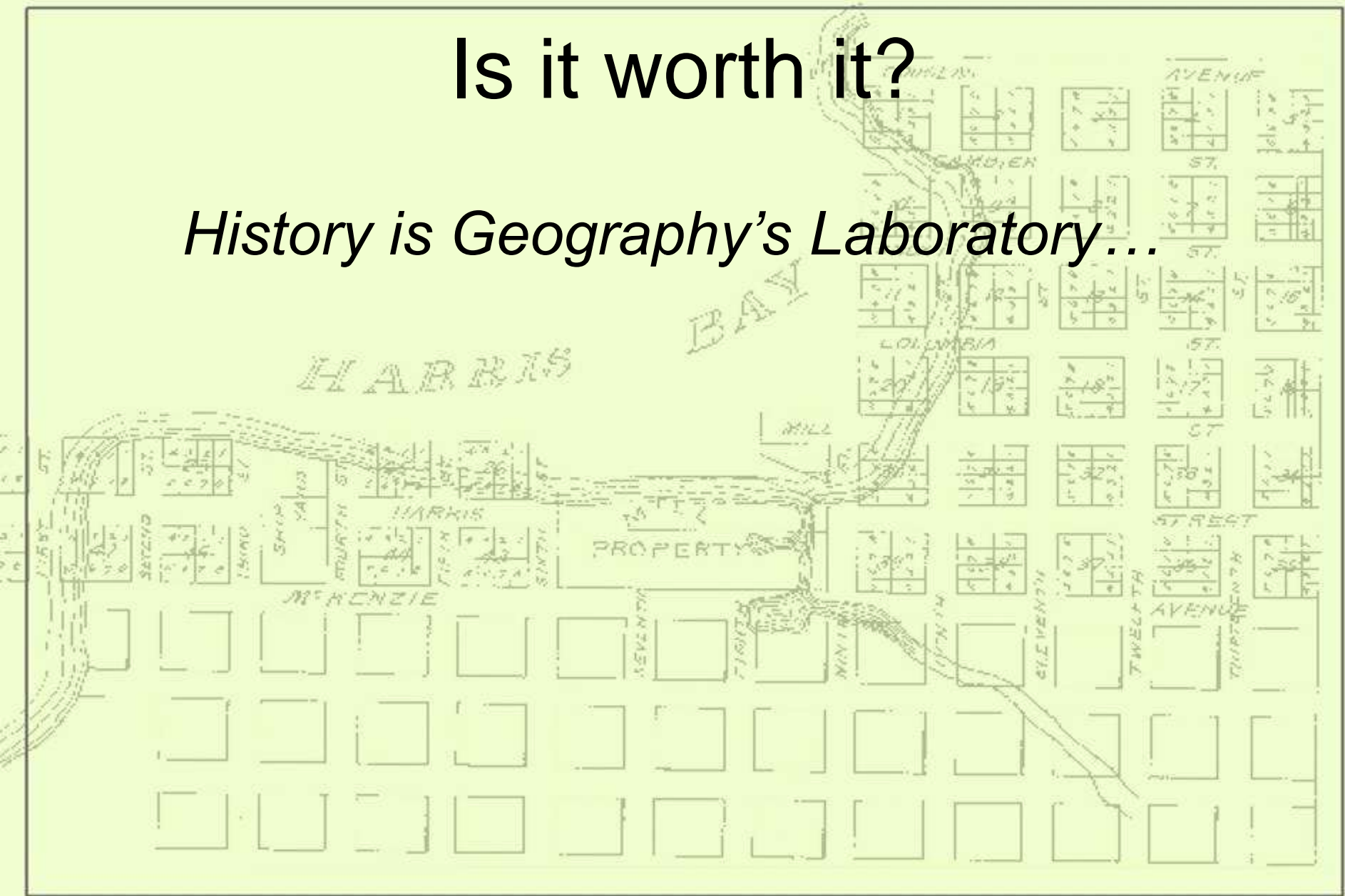
 - Enhance functionality

 - Convert to VBA (ArcGIS 8)

- **TGIS – Applications, Datasets and/or Standards**

Is it worth it?

History is Geography's Laboratory...





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fini...