Building and Disseminating Databases at the Kentucky Geological Survey

2017 Data Preservation Workshop, Salt Lake City, UT

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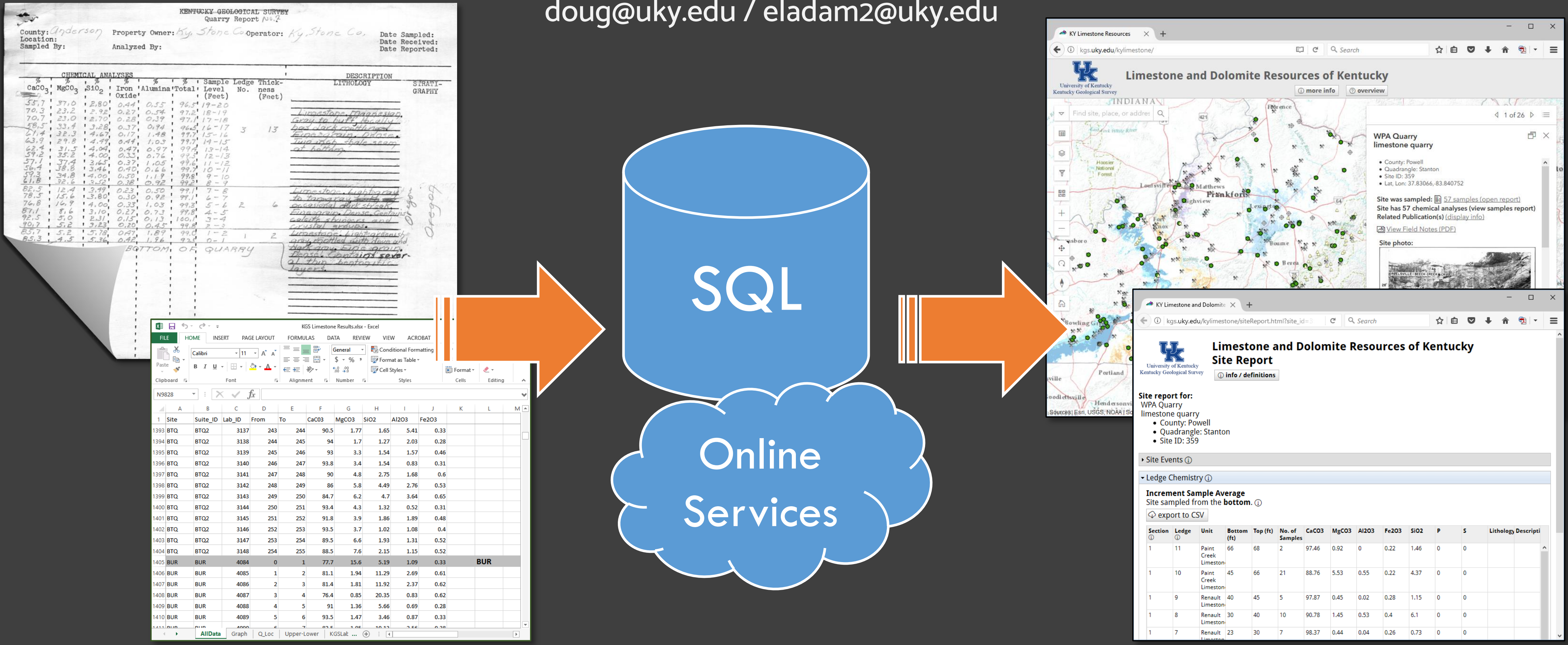


KGS IT / Data Infrastructure:

- Database Records:

  Over 16 million records – populated since ~1970's

  Relational Database (SQL)

  - Publications
  - Oil and gas
  - Coal
  - Groundwater
  - Minerals
  - Geotechnical
  - Geologic mapping
  - Research project data

- Document Scanning and Archiving:
  - Oil and gas documents: 770,000+ scanned (page-sized and elogs)
  - Publications: 7000+ scanned documents
  - Past research documents (field notes, data sheets)
  - Water well and spring documents*: ~800,000 documents

  *from KY Division of Water – no KGS scanning

KGS Website:

- Via KGS website: static and dynamic web pages and services
- Since 1996: KGS has had a website – one of most popular at UK
- Since 2001: started development of dynamic and internet map services
  - Access to KGS database records and GIS data
  - Access to scanned documents
  - All data and map services provided at no cost to users

Geologic information:

Rocks and minerals … Fossils … General KY Geology … Geoscience Education Resources … Geologic Mapping … Coal Research … Oil and Natural Gas Research … Carbon Sequestration … Karst Information … Groundwater Research … Earthquakes … Landslides … Foundation Engineering

Data services:

Publications and maps catalog … Oil and gas well records … Water wells and springs records … Groundwater quality … Coal borehole … Coal thickness and quality measurements … Well sample and core holdings … KYTC geotechnical data … KGS photos and images … Geologic descriptions … Coordinate conversion … GIS map services and downloads

Map Services:

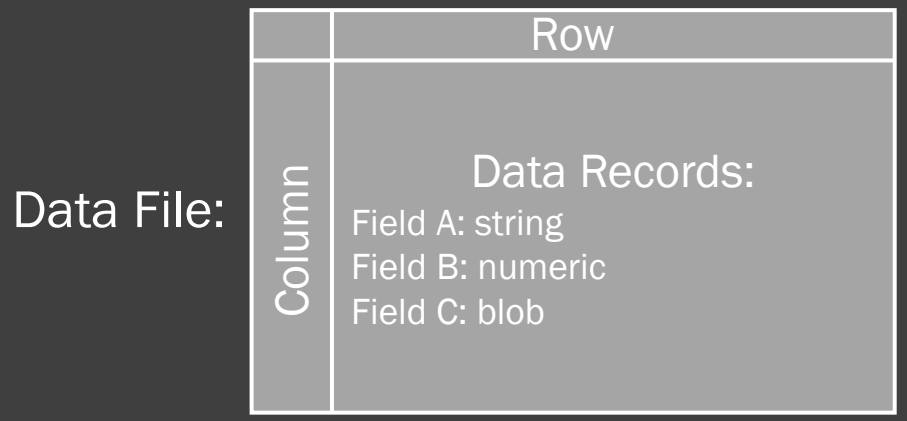
Geologic Map Service (Oil and gas wells…Water wells and springs…Coal data…Sinkholes…Landslides…Non-coal minerals and quarries…Core holdings…Outcrops) … Water Wells and Springs … Groundwater Quality … Coal Resource Information … Minerals Information … Kentucky Arches … Oil and Gas Permits … Class I and Class II Wells … Kentucky Energy Infrastructure … Landslide Information … Story Map Tours

Data Structure

2 basic types – both are valid as databases

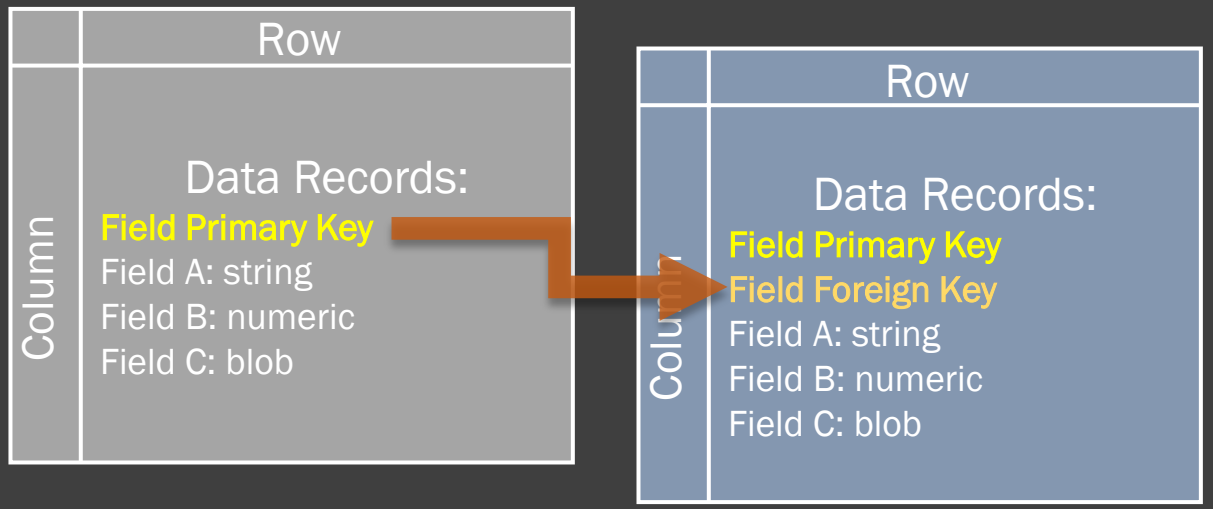
Flat File Database

- Single table of data
- Contains files, records, fields



Relational Database

- Multiple tables
- Records cross-referenced between tables (related)



Data Structure

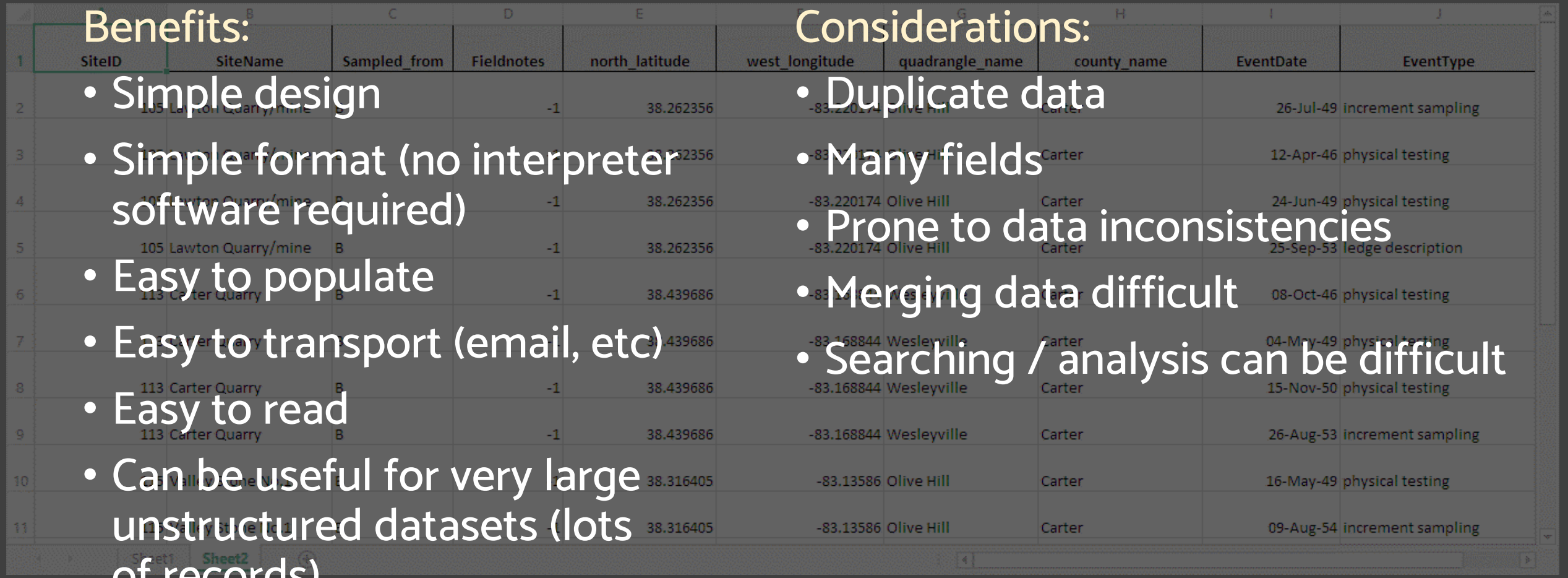
Flat File vs Relational Database

	A	B	C	D	E	F	G	H	I	J
1	SiteID	SiteName	Sampled_from	Fieldnotes	north_latitude	west_longitude	quadrangle_name	county_name	EventDate	EventType
2	105	Lawton Quarry/mine	B	-1	38.262356	-83.220174	Olive Hill	Carter	26-Jul-49	increment sampling
3	105	Lawton Quarry/mine	B	-1	38.262356	-83.220174	Olive Hill	Carter	12-Apr-46	physical testing
4	105	Lawton Quarry/mine	B	-1	38.262356	-83.220174	Olive Hill	Carter	24-Jun-49	physical testing
5	105	Lawton Quarry/mine	B	-1	38.262356	-83.220174	Olive Hill	Carter	25-Sep-53	ledge description
6	113	Carter Quarry	B	-1	38.439686	-83.168844	Wesleyville	Carter	08-Oct-46	physical testing
7	113	Carter Quarry	B	-1	38.439686	-83.168844	Wesleyville	Carter	04-May-49	physical testing
8	113	Carter Quarry	B	-1	38.439686	-83.168844	Wesleyville	Carter	15-Nov-50	physical testing
9	113	Carter Quarry	B	-1	38.439686	-83.168844	Wesleyville	Carter	26-Aug-53	increment sampling
10	115	Valley Stone No.1	B	-1	38.316405	-83.13586	Olive Hill	Carter	16-May-49	physical testing
11	115	Valley Stone No.1	B	-1	38.316405	-83.13586	Olive Hill	Carter	09-Aug-54	increment sampling

Sheet1 Sheet2

Data Structure

Flat File vs Relational Database



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114	Carter Quarry	B	-1	38.316405	-83.13586	Olive Hill	Carter	09-Aug-54	increment sampling

Benefits:

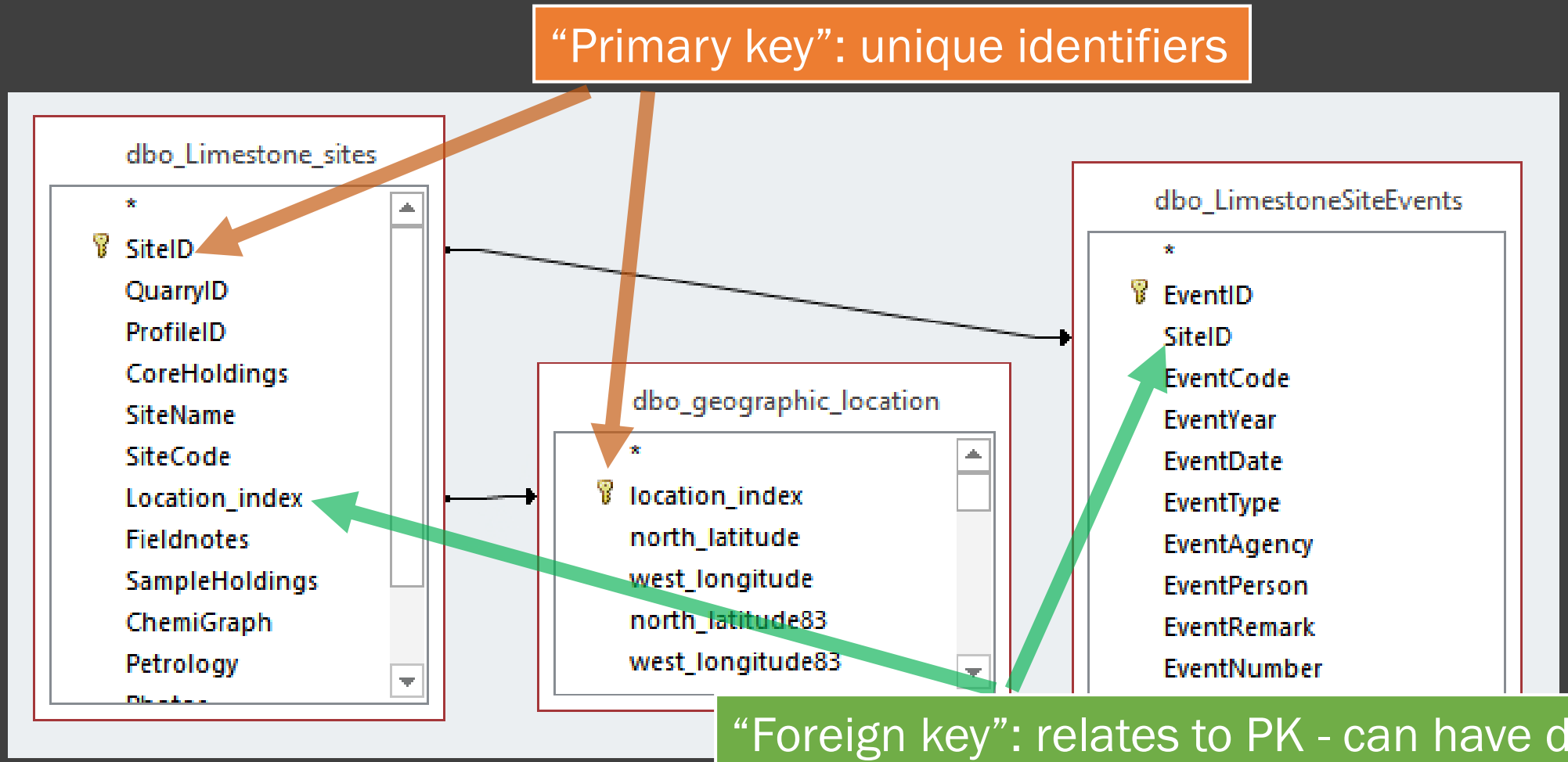
- Simple design
- Simple format (no interpreter software required)
- Easy to populate
- Easy to transport (email, etc)
- Easy to read
- Can be useful for very large unstructured datasets (lots of records)

Considerations:

- Duplicate data
- Many fields
- Prone to data inconsistencies
- Merging data difficult
- Searching / analysis can be difficult

Data Structure

Flat File vs Relational Database



Data Structure

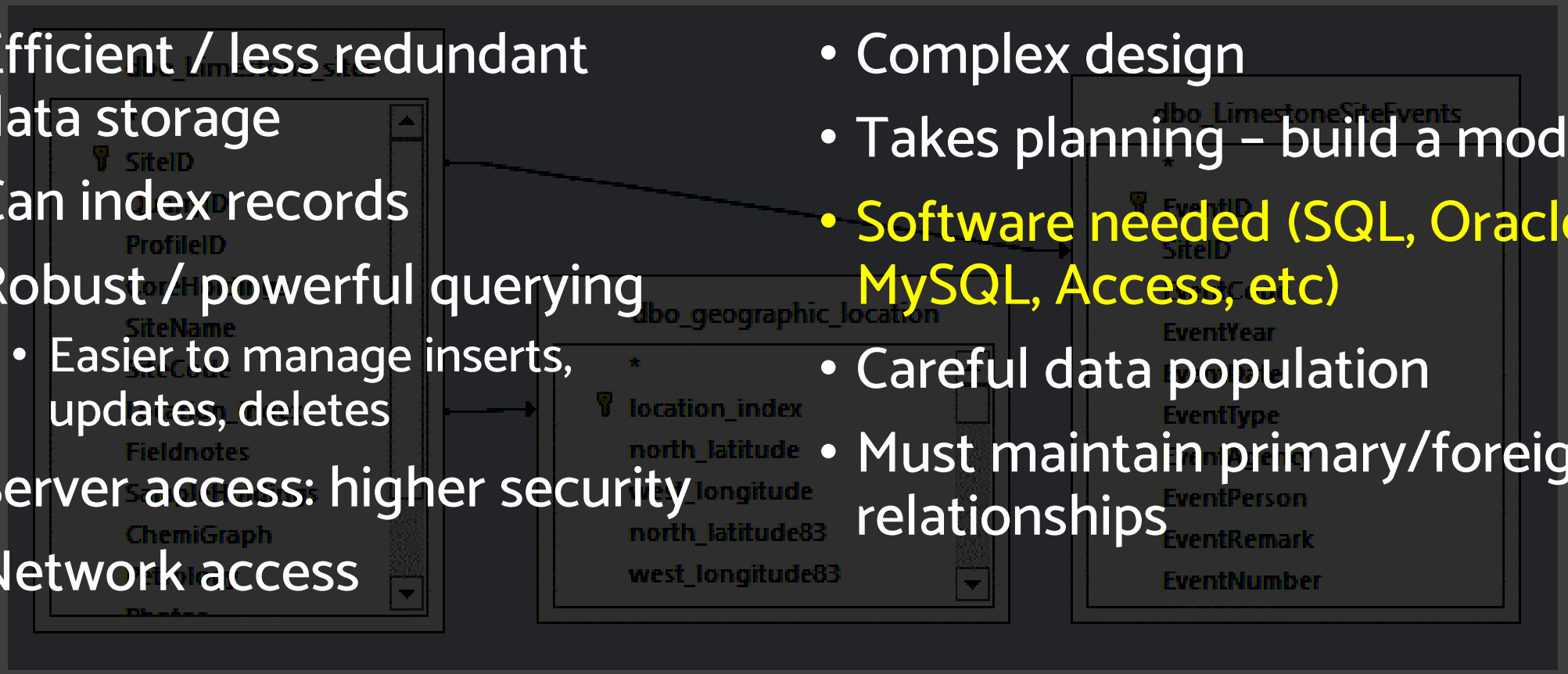
Flat File vs Relational Database

Benefits:

- Efficient / less redundant data storage
- Can index records
- Robust / powerful querying
  - Easier to manage inserts, updates, deletes
- Server access: higher security
- Network access

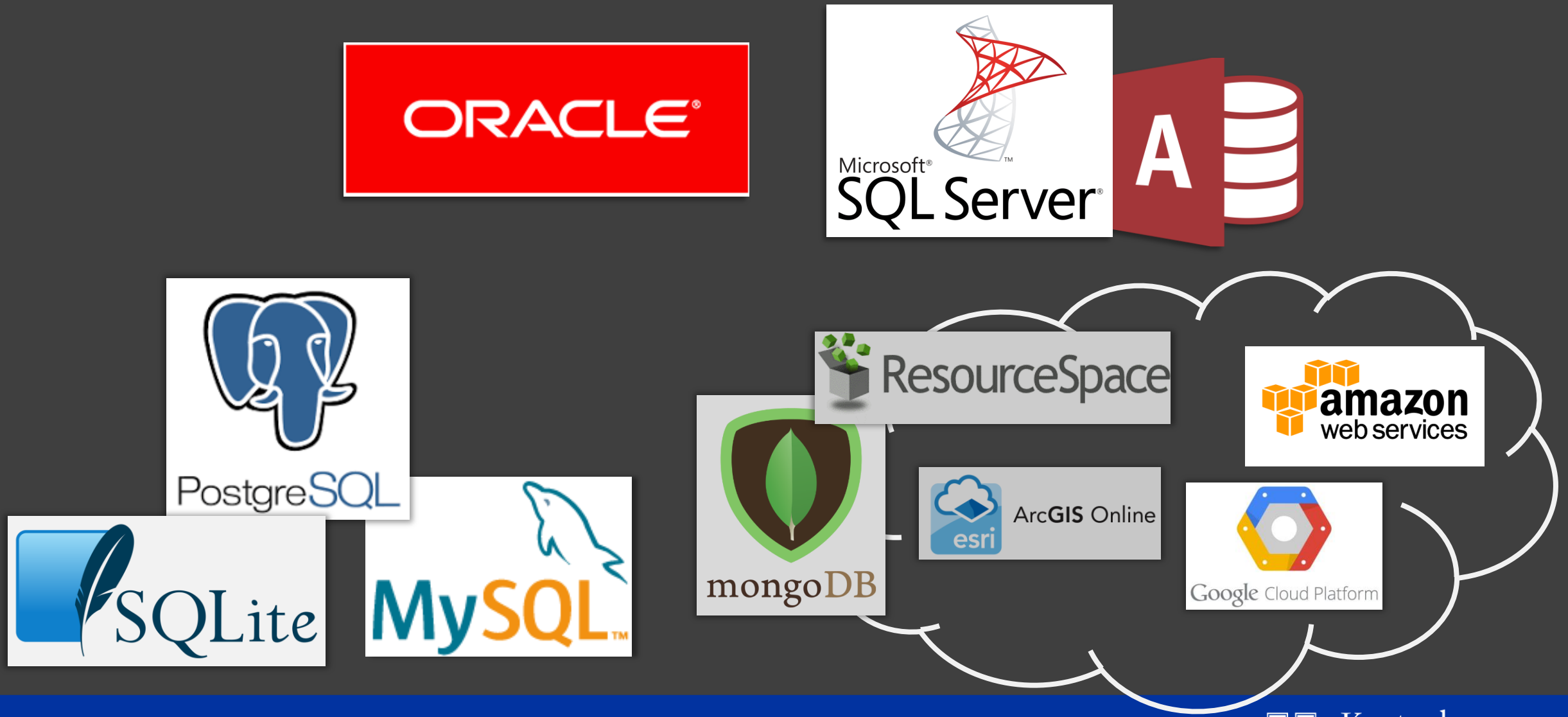
Considerations:

- Complex design
- Takes planning – build a model
- Software needed (SQL, Oracle, MySQL, Access, etc)
- Careful data population
- Must maintain primary/foreign key relationships



Design and build a database structure (schema/model)...

- Need database software/service – pick a flavor



Building a data structure:
flat data to relational database: example with KGS limestone sites database

	A	B	C	D	E	F	G	H	I	J
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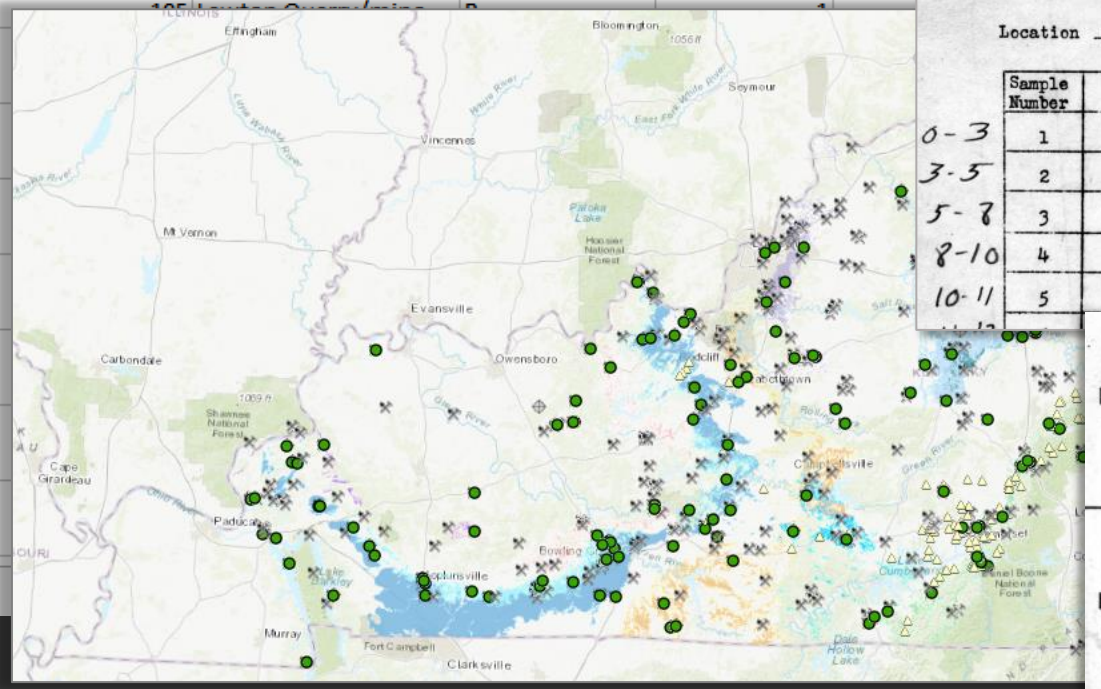

ANALYSIS OF LIMESTONE SAMPLES

Location Menifee Date Aug 4, 1953

Sample Number	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	$Ca_3P_2O_8$ %	$CaCO_3$ %	$MgCO_3$ %	Total %	
0-3 1	5.28	.32	.50		91.4	1.19	98.7	2581
3-5 2	2.71	.29	.11		95.0	.83	98.9	
5-8 3	4.14	.26	.79		92.4	1.22	98.8	
8-10 4	1.52	.18	.47		95.4	.91	98.5	
10-11 5	3.57	.56	.40		93.4	1.24	99.2	

Flat data to relational database... a journey

	A	B	C	D	E	F	G	H	I	J
1	SiteID	SiteName	Sampled_from	Fieldnotes	north_latitude	west_longitude	quadrangle_name	county_name	EventDate	EventType
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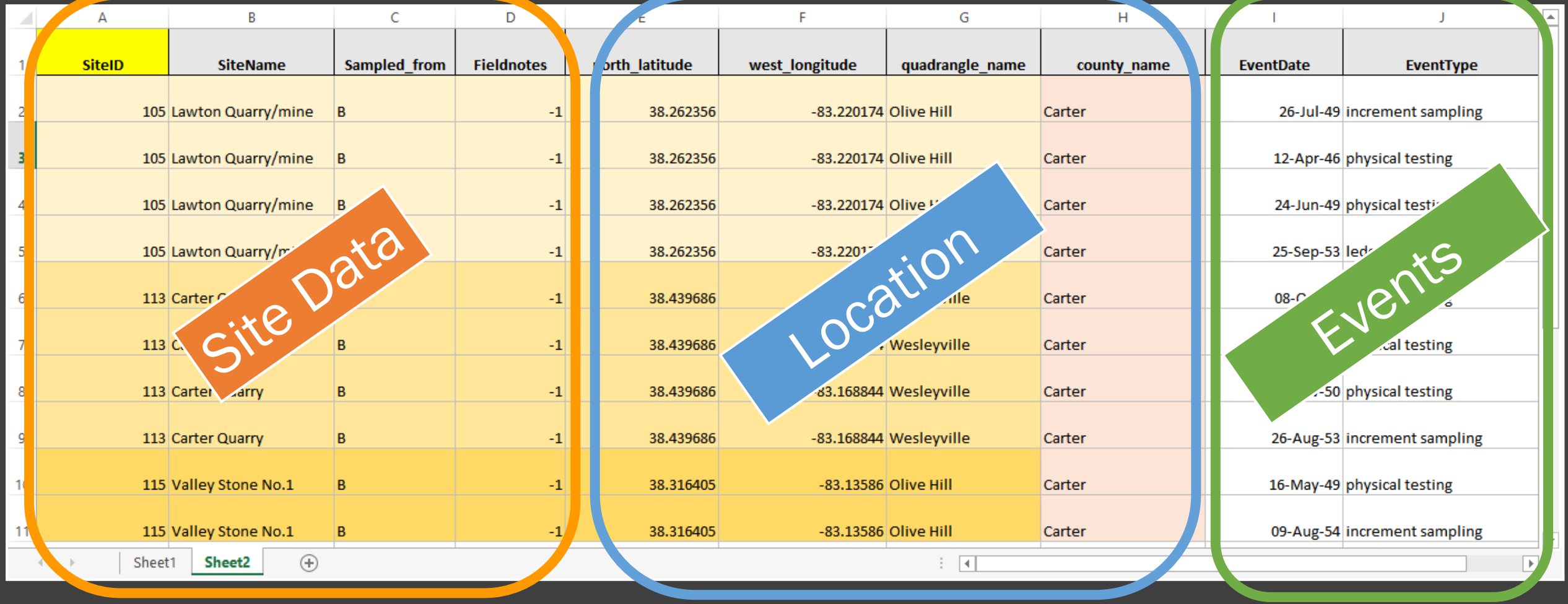
Sheet1 Sheet2

Identify “data segments” in flat data (or unstructured data)



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105	Lawton Quarry/m		-1	38.262356	-83.220		Carter	25-Sep-53	led
113	Carter C		-1	38.439686		ille	Carter	08-C	
113	C	B	-1	38.439686		Wesleyville	Carter		cal testing
113	Carter arry	B	-1	38.439686	83.168844	Wesleyville	Carter	-50	physical testing
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Sheet1 Sheet2

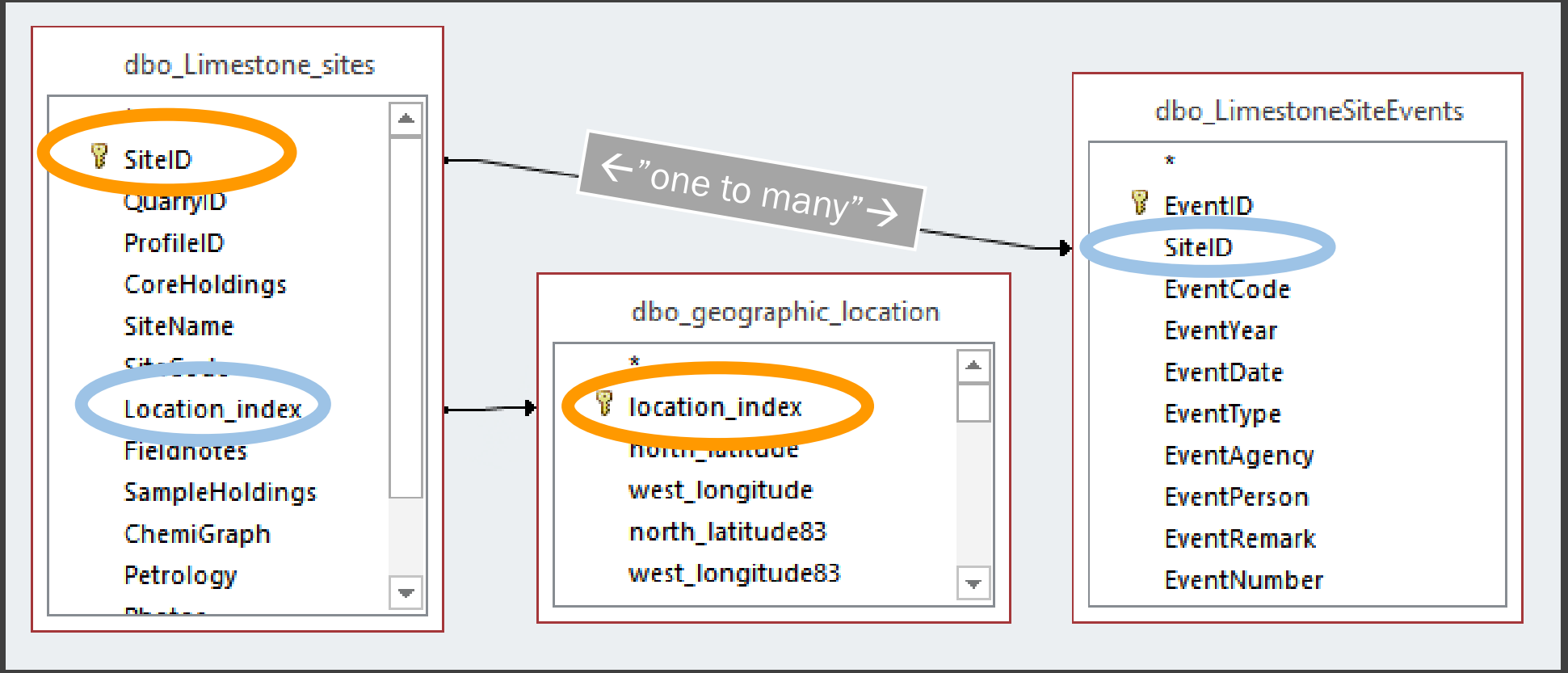
Site Data

Location

Events

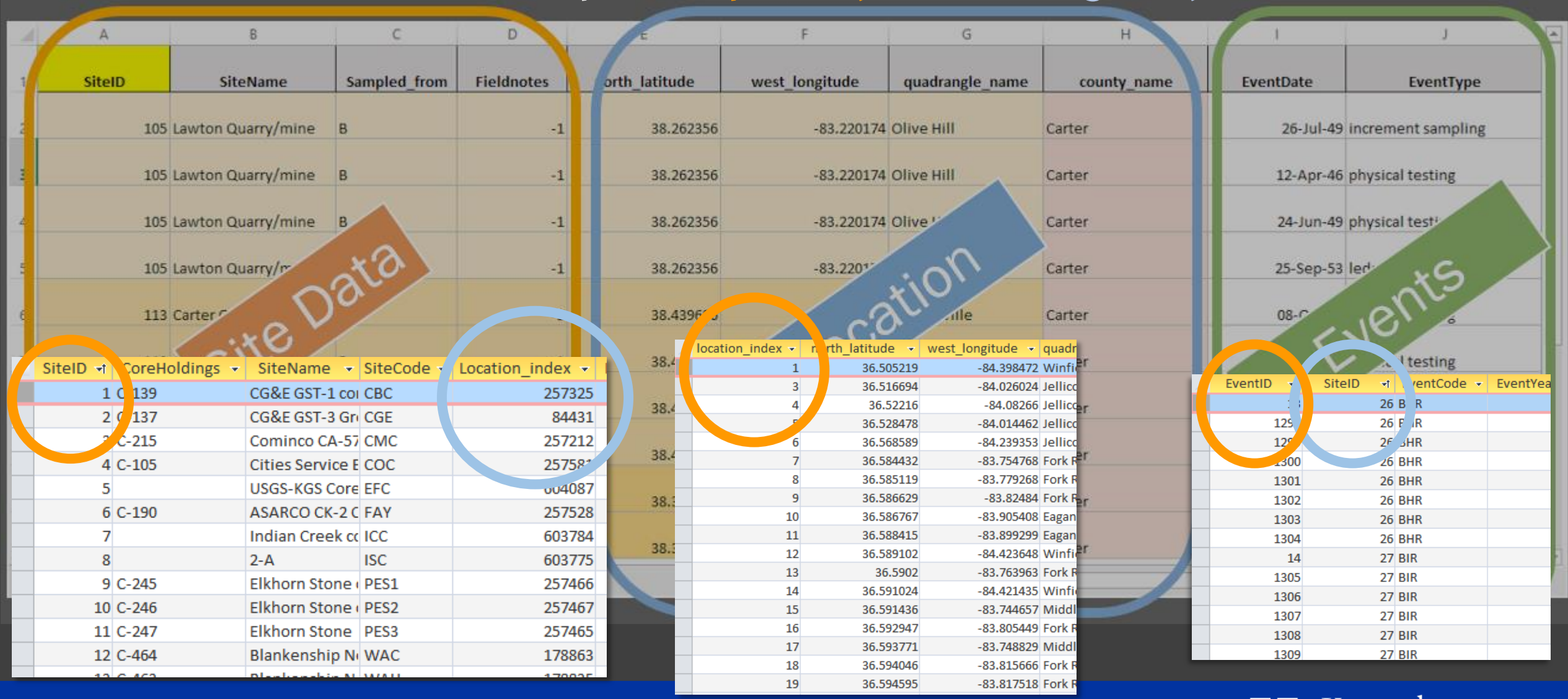
Design and build a database structure (schema/model)...

- Need database software – pick a flavor
- Design and build table schemas with primary and foreign keys



Migrate data from flat tables / populate tables in the relational database

**maintain relationships with primary - to - foreign keys!



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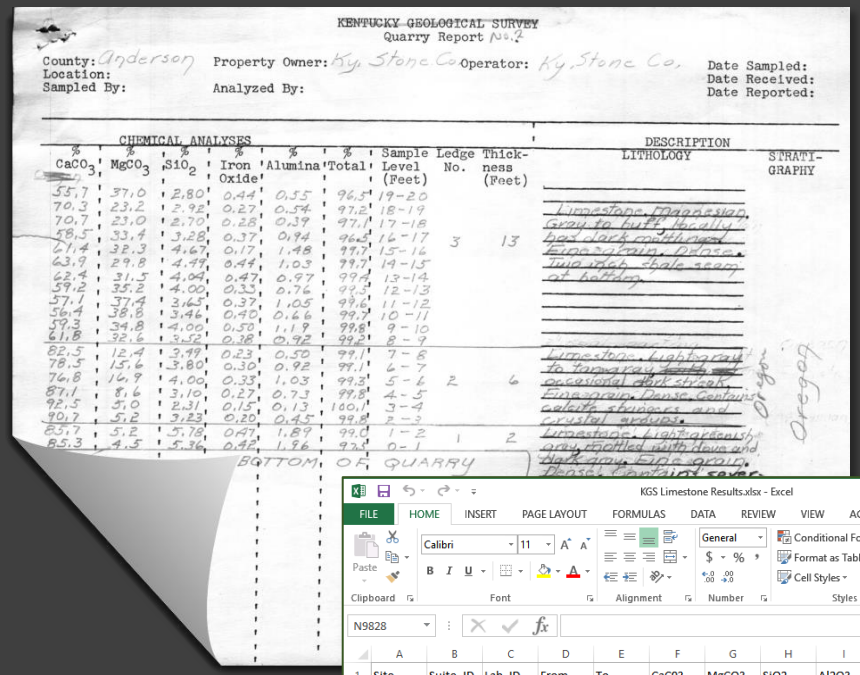
113	Carter C			38.4396		ille	Carter	08-C	

SiteID	CoreHoldings	SiteName	SiteCode	Location_index
1	C 139	CG&E GST-1 co	CBC	257325
2	C 137	CG&E GST-3 Gr	CGE	84431
3	C-215	Cominco CA-57	CMC	257212
4	C-105	Cities Service E	COC	257581
5		USGS-KGS Core	EFC	604087
6	C-190	ASARCO CK-2 C	FAY	257528
7		Indian Creek co	ICC	603784
8		2-A	ISC	603775
9	C-245	Elkhorn Stone (	PES1	257466
10	C-246	Elkhorn Stone (	PES2	257467
11	C-247	Elkhorn Stone	PES3	257465
12	C-464	Blankenship N	WAC	178863

location_index	rth_latitude	west_longitude	quadr
1	36.505219	-84.398472	Winfi
3	36.516694	-84.026024	Jellico
4	36.52216	-84.08266	Jellico
5	36.528478	-84.014462	Jellico
6	36.568589	-84.239353	Jellico
7	36.584432	-83.754768	Fork R
8	36.585119	-83.779268	Fork R
9	36.586629	-83.82484	Fork R
10	36.586767	-83.905408	Eagan
11	36.588415	-83.899299	Eagan
12	36.589102	-84.423648	Winfi
13	36.5902	-83.763963	Fork R
14	36.591024	-84.421435	Winfi
15	36.591436	-83.744657	Middl
16	36.592947	-83.805449	Fork R
17	36.593771	-83.748829	Middl
18	36.594046	-83.815666	Fork R
19	36.594595	-83.817518	Fork R

EventID	SiteID	EventCode	EventYea
1	26	BHR	
129	26	BHR	
129	26	BHR	
1300	26	BHR	
1301	26	BHR	
1302	26	BHR	
1303	26	BHR	
1304	26	BHR	
14	27	BIR	
1305	27	BIR	
1306	27	BIR	
1307	27	BIR	
1308	27	BIR	
1309	27	BIR	

Methods for populating a relational database



KENTUCKY GEOLOGICAL SURVEY
Quarry Report No. 2

County: Anderson Property Owner: Ky. Stone Co. Operator: Ky. Stone Co.
Location: Date Sampled:
Sampled By: Analyzed By: Date Received:
Date Reported:

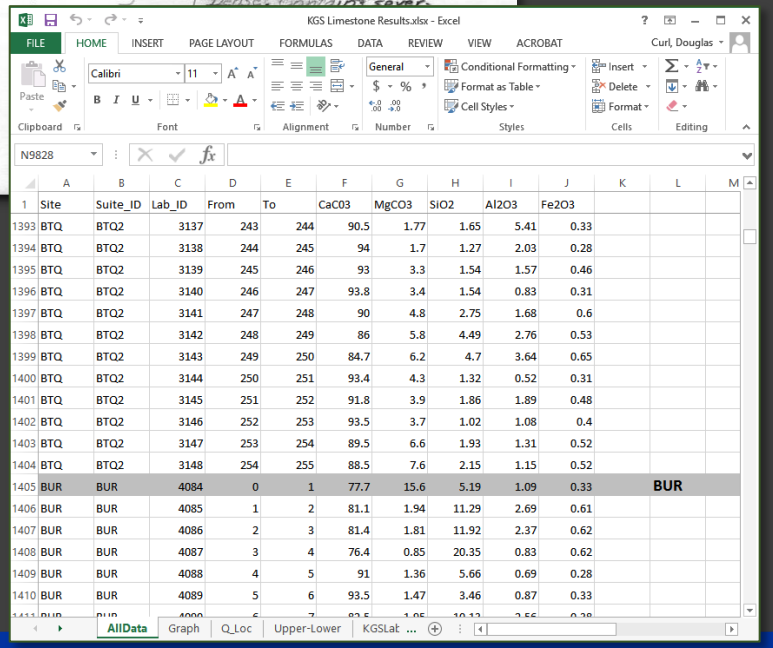
CHEMICAL ANALYSES

% $CaCO_3$	% $MgCO_3$	% SiO_2	% Iron Oxide	% Alumina	% Total	Sample Level (Feet)	Ledge No.	Thickness (Feet)
55.7	37.0	2.80	0.44	0.55	96.5	19-20		
70.3	23.2	2.92	0.27	0.54	97.2	18-19		
70.7	23.0	2.70	0.28	0.39	97.1	17-18		
58.5	33.4	3.28	0.37	0.94	96.5	16-17	3	13
61.4	32.3	4.67	0.17	1.48	99.7	15-16		
63.9	29.8	4.49	0.44	1.03	99.7	14-15		
62.4	31.5	4.04	0.47	0.97	99.4	13-14		
59.2	35.2	4.00	0.33	0.76	99.5	12-13		
57.1	37.4	3.65	0.37	1.05	99.6	11-12		
56.4	38.8	3.46	0.40	0.46	99.7	10-11		
59.3	34.8	4.00	0.52	1.19	99.8	9-10		
61.8	32.6	3.42	0.38	0.92	99.2	8-9		
82.5	12.4	3.49	0.23	0.50	99.1	7-8		
78.5	15.6	3.80	0.30	0.92	99.1	6-7		
76.8	16.9	4.00	0.33	1.03	99.3	5-6	2	6
87.1	8.6	3.10	0.27	0.73	99.8	4-5		
92.5	5.0	2.31	0.15	0.13	100.1	3-4		
90.7	5.2	3.23	0.20	0.45	99.8	2-3		
85.7	5.2	5.78	0.47	1.89	99.0	1-2	1	2
85.3	4.5	5.36	0.48	1.96	97.6	0-1		

DESCRIPTION

LITHOLOGY	STRATIGRAPHY
Limestone, Magnesian, Gray to buff, locally has dark mottlings. Fine grain. Dense. Two inch shale seam at bottom.	Oregon
Limestone, light gray to tan, gray to buff, occasional dark streaks. Fine grain. Dense. Contains calcite stringers and crystal druses.	Oregon
Limestone, light greenish gray, mottled with brown and dark gray. Fine grain. Dense. Contains several	

BOTTOM OF QUARRY



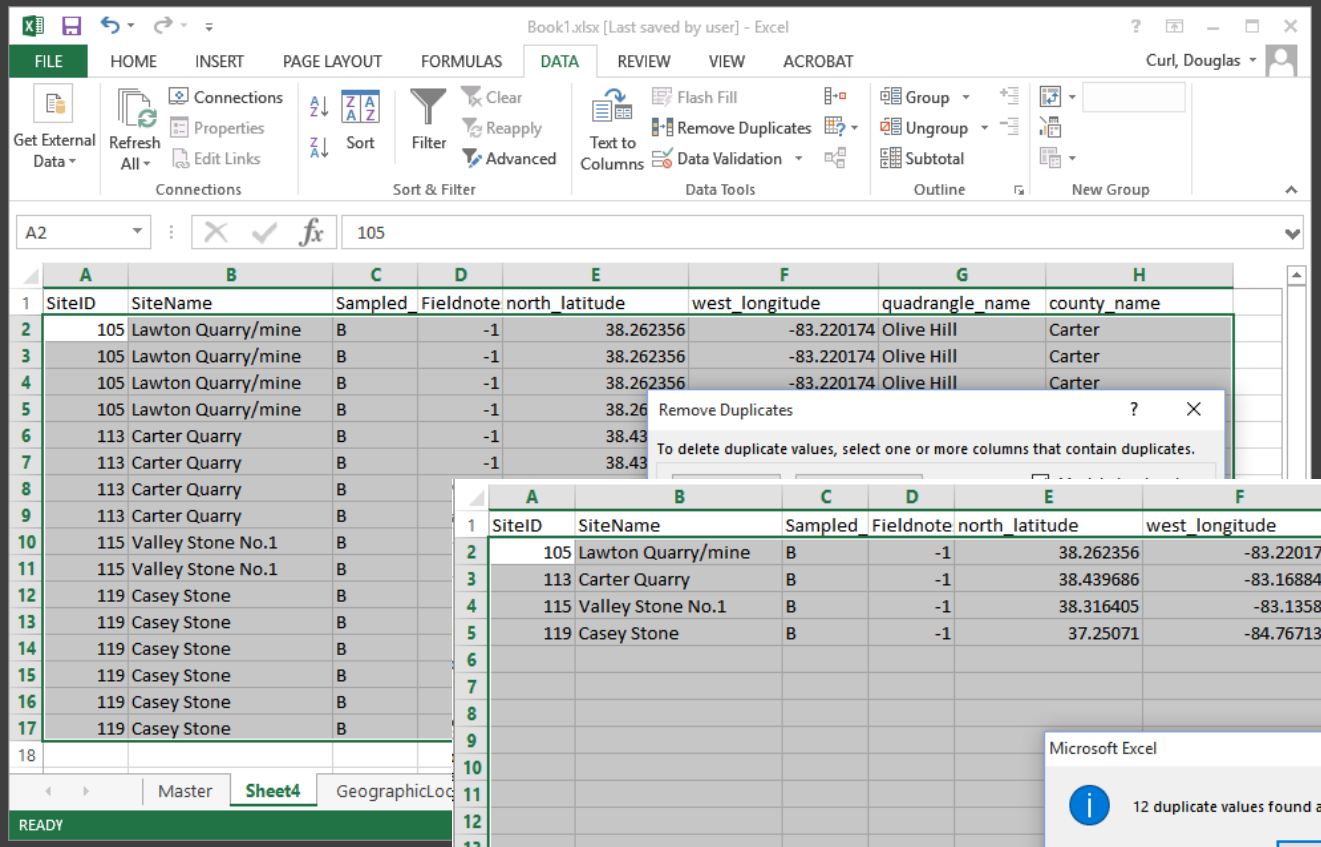
KGS Limestone Results.xlsx - Excel

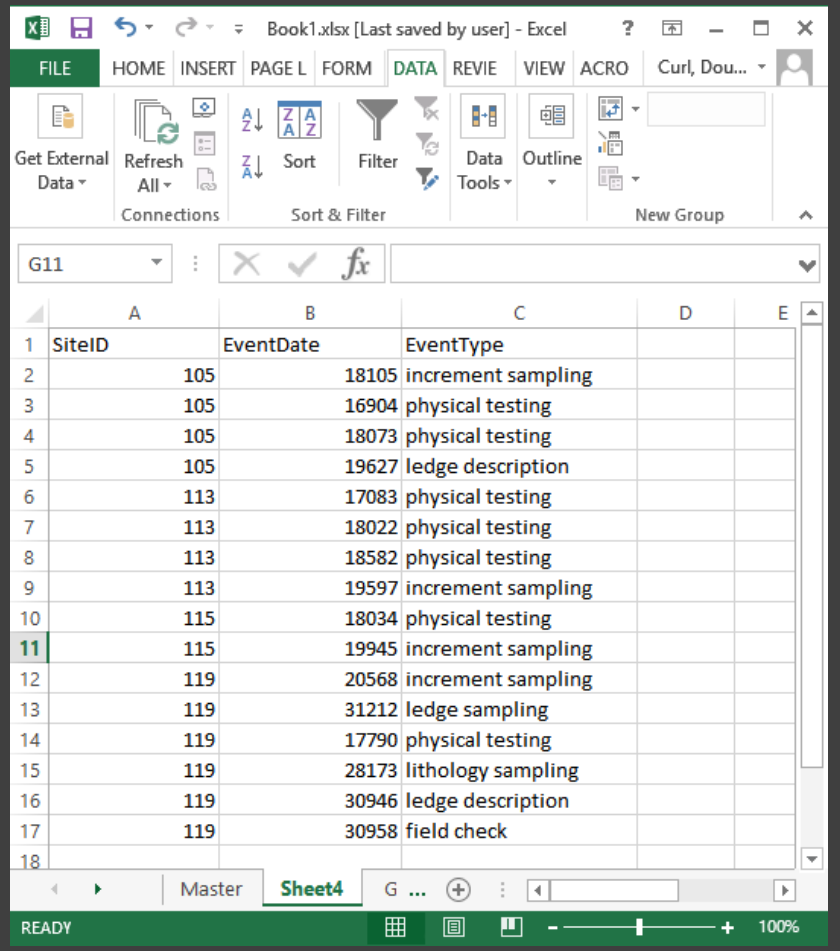
	Site	Suite_ID	Lab_ID	From	To	CaCO3	MgCO3	SiO2	Al2O3	Fe2O3	
1393	BTQ	BTQ2	3137	243	244	90.5	1.77	1.65	5.41	0.33	
1394	BTQ	BTQ2	3138	244	245	94	1.7	1.27	2.03	0.28	
1395	BTQ	BTQ2	3139	245	246	93	3.3	1.54	1.57	0.46	
1396	BTQ	BTQ2	3140	246	247	93.8	3.4	1.54	0.83	0.31	
1397	BTQ	BTQ2	3141	247	248	90	4.8	2.75	1.68	0.6	
1398	BTQ	BTQ2	3142	248	249	86	5.8	4.49	2.76	0.53	
1399	BTQ	BTQ2	3143	249	250	84.7	6.2	4.7	3.64	0.65	
1400	BTQ	BTQ2	3144	250	251	93.4	4.3	1.32	0.52	0.31	
1401	BTQ	BTQ2	3145	251	252	91.8	3.9	1.86	1.89	0.48	
1402	BTQ	BTQ2	3146	252	253	93.5	3.7	1.02	1.08	0.4	
1403	BTQ	BTQ2	3147	253	254	89.5	6.6	1.93	1.31	0.52	
1404	BTQ	BTQ2	3148	254	255	88.5	7.6	2.15	1.15	0.52	
1405	BUR	BUR	4084	0	1	77.7	15.6	5.19	1.09	0.33	BUR
1406	BUR	BUR	4085	1	2	81.1	1.94	11.29	2.69	0.61	
1407	BUR	BUR	4086	2	3	81.4	1.81	11.92	2.37	0.62	
1408	BUR	BUR	4087	3	4	76.4	0.85	20.35	0.83	0.62	
1409	BUR	BUR	4088	4	5	91	1.36	5.66	0.69	0.28	
1410	BUR	BUR	4089	5	6	93.5	1.47	3.46	0.87	0.33	

Populating a relational database

Spreadsheet conversion: somewhat “brute” force

- deal with existing data
- one-time processing

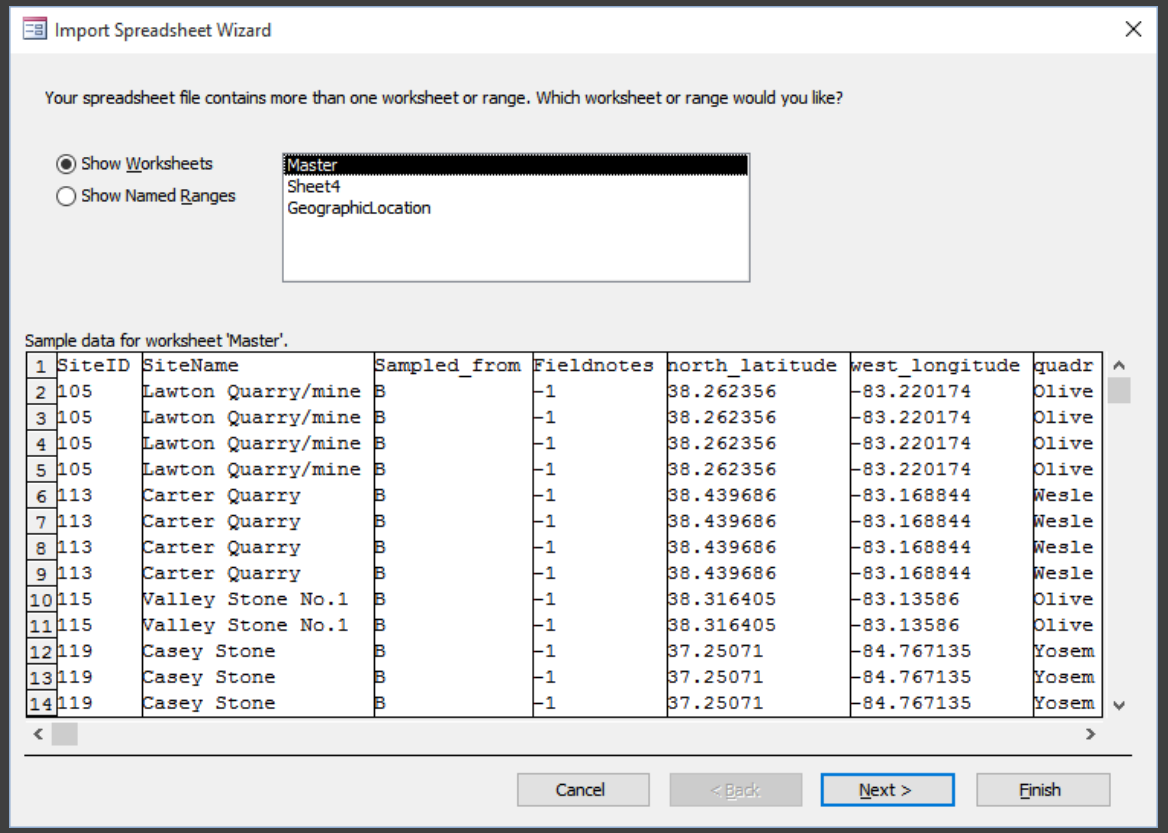




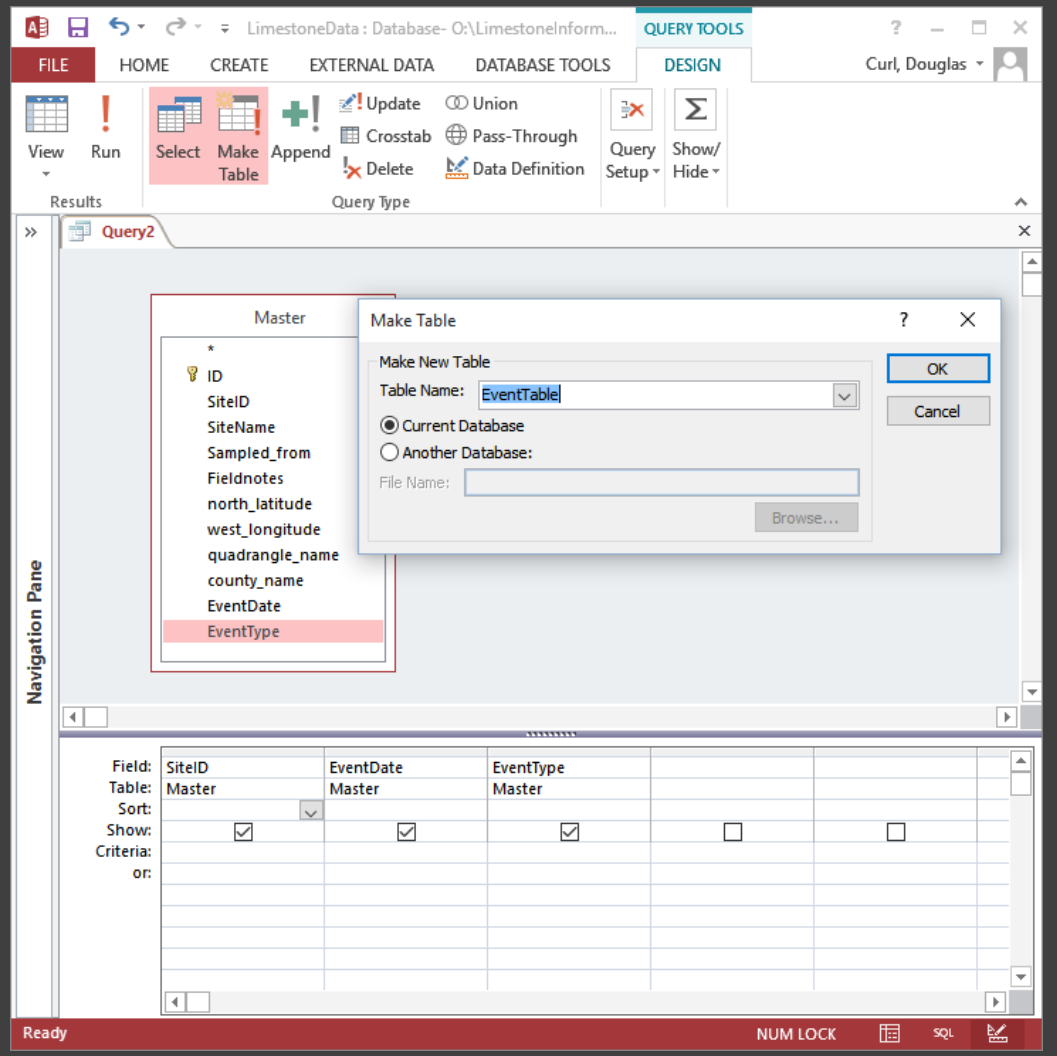
Populating a relational database

Spreadsheet conversion: import into a software like Access – less brute force

- query table to build new tables
- deal with existing data
- one-time processing



	SiteID	SiteName	Sampled_from	Fieldnotes	north_latitude	west_longitude	quadr
2	105	Lawton Quarry/mine	B	-1	38.262356	-83.220174	Olive
3	105	Lawton Quarry/mine	B	-1	38.262356	-83.220174	Olive
4	105	Lawton Quarry/mine	B	-1	38.262356	-83.220174	Olive
5	105	Lawton Quarry/mine	B	-1	38.262356	-83.220174	Olive
6	113	Carter Quarry	B	-1	38.439686	-83.168844	Wesle
7	113	Carter Quarry	B	-1	38.439686	-83.168844	Wesle
8	113	Carter Quarry	B	-1	38.439686	-83.168844	Wesle
9	113	Carter Quarry	B	-1	38.439686	-83.168844	Wesle
10	115	Valley Stone No.1	B	-1	38.316405	-83.13586	Olive
11	115	Valley Stone No.1	B	-1	38.316405	-83.13586	Olive
12	119	Casey Stone	B	-1	37.25071	-84.767135	Yosem
13	119	Casey Stone	B	-1	37.25071	-84.767135	Yosem
14	119	Casey Stone	B	-1	37.25071	-84.767135	Yosem



Populating a relational database

Spreadsheet conversion: write a program (Python, VB, etc) to parse table

- requires programming
- can re-use
- could be efficient means for population

	A	B	C	D	E	F	G	H
1	SiteID	SiteName	Sampled_from	Fieldnotes	north_latitude	west_longitude	quadrangle_name	county_name
2	105	Lawton Quarry/mine	B	-1	38.262356	-83.220174	Olive Hill	Carter
3	105	Lawton Quarry/mine	B	-1	38.262356	-83.220174	Olive Hill	Carter
		Quarry/mine	B	-1	38.262356	-83.220174	Olive Hill	Carter
		Quarry/mine	B	-1	38.262356	-83.220174	Olive Hill	Carter
		Quarry	B	-1	38.439686	-83.168844	Wesleyville	Carter
		Quarry	B	-1	38.439686	-83.168844	Wesleyville	Carter
		Quarry	B	-1	38.439686	-83.168844	Wesleyville	Carter
		Quarry	B	-1	38.439686	-83.168844	Wesleyville	Carter
		Stone No.1	B	-1	38.316405	-83.13586	Olive Hill	Carter
		Stone No.1	B	-1	38.316405	-83.13586	Olive Hill	Carter

GeologicMappingProfilesReplica.py - N:\arcgisserver\ArcGIS_Projects_10pt1\CollectorProjects\GeologicMappingPr...

File Edit Format Run Options Window Help

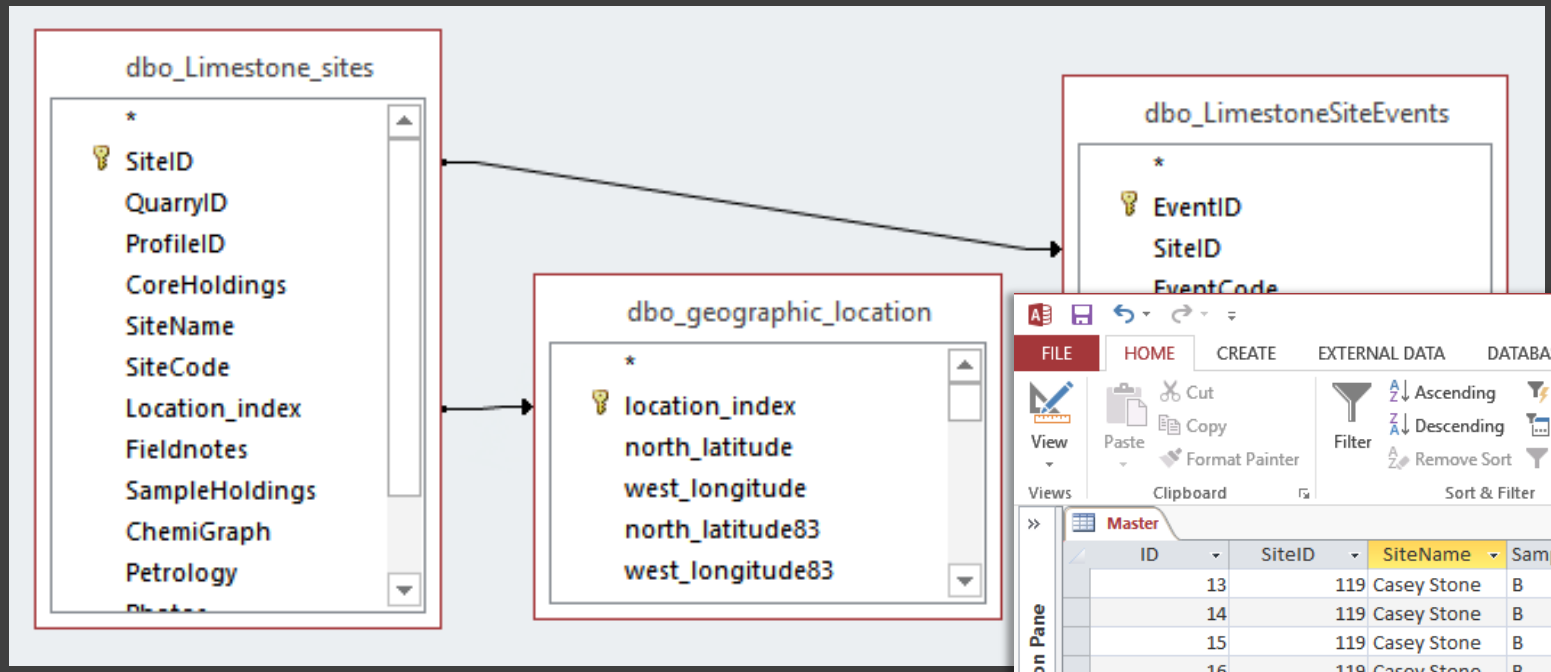
```
                        pull_to_local(attachment_file, attachment['id'],
                                      '', 'jpg')
                    except urllib2.HTTPError:
                        raise urllib2.HTTPError('httperror')
        group_photos(root_file, "ALL")

    def pull_attachments(self, query, field):
        query['token'] = self.token
        os.chdir(self.destination)
        layers = get_service_info(self.fs_url, self.token)['layers']
        root_name = self.get_root_name() + "_Photos"
        if os.path.exists(root_name):
            shutil.rmtree(root_name)
        service_file = create_and_set_dir(root_name)
        attachments = get_service_info(self.layer_url,
            self.token)['hasAttachments']
        if self.layer_id and attachments:
            self.find_attachments(query, layers[int(self.layer_id)], field)
        else:
            for layer in layers:
                if get_service_info(add_path(self.fs_url, layer['id']),
                    self.token)['hasAttachments']:
                    os.chdir(service_file)
                    query['objectIds'] = ''
                    self.find_attachments(query, layer, field)

    def replicate(self, query):
        query['token'] = self.token
        replica_url = add_path(self.fs_url, 'createReplica')
        #MUST ADD THE TOKEN TO THE URL:
        arcpy.AddMessage(replica_url)
        zip_url = get_response2(replica_url, query)['responseUrl']+"?token="+self.token
        arcpy.AddMessage(zip_url)
        zip_file = get_response(zip_url, get_json=False)
        zip_name = pull_to_local(zip_file, self.get_root_name(), self.destination, 'zip')
        return unzip_to_local(zip_name,self.destination)

    def pull_replica(self, query):
        query['token'] = self.token
        layers = get_service_info(self.fs_url, self.token)['layers']
        if self.layer_id:
            query['layers'] = self.layer_id
            return self.replicate(query)
        else:
            query['layers'] = [layer['id'] for layer in layers]
            return self.replicate(query)
```

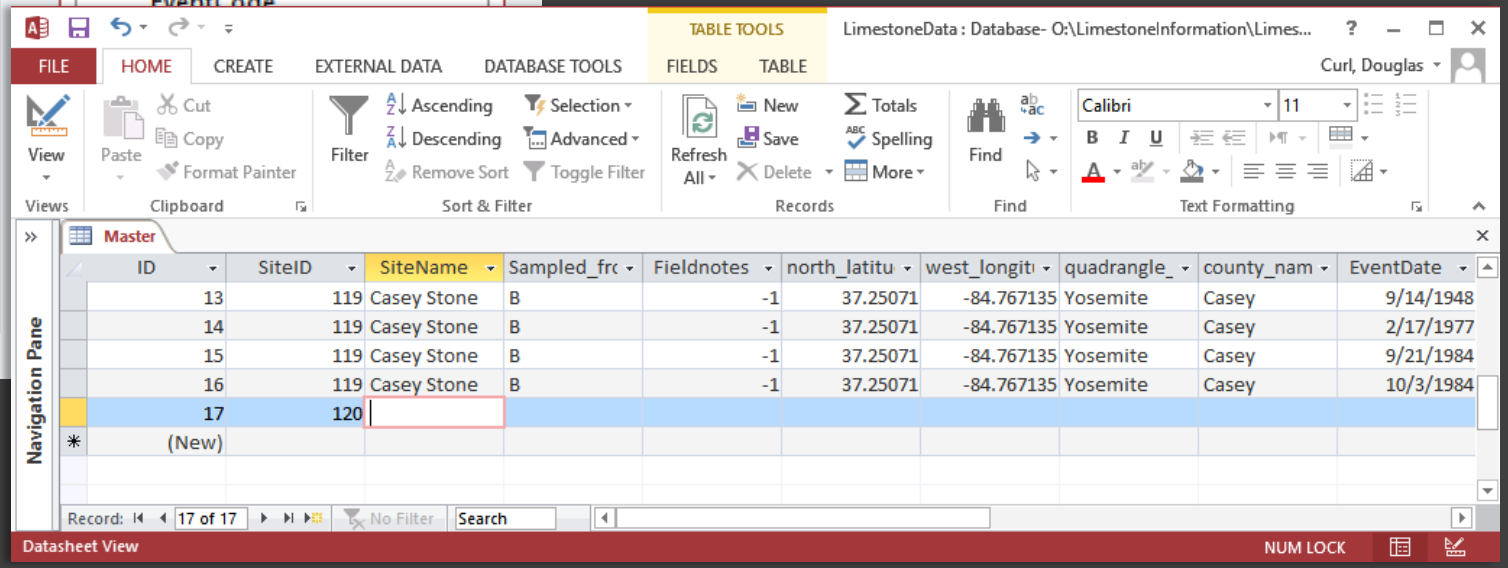
Ln: 1 Col: 0

Populating a relational database

Direct data entry:

- can plan model and enter into datasheet views
- fast setup for data entry
- prone to data inconsistencies / errors & may not be very flexible for deployment

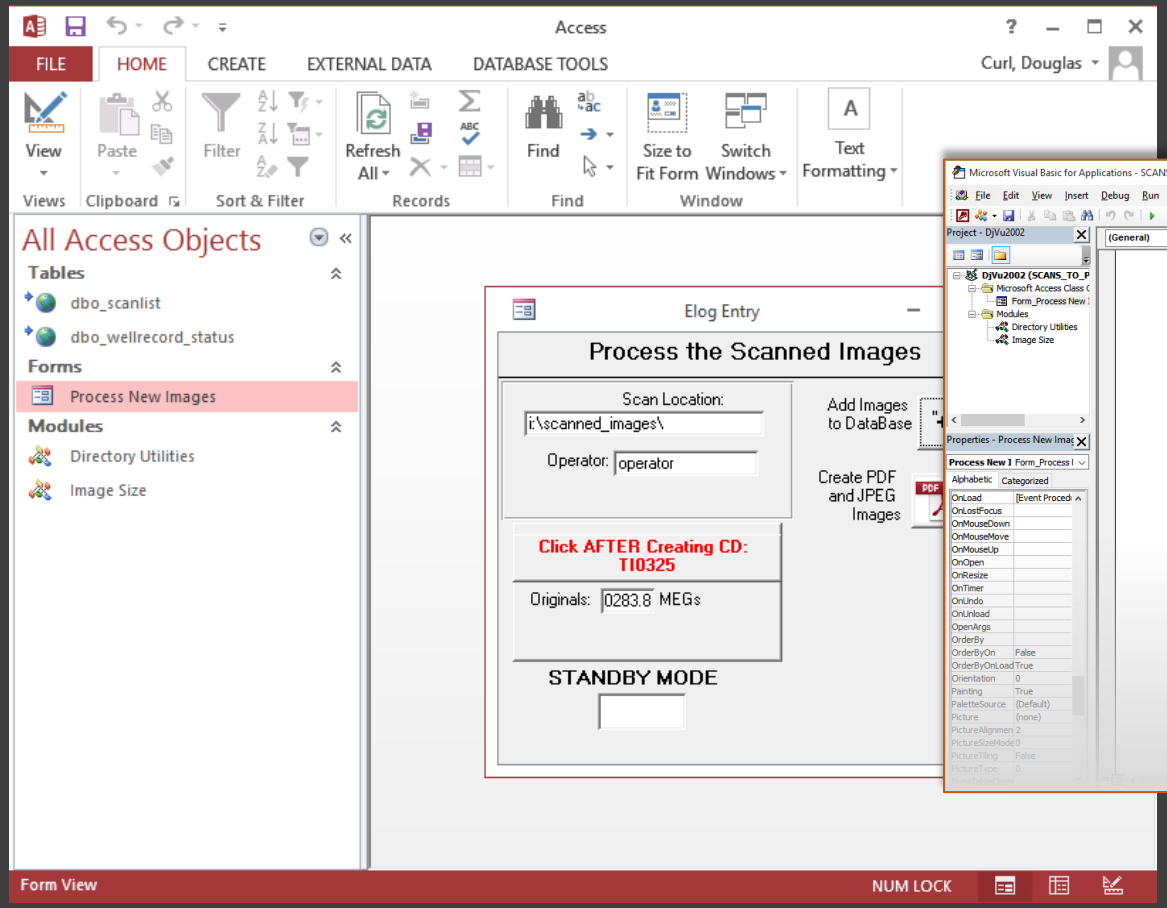


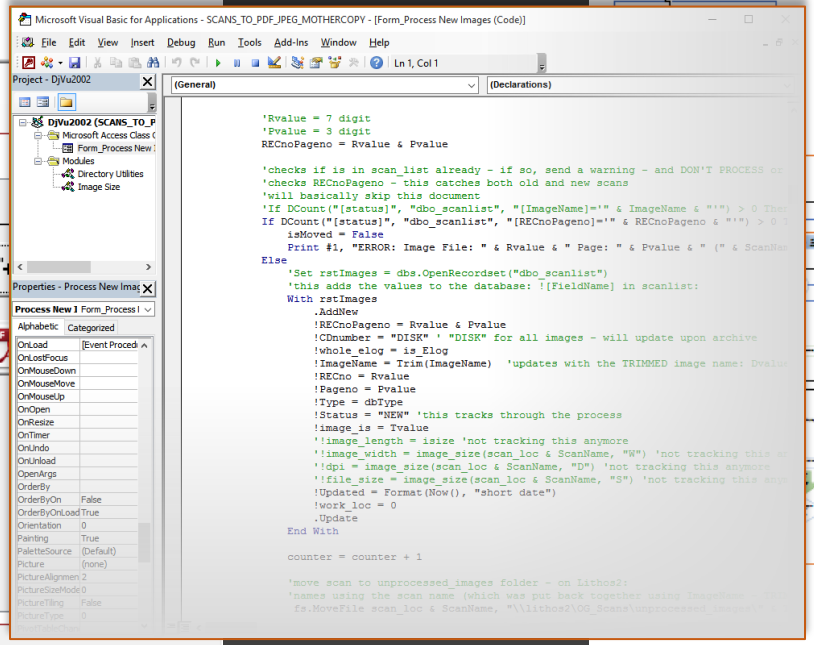


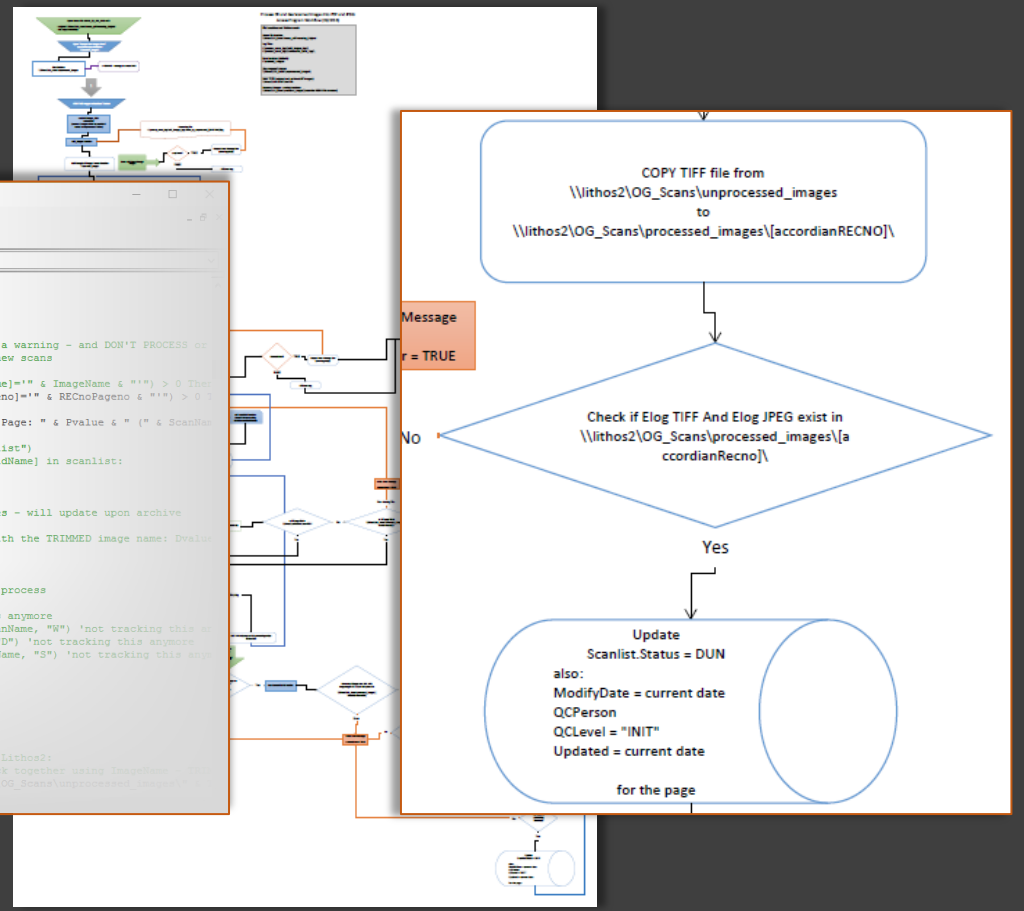
Populating a relational database

Access (or similar) forms: easy to use front-end / requires setup

- long-term use, reduce data entry error, inexperienced users, less-flexible deployment
- incorporate other processes (this one converts and moves scanned images)



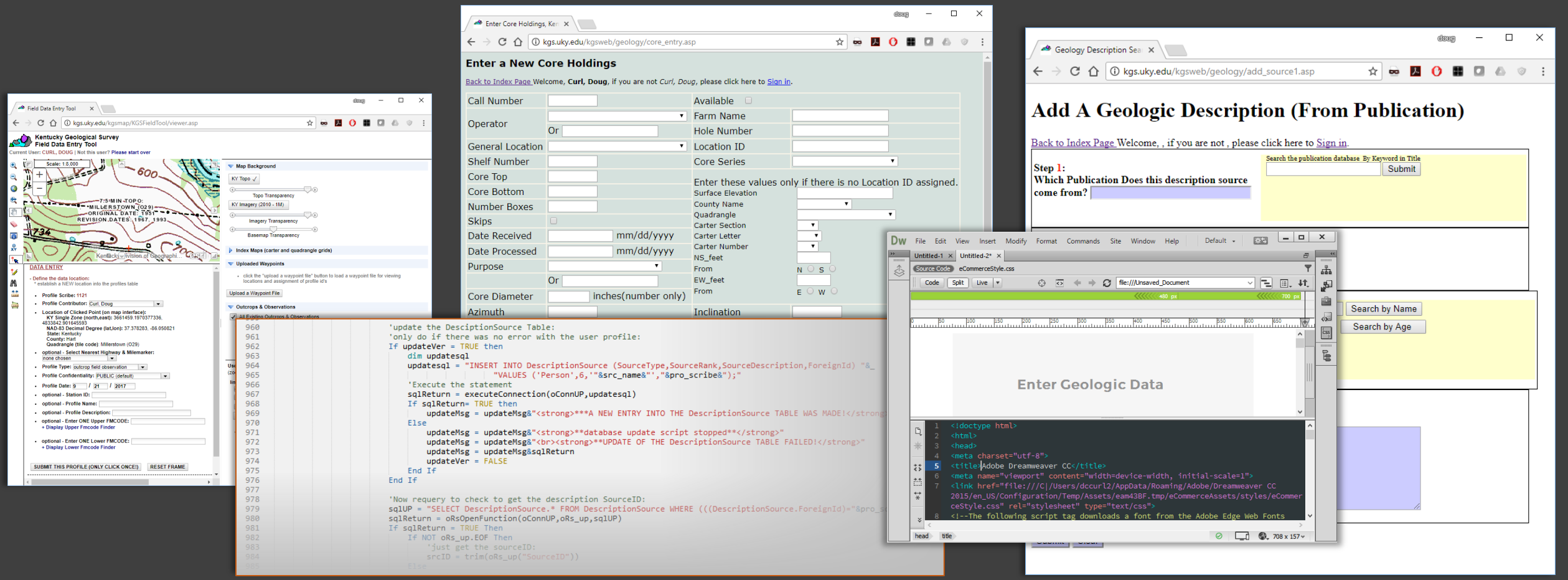




Populating a relational database

Web forms: easy to use front-end / may require extensive programming

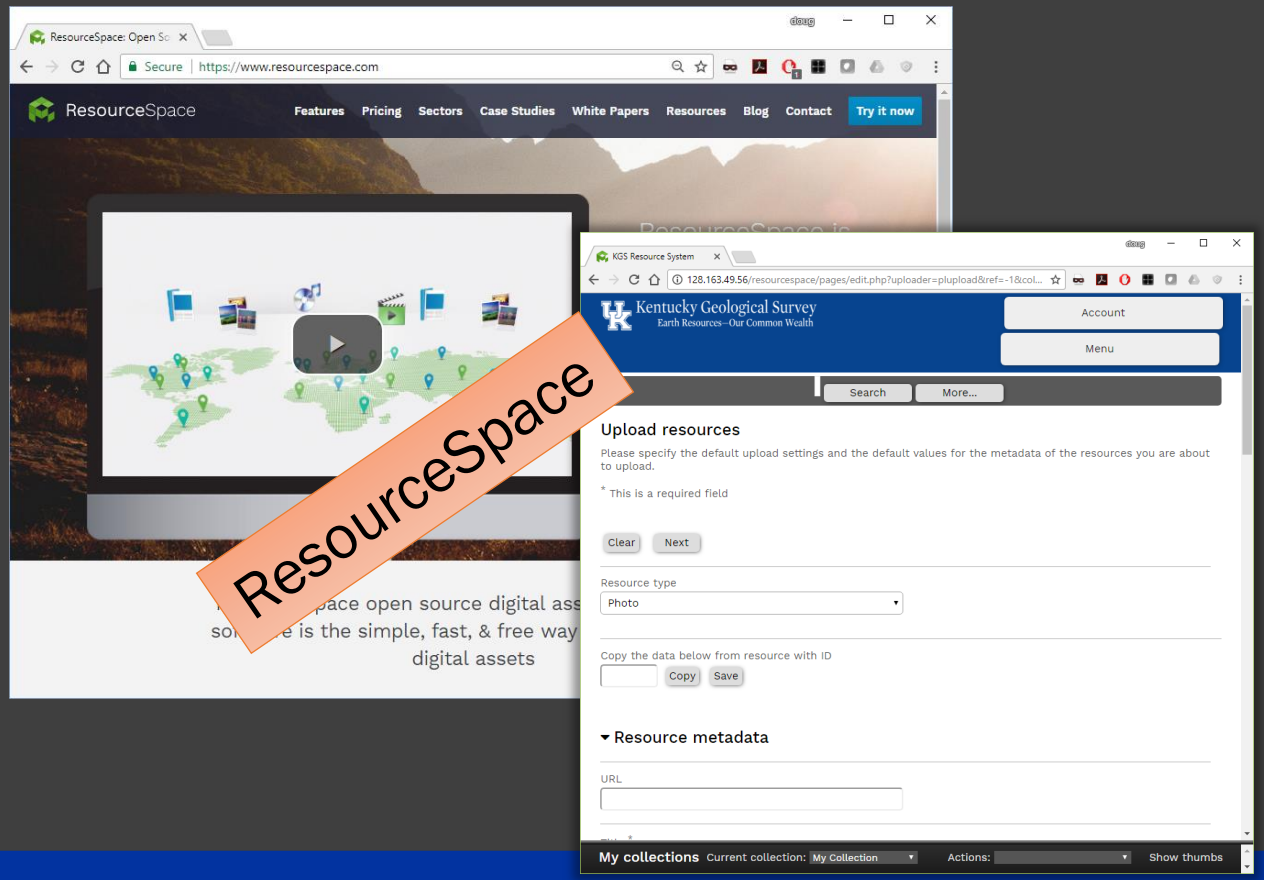
- long-term use, reduce data entry error, inexperienced users, flexible deployment
- need to host on a server or via web services

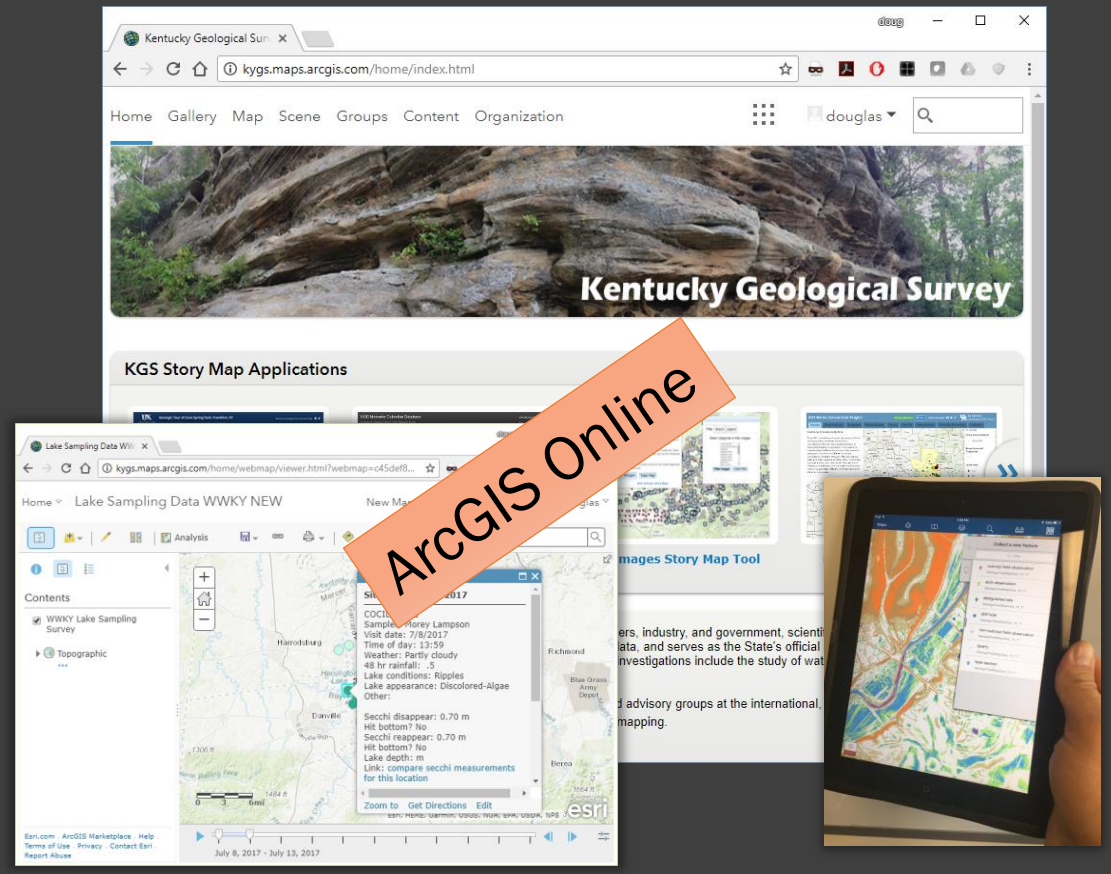


Populating a relational database

Cloud web services: relatively new frontier - lots of options

- launch relatively quickly, no hardware/software maintenance
- data maintenance / entry tools available, long term use (just pay the fee!), flexible deployment
- depending on service – may not be clear on how data is stored – but, do you care?





Why build a relational database?

- Organize and sustain your related data
- Typically server-based: centralize and serve to organization / public
  - Bonus: can secure your data
- Can export data into “flat tables” using queries
- Can make “views” to simplify data visualization

But:

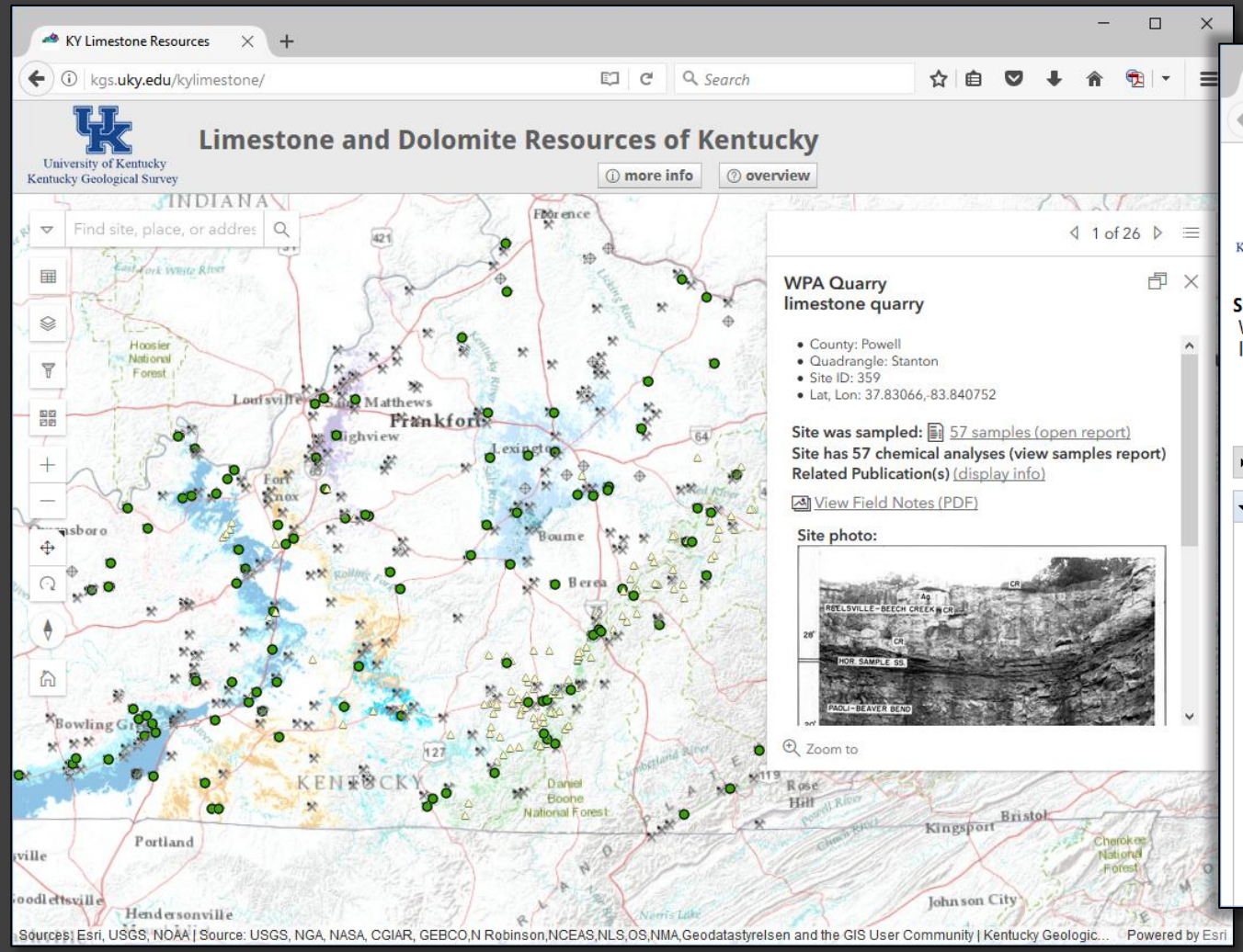
- Careful planning / knowing your data is essential
- Helpful skills:
  - programming (SQL, Python, VB, etc)
  - server hardware / software knowledge
  - spreadsheet wrangling

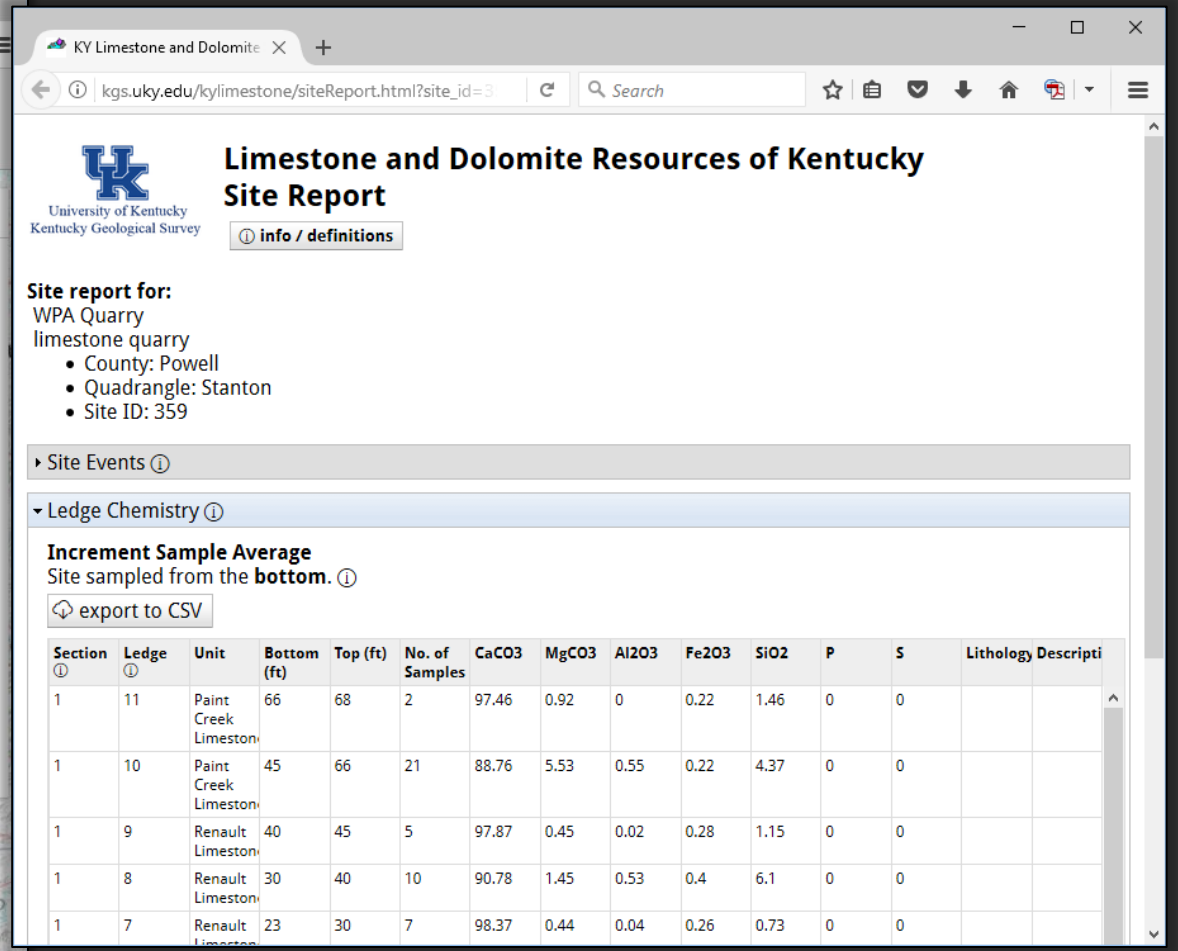
KGS IT / Data Infrastructure:

- In-house data storage:
  - SQL server 2014 (virtualized Win Server 2012) – relational database
  - File server (virtualized Win Server 2012)
- Data Management:
  - Microsoft Suite (Excel, Access, etc)
  - Adobe Suite (Acrobat, Photoshop, Illustrator)
  - ArcGIS
  - ResourceSpace (newbies)

- ArcGIS Server / ArcGIS Online org account
- Web Presence:
  - IIS (virtualized Win Server 2008)
  - Backend: ASP classic / PHP
  - Frontend: HTML 5 (Javascript/HTML/CSS / Dojo, JQuery, Highcharts, etc)
  - ESRI Javascript API (map services)

Biggest benefit for KGS: Data Dissemination





Section	Ledge	Unit	Bottom (ft)	Top (ft)	No. of Samples	CaCO3	MgCO3	Al2O3	Fe2O3	SiO2	P	S	Lithology	Descripti
1	11	Paint Creek Limeston	66	68	2	97.46	0.92	0	0.22	1.46	0	0		
1	10	Paint Creek Limeston	45	66	21	88.76	5.53	0.55	0.22	4.37	0	0		
1	9	Renault Limeston	40	45	5	97.87	0.45	0.02	0.28	1.15	0	0		
1	8	Renault Limeston	30	40	10	90.78	1.45	0.53	0.4	6.1	0	0		
1	7	Renault Limeston	23	30	7	98.37	0.44	0.04	0.26	0.73	0	0		

Thanks!