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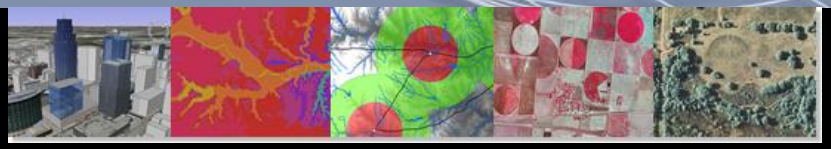
National Geospatial Program Office



11th Annual
GIS Day @ KU

Geospatial Semantics for Topographic Data

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Objectives

Present semantics of geospatial data from USGS perspective

Provide basis for creating geospatial semantic data in machine readable form from existing data

Provide examples of using geospatial semantics for mapping and connecting USGS data with other data

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Outline

Background – *The National* Map of the USGS and the need for geospatial semantics

Background – The Semantic Web

Ontology and Semantics for Geospatial Data

CEGIS Topographic Semantics
- Taxonomy, vocabulary, implementation

Using Geospatial Semantics

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Why Geospatial Semantics?

Volume – multiple nationwide datasets at high resolution

Structure – variety of structures, vector and raster, many different formats

Semantics – various attribution and relation schemes, some feature-based, some layers

Integration of multiple datasets – for maximum utility all datasets should be able to be integrated to produce new data and information

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Dataset	Geometry/ Format	Attribution/ Scaling	URL
National Hydrography Dataset (NHD)	Vector	Discrete/nominal	http://viewer.nationalmap.gov/viewer/nhd.html?p=nhd
National Transportation Dataset	Vector; tables	Discrete/nominal	http://viewer.nationalmap.gov/viewer/ http://gisdata.usgs.net/website/MRLC/viewer.htm
National Boundaries Dataset	Vector	Discrete/nominal	http://viewer.nationalmap.gov/viewer/
National Structures Dataset	Vector	Discrete/nominal	http://viewer.nationalmap.gov/viewer/
Geographic Names Information System (GNIS)	Vector	Discrete/nominal	http://geonames.usgs.gov/domestic/download_data.htm
National Elevation Dataset (NED)	Raster	Continuous/ratio	http://viewer.nationalmap.gov/viewer/ http://seamless.usgs.gov/website/seamless/viewer.htm
National Digital Orthophotos	Raster	Continuous/ interval	http://www.ndop.gov/data.html; http://viewer.nationalmap.gov/viewer/ http://gisdata.usgs.net/website/MRLC/viewer.htm
National Land Cover Dataset (NLCD)	Raster	Discrete/nominal	http://viewer.nationalmap.gov/viewer/ http://gisdata.usgs.net/website/MRLC/viewer.htm
Global Land Cover Dataset	Raster	Discrete/nominal	http://landcover.usgs.gov/landcoverdata.php
LiDAR	Point	Continuous/ratio	http://viewer.nationalmap.gov/viewer/
Satellite images	Raster	Continuous/interval	http://edcsns17.cr.usgs.gov/NewEarthExplorer/; http://glovis.usgs.gov/
Hazards (Earthquakes, Volcanoes)	Graphics	Multiple forms	http://earthquake.usgs.gov/hazards/; http://volcanoes.usgs.gov/activity/status.php
Minerals	Vector; text	Discrete/nominal	http://mrdata.usgs.gov/; http://tin.er.usgs.gov/mrds/ http://tin.er.usgs.gov/geochem/; http://crustal.usgs.gov/geophysics/index.html
Energy	Vector; databases	Multiple forms	http://energy.usgs.gov/search.html
Landscapes and Coasts	Reports	Discrete/nominal	http://geochange.er.usgs.gov/info/holdings.html
Astrogeology	Databases	Discrete/nominal	http://astrogeology.usgs.gov/DataAndInformation/
Geologic Map Database	Vector; maps; text	Discrete/nominal	http://ngmdb.usgs.gov/
Geologic Data Digital Data Series	Maps; tables	Discrete/nominal	http://pubs.usgs.gov/dds/dds-060/
National Water Information System	Graphics; tables	Continuous/ratio	http://wdr.water.usgs.gov/nwisgmap/
Floods and High Flow	Graphics; tables	Continuous/ratio	http://waterwatch.usgs.gov/new/index.php?id=ww
Drought	Graphics; tables	Continuous/ratio	http://waterwatch.usgs.gov/new/index.php?id=ww
Monthly Stream Flow	Graphics; tables	Continuous/ratio	http://waterwatch.usgs.gov/new/index.php?id=ww
Ground Water	Vector; tables;	Continuous/ratio	http://waterdata.usgs.gov/nwis/gw/; http://groundwaterwatch.usgs.gov/
Water Quality	Graphics	Continuous/ratio	http://waterdata.usgs.gov/nwis/qw/; http://waterwatch.usgs.gov/wqwatch/
National Biological Information Infra-structure (NBII)	Graphics; vector; geodatabases	Multiple forms	http://www.nbii.gov/portal/server.pt/community/nbii_home/236
Vegetation Characterization	Vector; databases	Multiple forms	http://biology.usgs.gov/npsveg/
Wildlife	Vector; text;video	Multiple forms	http://www.nwhc.usgs.gov/
Invasive Species	Vector; databases; graphics, image	Multiple forms	http://www.nbii.gov/portal/server.pt/community/invasive_species/221

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The National Map – http://nationalmap.gov/

The National Map is a collaborative effort to improve and deliver topographic information for the nation

The goal of *The National Map* is to become the nation's source for trusted, nationally consistent, integrated and current topographic information available online for a broad-range of uses

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The National Map

Screen shot from *The National Map* home page on the WWW

http://nationalmap.gov/

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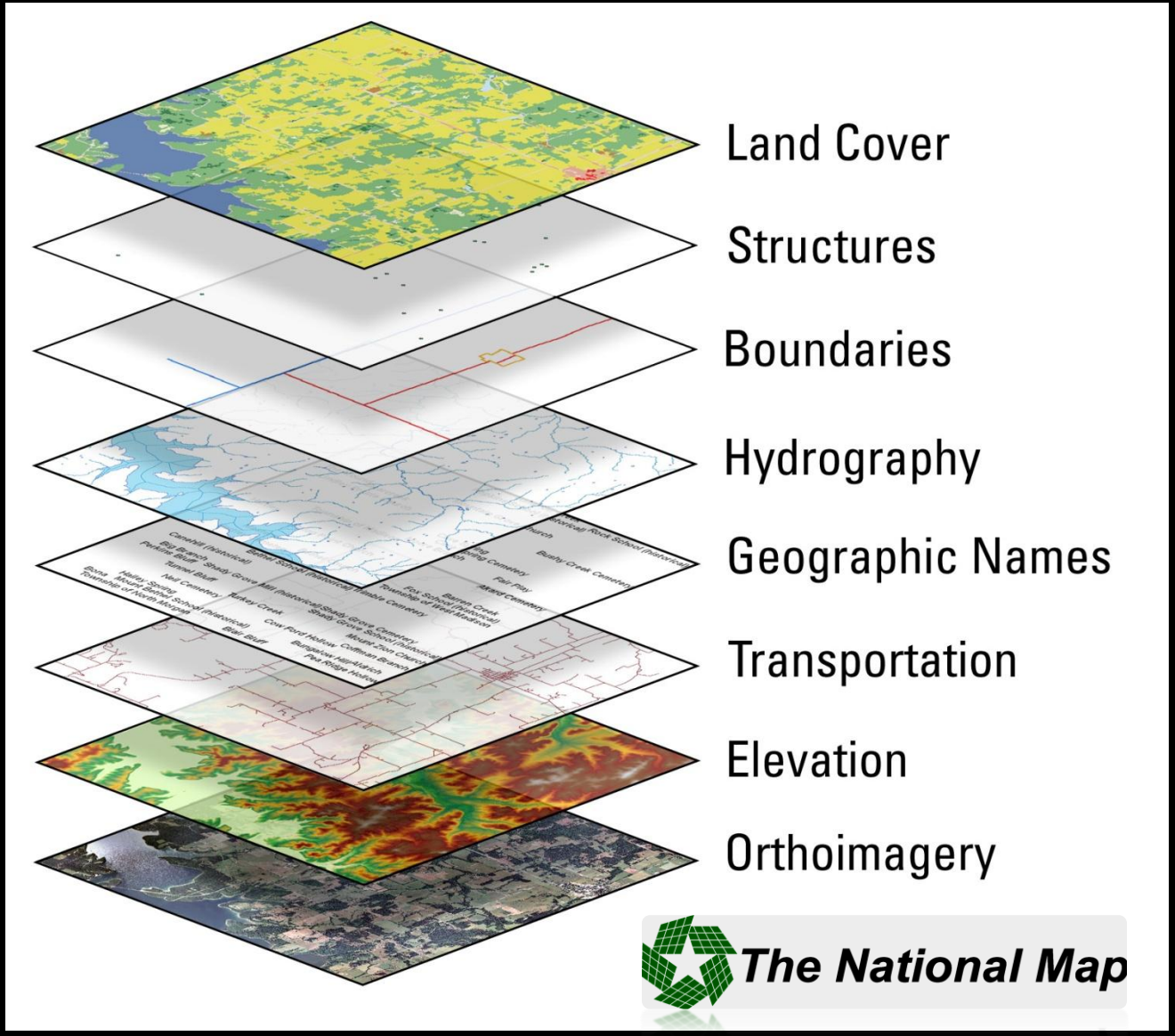
The 8 Layers of *The National Map*



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Datasets of *The National Map*

National Land Cover Dataset (1992, 2000, 2006)

National Elevation Dataset (3,1,1/3,1/9 arc-sec)

National Digital Orthophoto Dataset (multiple dates, multiple resolutions, 1m, 1/3 m urban areas)

National Hydrography Dataset (NHD) (Medium, High, Local resolution)

Geographic Names Information System (GNIS)

National Structures Dataset

National Boundaries Dataset (US, state, county, minor civil divisions, governmental units)

National Transportation Dataset (TIGER and others)

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Products of *The National Map*

Data display through *The National Map* viewer

http://viewer.nationalmap.gov/viewer/

Palanterra, joint development – NGA, ESRI, USGS

Display user selected data from *The National Map*

Data download of 8 layers

Mashups with other data using KML

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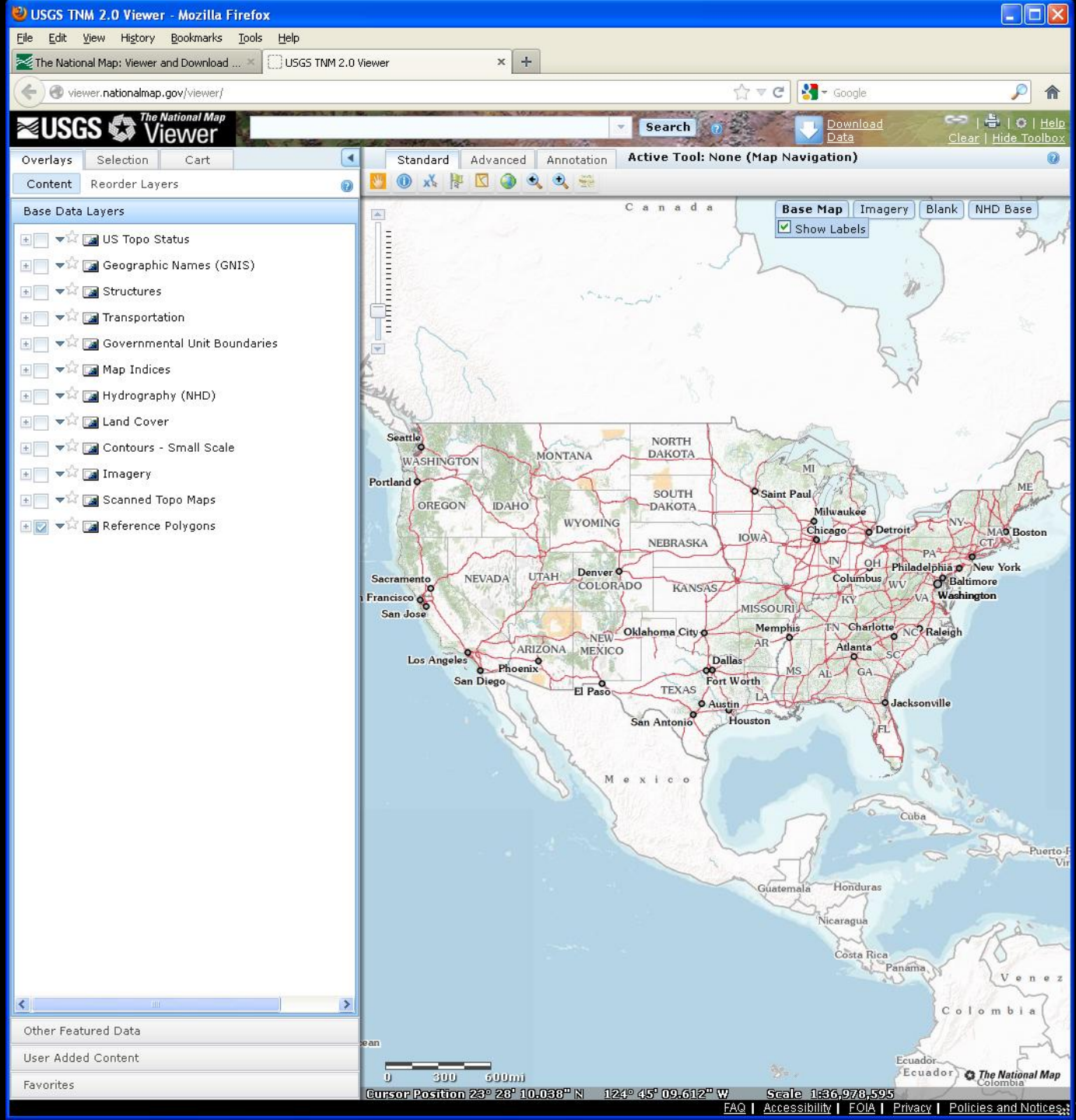
Screen shot from *The National Map Viewer* home page on the WWW

http://viewer.nationalmap.gov/viewer/



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Products of *The National Map*

US Topo – New 1:24,000-scale topographic maps in GeoPDF; Complete U.S. coverage 2009-2011; available now for free download from USGS Map Store, beginning revision on 3-year cycle – Produce over 100 maps per day

http://nationalmap.gov/ustopo/index.html

Digital, georeferenced versions of all previous topographic maps for a specified 7.5-minute area; more than 175,000 maps are available

http://nationalmap.gov/historical/

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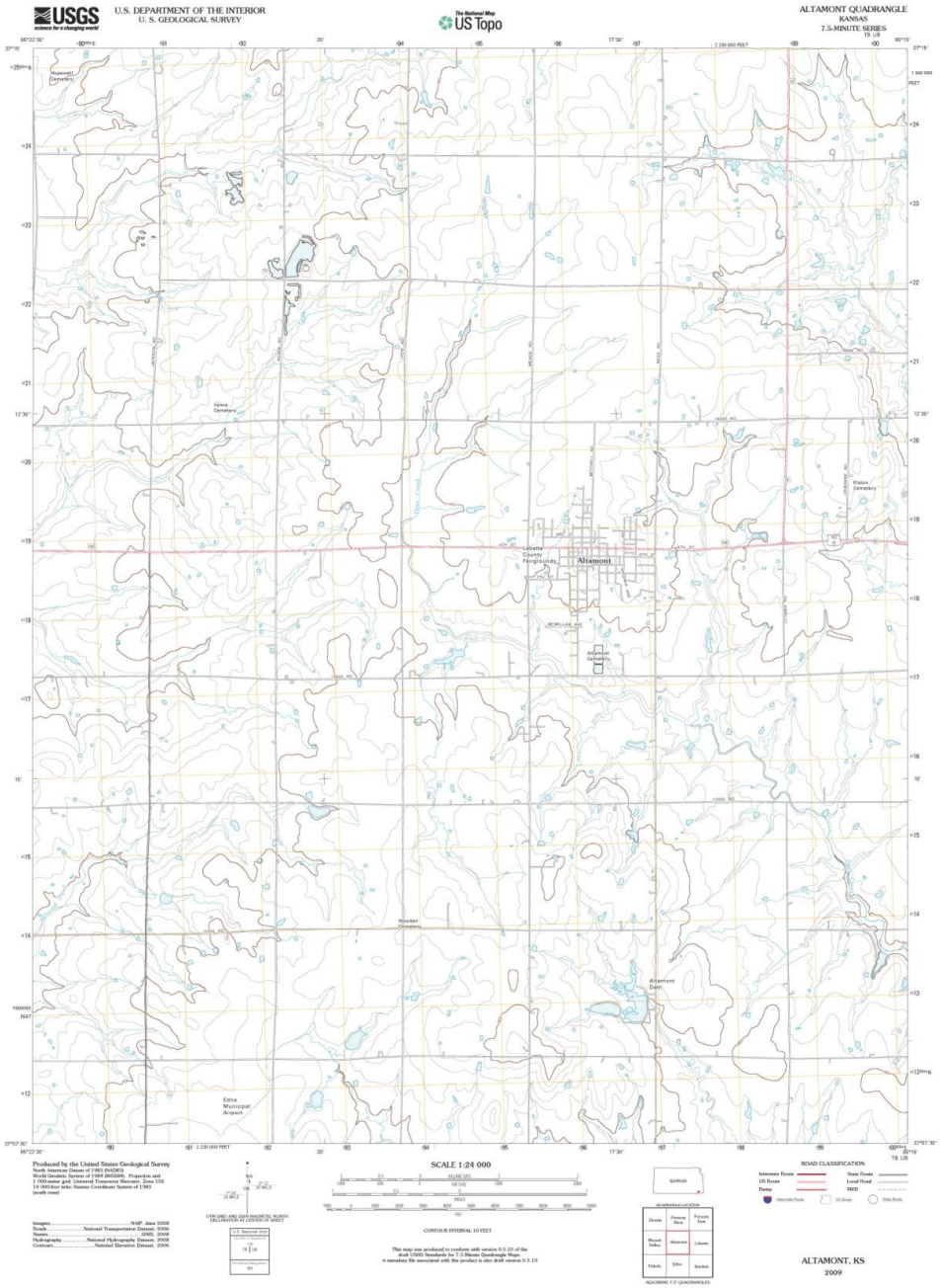
US Topo
Altamont, KS



Semantic Web – What is it?

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World Wide Web

Web of documents

Access is through Web pages which are documents

Search is a search for documents, perhaps containing specific words, phrases, concepts

Each page or set of pages is accessed by a Uniform Resource Locator (URL)

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Semantic Web

Semantic Web is a web of data that can be processed by machines

Data are linked, access is through data links

Format is not pages, but data are stored as Resource Description Framework (RDF) triples

Triple is subject, predicate, object

Data elements linked by Uniform Resource Identifier (URI

Information is queried by SPARQL Protocol and RDF Query Language (SPARQL)

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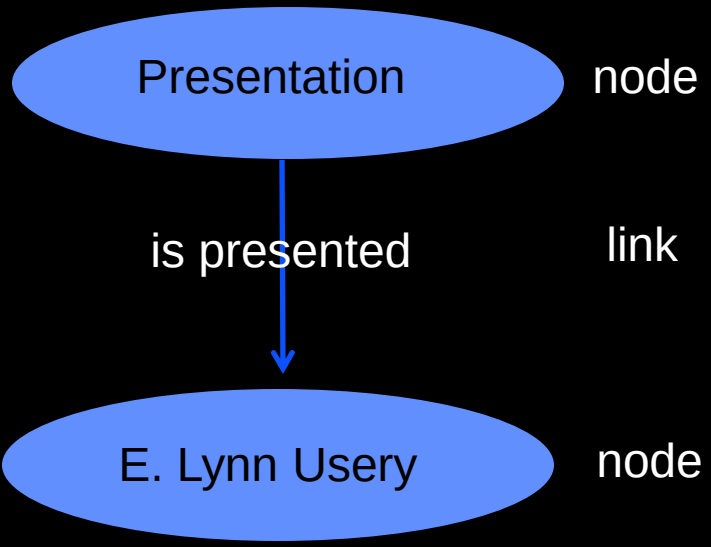
Semantic Web – Examples of Triples

The presentation “Geospatial Semantics for Topographic Data” is presented by E. Lynn Usery.

Subject: Presentation “Geospatial Semantics for Topographic Data”

Predicate: is presented

Object: E. Lynn Usery



Uses nodes and links of graph theory

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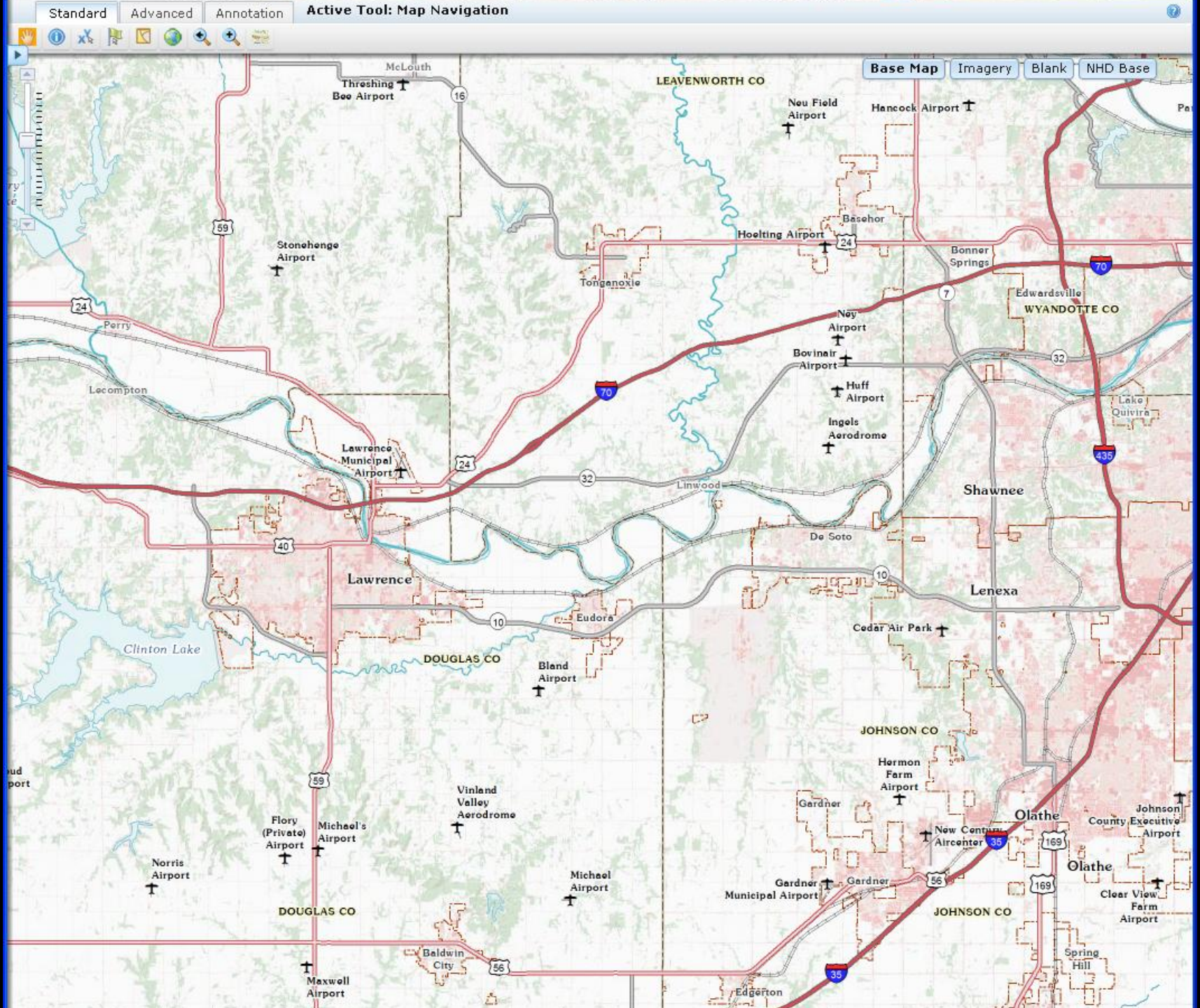
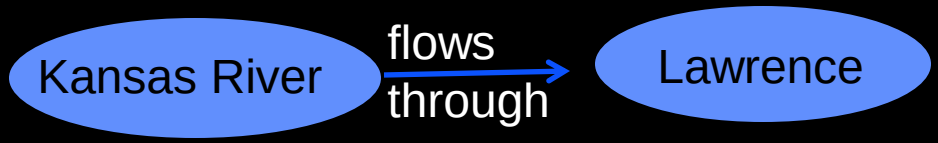

Standard
Advanced
Annotation
Active Tool: Map Navigation
Base Map
Imagery
Blank
NHD Base
McLouth
Threshing Bee Airport
LEAVENWORTH CO
Neu Field Airport
Hancock Airport
Basehor
Hoelting Airport
Bonner Springs
Stonehenge Airport
Tonganoxie
Edwardsville
WYANDOTTE CO
Noy Airport
Bovinair Airport
Huff Airport
Perry
Lecompton
Ingels Aerodrome
Lake Quivira
Lawrence Municipal Airport
Linwood
Shawnee
De Soto
Lawrence
Lenexa
Eudora
Cedar Air Park
Clinton Lake
DOUGLAS CO
Bland Airport
JOHNSON CO
Hermon Farm Airport
Vinland Valley Aerodrome
Gardner
Olathe
Johnson County Executive Airport
Flory (Private) Airport
Michael's Airport
New Century Aircenter
Norris Airport
Michael Airport
Gardner Municipal Airport
Olathe
Clear View Farm Airport
DOUGLAS CO
JOHNSON CO
Baldwin City
Spring Hill
Maxwell Airport
Edgerton

Semantic Web – Inference and Axioms

Kansas River flows through Lawrence



Subject: Kansas River

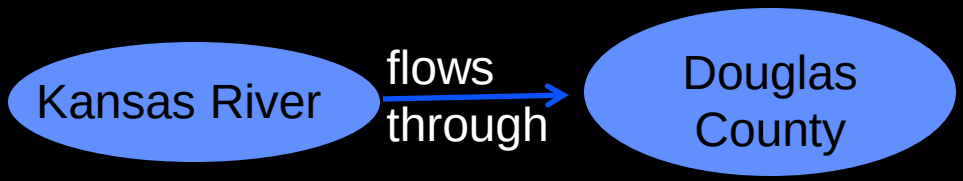
Predicate: flows through

Object: Lawrence

If Kansas River flows through Lawrence

and Lawrence is contained by Douglas County

Then Kansas River flows through Douglas County



Semantic Web RDF format

An *RDF triple* contains three components:

the *subject*, which is an RDF URI reference or a blank node

the *predicate*, which is an RDF URI reference

the *object*, which is an RDF URI reference, a literal or a blank node

An *RDF graph* is a set of RDF triples

An example URI:

<http://cegis.usgs.gov/TopoVocab/1.0/Terrain#/crater>

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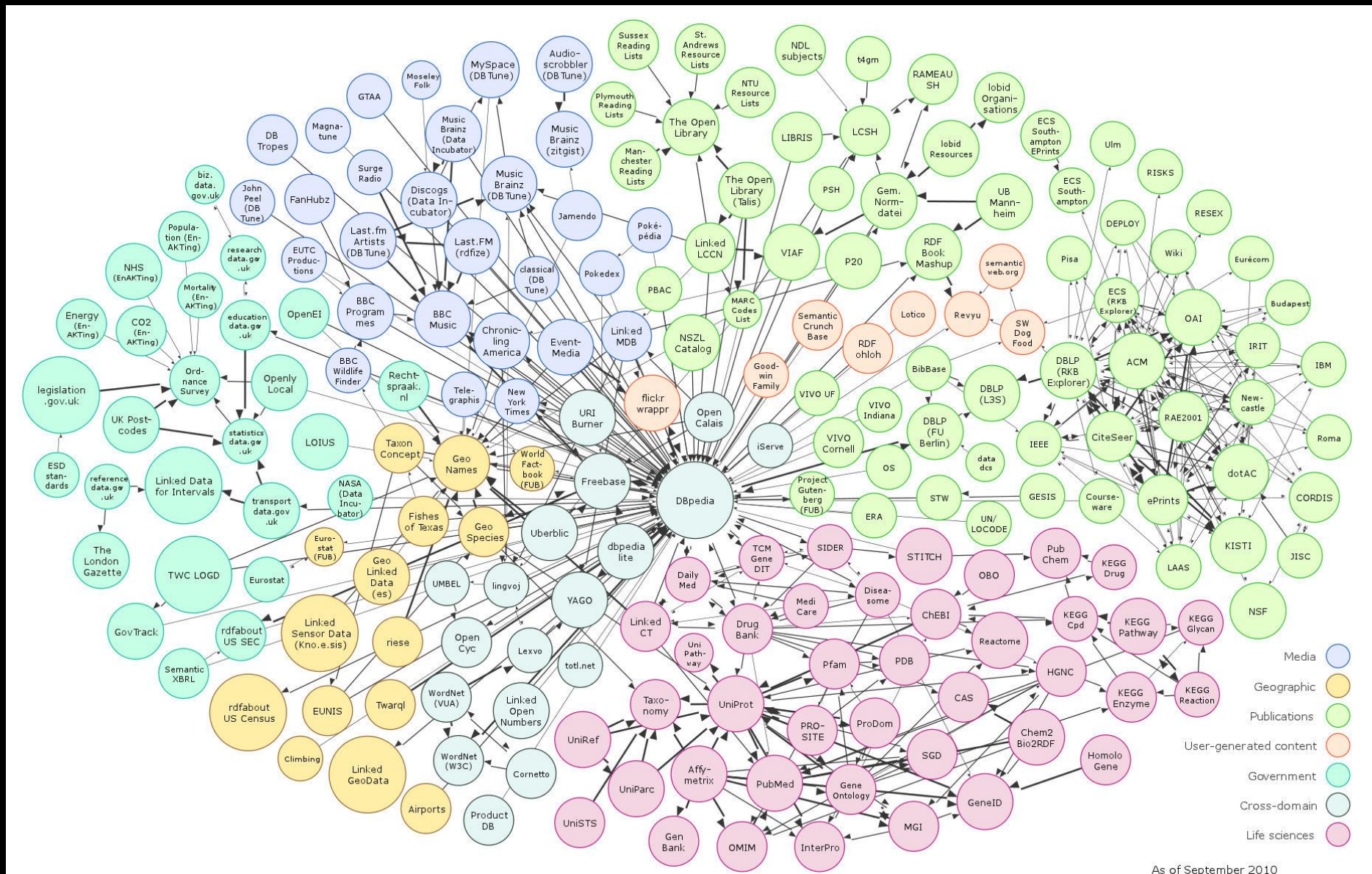
Open Linked Data

With over 38 billion triples, the Open Linked Data cloud presents difficulties for visualization, use, and analysis. In this visualization, colors distinguish different themes (Dadzie and Rowe, 2011).



Examples of Geospatial Semantics

Hill surrounded by valleys that enclose streambeds, streams, bounded by other hills

Stream includes stream bed, water in stream, source, left bank, right bank, stream bottom, mouth, has tributaries, flows into stream, lake, bay

Canyon has floor, walls, mouth, surrounding mountains and hills

Urban park has trees, open space, playground, buildings, walkways

The semantics provide meaning to the features

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An Ontology for Topographic Data based on Geospatial Semantics

A taxonomy of all features on standard topographic maps

A formal machine readable vocabulary of feature names and definitions

Predicates formed from attributes and relationships of the features

Actual instance data, including geometric coordinates and topological relations, encoded as predicates in a machine interpretable triple format

All built as RDF with URIs and interlinked

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Feature Domains – A Taxonomy for Topographic Map Data

Events

Divisions

Built-up areas

Ecological regime

Surface water

Terrain

Domains derived from ground surveys incorporated in DLG standards

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Events

Security		**Historical site**	
Hazard	Hazard zone	Military history	Archeological site
Earthquake	Incident	Historical marker	Cliff dwelling
Flood	Fire	Tree	Ruins
Area to be submerged	Restricted area		

Divisions

Civil Units

Cadastral
Parcel
Public Land Survey System
Land grant
Homestead entry
Survey line
Principle meridian
Baseline
Survey point
Point monument
Survey corner

Government unit
Municipality
City
Town
Villiage

Nation
Territory
Tribal reservation
State
County
Census
State
County
Census county division
Block group
Block

Tract
Special use zone
Time zone
Nature reserve

Boundaries

Fenceline
Hedge
Place
Region
Locale
Boundary line
Boundary point
Hydrologic unit

Shipping

Lane
Traffic separation scheme area
Pilot water
Roundabout
Inshore trafic zone
Exclusive Economic Zone

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Built-up

Transportation and warehousing	60
Entertainment and Recreation	26
Utilities	16
Resource Extraction	13
Structure	12
Agriculture and Fishing	11
Military	10
Communication	7
Waste Management	7
Real Estate	6
Place of Worship	6
Manufacturing	4
Institutions	3
Burial Grounds	3
Disturbed Surface	3
Trade	3

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Ecological Regime

Tundra

Desert

Grassland

Scrub

Forest

Pasture

Cultivated Cropland

Transition area

Nature reserve

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Natural/Artificial
Reach
hasPart: Bottom
Channel
Pond
Basin

Natural

Marine/Estuarine

Cove
Foreshore
Flat
Ice field (regional)

Marine
Ocean
Sea
Gulf
Submerged Stream
Shore
hasPart: Shingle
Shoreline
Beach
Ice floe (regional)
Polyna (regional)

Estuarine
Estuary
Bay
Inlet

Freshwater

Watercourse
Stream
hasPart: Mouth
hasPart: Source
hasPart: Streambed
hasPart: Streambanks
hasPart: Crossing
hasPart: Ford

River
Creek
Brook
Arroyo
Rapids
Bend
Falls
Cascade
Waterfall
Innundation area
Spring
Mud pot
Geyser
Slope spring
Ice berg (regional)
hasPart: Iceberg tongue
Glacier (regional)
Crevasse (regional)

Wetland
Marsh
Swamp
Bog

Waterbody
Lake
Ice cap (regional)
Snow field (regional)
Sastrugi (regional)

Artificial

Impounded
Reservoir
Fish ladder

Diked
Levee
Embankment
hasPart: Revetment
Dam
Masonry shore

Channel
Siphon
Aqueduct
Canal
Flume
Turning basin

Flow Control
Weir
Lock
*hasPart:*Lock chamber
hasPart: Stram
Spillway
Jetty
Breakwater
Water intake

Pump

Surface Water

Terrain includes 56 USGS landform features

- Aeolian
- Arch
- Bar
- Basin
- Beach
- Bench
- Cape
- Catchment
- Cave
- Chimney
- Cirque
- Cliff
- Coast
- Crater
- Delta
- Dish
- Divide
- Drainage basin
- Dunes
- Fault
- Floodplain
- Fracture
- Fumarole
- Gap
- Glacial
- Ground surface
- Hill
- Incline
- Island
- Island cluster
- Isthmus
- Karst
- Lava
- Mineral pile
- Moraine
- Mount
- Mountain Range
- Peak
- Peneplain
- Peninsula
- Pinnacle
- Plain
- Plateau
- Quicksand
- Reef
- Ridge
- Ridge line
- Salt pan
- Shaft
- Sink
- Solution chimneys
- Summit
- Talus
- Terrace
- Valley
- Volcano

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Topographic Vocabulary

Examples from:

- Events
- Divisions
- Builtup
- Ecological regime
- Surface water
- Terrain

Available from Ontology Project Webpage:

http://cegis.usgs.gov/ontology.html

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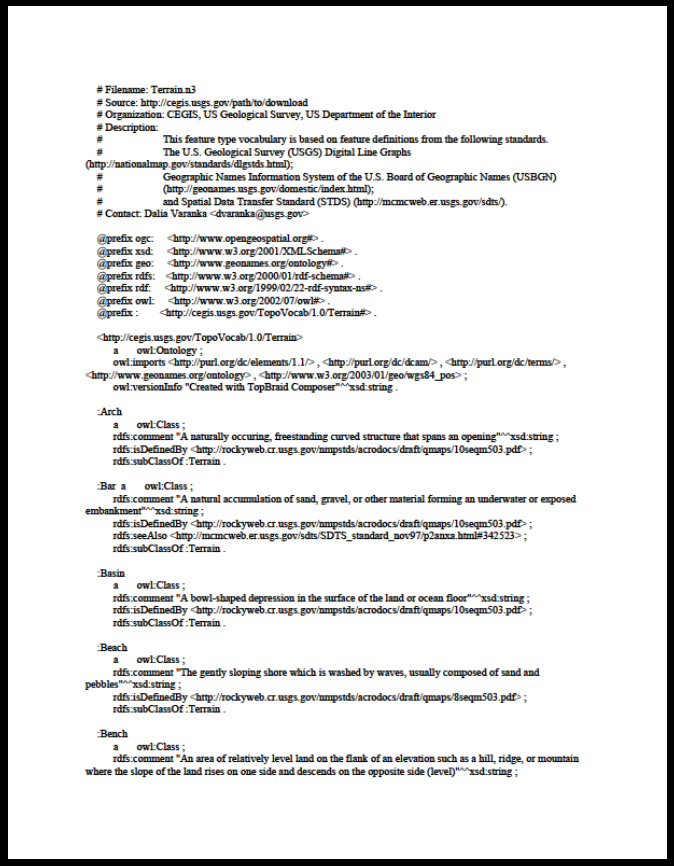
Terrain Vocabulary



```
# Filename: Terrain.n3
# Source: http://cegis.usgs.gov/path/to/download
# Organization: CEGIS, US Geological Survey, US Department of the Interior
# Description:
#                This feature type vocabulary is based on feature definitions from the following standards.
#                The U.S. Geological Survey (USGS) Digital Line Graphs
(http://nationalmap.gov/standards/dlgstds.html);
#                Geographic Names Information System of the U.S. Board of Geographic Names (USBGN)
#                (http://geonames.usgs.gov/domestic/index.html);
#                and Spatial Data Transfer Standard (STDS) (http://mcmcweb.er.usgs.gov/sdts/).
# Contact: Dalia Varanka <dvaranka@usgs.gov>

@prefix ogc:    <http://www.opengeospatial.org#> .
@prefix xsd:    <http://www.w3.org/2001/XMLSchema#> .
@prefix geo:    <http://www.geonames.org/ontology#> .
@prefix rdfs:   <http://www.w3.org/2000/01/rdf-schema#> .
@prefix rdf:    <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix owl:    <http://www.w3.org/2002/07/owl#> .
@prefix :       <http://cegis.usgs.gov/TopoVocab/1.0/Terrain#> .

<http://cegis.usgs.gov/TopoVocab/1.0/Terrain>
      a      owl:Ontology ;
      owl:imports <http://purl.org/dc/elements/1.1/> , <http://purl.org/dc/dcam/> , <http://purl.org/dc/terms/> ,
<http://www.geonames.org/ontology> , <http://www.w3.org/2003/01/geo/wgs84_pos> ;
      owl:versionInfo "Created with TopBraid Composer"^^xsd:string .

:Arch
      a      owl:Class ;
      rdfs:comment "A naturally occuring, freestanding curved structure that spans an opening"^^xsd:string ;
      rdfs:isDefinedBy <http://rockyweb.cr.usgs.gov/nmpstds/acrodocs/draft/qmaps/10seqm503.pdf> ;
      rdfs:subClassOf :Terrain .

:Bar  a      owl:Class ;
      rdfs:comment "A natural accumulation of sand, gravel, or other material forming an underwater or exposed
embankment"^^xsd:string ;
      rdfs:isDefinedBy <http://rockyweb.cr.usgs.gov/nmpstds/acrodocs/draft/qmaps/10seqm503.pdf> ;
      rdfs:seeAlso <http://mcmcweb.er.usgs.gov/sdts/SDTS_standard_nov97/p2anxa.html#342523> ;
      rdfs:subClassOf :Terrain .

:Basin
      a      owl:Class ;
      rdfs:comment "A bowl-shaped depression in the surface of the land or ocean floor"^^xsd:string ;
      rdfs:isDefinedBy <http://rockyweb.cr.usgs.gov/nmpstds/acrodocs/draft/qmaps/10seqm503.pdf> ;
      rdfs:subClassOf :Terrain .

:Beach
      a      owl:Class ;
      rdfs:comment "The gently sloping shore which is washed by waves, usually composed of sand and
pebbles"^^xsd:string ;
      rdfs:isDefinedBy <http://rockyweb.cr.usgs.gov/nmpstds/acrodocs/draft/qmaps/8seqm503.pdf> ;
      rdfs:subClassOf :Terrain .

:Bench
      a      owl:Class ;
      rdfs:comment "An area of relatively level land on the flank of an elevation such as a hill, ridge, or mountain
where the slope of the land rises on one side and descends on the opposite side (level)"^^xsd:string ;
```

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Geographic feature instances

Example from Terrain for raster data

- Meteor Crater instance

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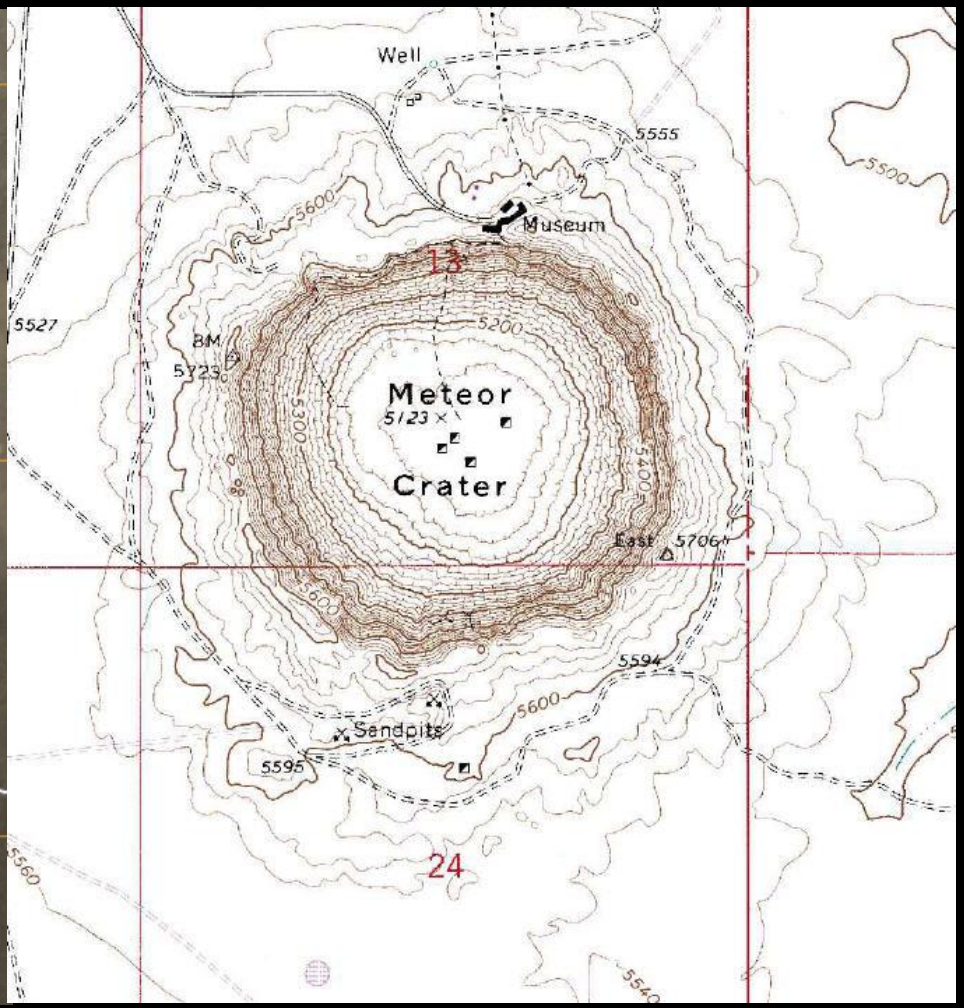
Meteor Crater
Example Feature from Raster Data



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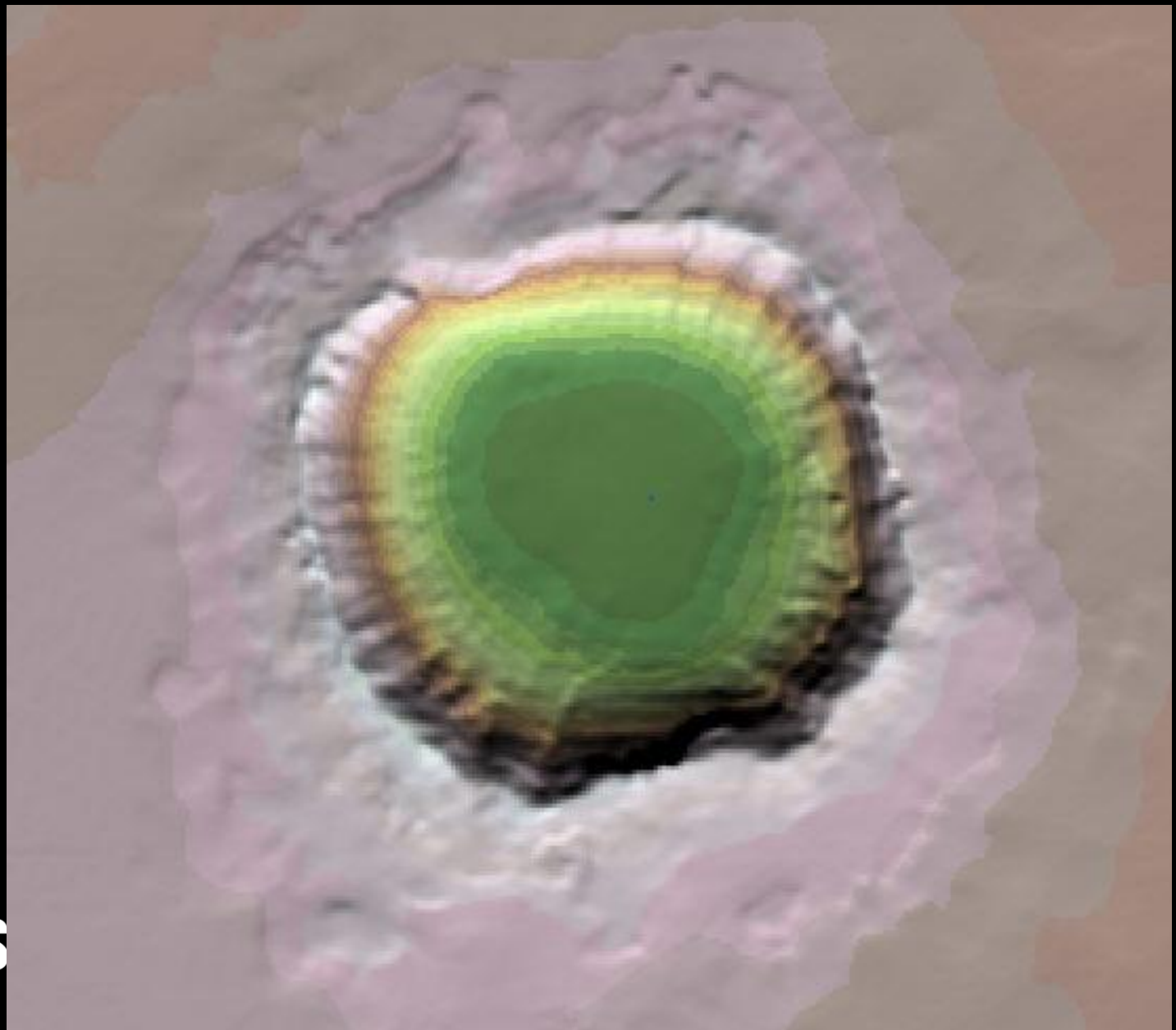
Meteor Crater – Shaded Relief Image



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Meteor Crater Attributes and Relationships

- **Feature** Crater
- **Definition** Circular-shaped depression at the summit of a volcanic cone or one on the surface of the land caused by the impact of a meteorite; a manmade depression caused by an explosion (caldera, lua).
- **Instance** Meteor Crater
- GNIS ID 7945
- **Attributes**

Location	UTM	E 497,959.94 m	N 3,876,020.68 m	Zone 12	
	PLSS	T 19 N, R 12 1/2 E, Section 13 and 24			
	MBR	Max E 498,536.79 m	Min E 497,317.62 m		
		Max N 3,876,632.29 m	Min N 3,875,479.58		
Elevation	High	5,723 ft			
	Low	5,123 ft			
Depth	600 ft				
Shape	Circular				
	Inner Diameter	0.50 mi (0.833 km)			
	Outer Diameter	0.75 mi (1.25 km)			
Rim width	0.125 mi (0.2 km)				
Contour at outer perimeter		5,600 ft			
Contour at inner perimeter		5,180 ft			

- **Relationships**

Surrounded by roads		
Adjacent to Museum	Museum Name:	Meteor Crater Museum
Near sand pits		
Near well		
Benchmarks on crater	BM 5723	BM East 5706

USGS

Example of Meteor Crater in RDF/OWL

```
@prefix ogc:     <http://www.opengis.net/> .
@prefix xsd:     <http://www.w3.org/2001/XMLSchema#> .
@prefix geoname:     <http://www.geonames.org/ontology#> .
@prefix rdfs:    <http://www.w3.org/2000/01/rdf-schema#> .
@prefix rdf:     <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix owl:     <http://www.w3.org/2002/07/owl#> .
@prefix dcterms: <http://purl.org/dc/terms/>
@prefix dbpedia: <http://dbpedia.org/ontology/>
@prefix geo:     <http://www.opengis.net/ont/OGC-GeoSPARQL/1.0/>
@prefix usgsTopo:        <http://cegis.usgs.gov/TopoVocab/1.0/Terrain#> .
@prefix usgsBuiltUp:     <http://cegis.usgs.gov/TopoVocab/1.0/BuiltUpAreas#> .
@prefix usgs:     <http://cegis.usgs.gov/ontology/instances#> .

<http://cegis.usgs.gov/ontology/instances> a owl:ontology


usgs:_7945              a usgsTopo:crater;
                                a geo:Feature ;
                                geo:hasGeometry usgs:_7945geo ;
                                geoname:name Meteor Crater"
                                rdfs:comment "A meteor crater";
                                usgsTopo:hasBenchmark usgs:_5723 ;
                                usgsTopo:hasBenchmark usgs:_e5706 ;
                                dcterms:identifier "7945" ;
                                dcterms:description "Circular-shaped depression on the surface of the land
caused by the impact of a meteorite"

usgs:_7945geo a geo:Geometry ;
                                usgsTopo:hasShape "circular" ;
                                usgsTopo:width "0.2km" ;
                                usgsTopo:innerDiameter "833m" ;
                                usgsTopo:outerDiameter "1250m" ;
                                usgsTopo:hasUTM "E 497959.94m  N 3876020.68m Zone 12";
                                usgsTopo:hasPLSS "T 19 N, R 12 1/2 E, Section 13 and 24";
                                usgsTopo:hasMBR "Max E 489536.79m  Min E 497317.62m  Max N
3876632.29m  Min N 3875479.58m";
                                dbpedia:MaximumElevation "5723ft";
                                dbpedia:MinimumElevation "5123ft";
                                dbpedia:MaximumDepth "600ft" .

usgs:_3876              a usgsBuiltUp:Road      ;
                                geo:hasGeometry usgs:_3876geo ;
                                geoname:name "Crater Road" .


usgs:_3876geo           a geo:Geometry ;
                                geo:asWKT "WKT string literal" .

usgs:_8763              a usgsBuiltUp:Building ;
                                geoname:name "Meteor Crater Museum" ;
                                geo:hasGeometry usgs:_8763geo .

usgs:_8763geo           a geo:Geometry ;
                                geo:asWKT "WKT string literal" .

usgs:_9863              a usgsBuiltUp:Well ;
```

USGS

Converting Data to RDF from *The National Map*

USGS has developed an online, publically accessible tool to convert data from the relational databases of *The National Map* to RDF triple form

The user simply specifies the area to be converted by either a named reference, Polk County, MO for example, or from a polygon boundary in shapefile or wkt format

USGS

USGS Sample Data as RDF

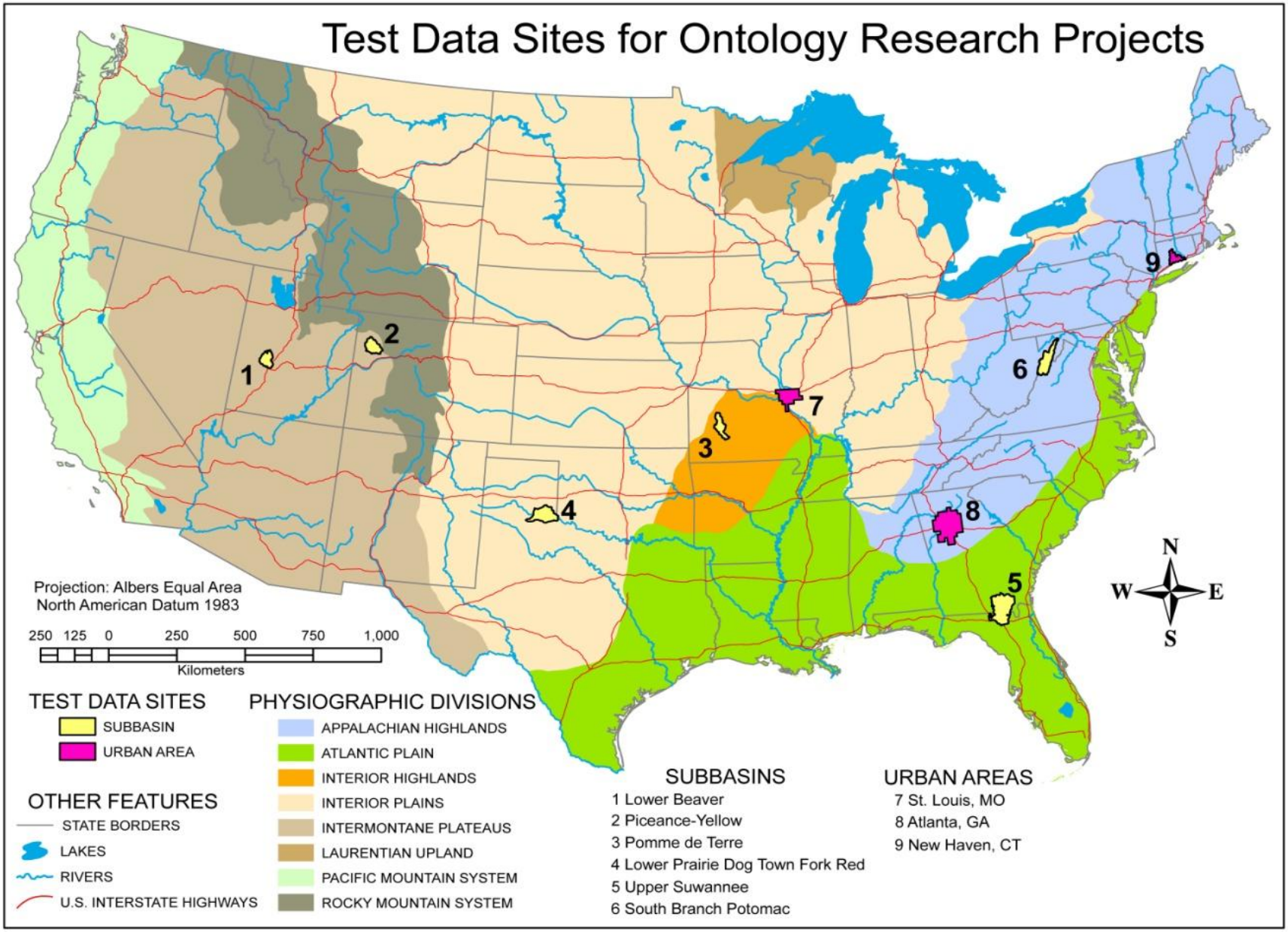
Availability

- Nine test areas – converted for hydrography, transportation, boundaries, structures

- Geographic names have been converted for entire country

- Access through Ontology Project web site and through CEGIS SPARQL Endpoint

USGS


Test Data Sites for Ontology Research Projects
Projection: Albers Equal Area
North American Datum 1983
250 125 0 250 500 750 1,000
Kilometers
N
W
E
S
TEST DATA SITES
SUBBASIN
URBAN AREA
OTHER FEATURES
STATE BORDERS
LAKES
RIVERS
U.S. INTERSTATE HIGHWAYS
PHYSIOGRAPHIC DIVISIONS
APPALACHIAN HIGHLANDS
ATLANTIC PLAIN
INTERIOR HIGHLANDS
INTERIOR PLAINS
INTERMONTANE PLATEAUS
LAURENTIAN UPLAND
PACIFIC MOUNTAIN SYSTEM
ROCKY MOUNTAIN SYSTEM
SUBBASINS
1 Lower Beaver
2 Piceance-Yellow
3 Pomme de Terre
4 Lower Prairie Dog Town Fork Red
5 Upper Suwannee
6 South Branch Potomac
URBAN AREAS
7 St. Louis, MO
8 Atlanta, GA
9 New Haven, CT

SPARQL Endpoint

A URL that allows access to an RDF triplestore

USGS SPARQL Endpoint for Topographic Data

http://usgs-ybother.srv.mst.edu:8890/parliament

USGS

Mapping from RDF requires Geometry

Geometry is handled as strings of coordinates represented as Well Known Text (WKT) or as Geography Markup Language (GML).

The geometry (coordinates) are represented in the triple as subjects or more commonly objects.

GeoSPARQL was developed as an Open Geospatial Consortium (OGC) standard to handle geometry (as coordinates) and the common topological relations used with geospatial data

USGS

GeoSPARQL Ontology

geo:SpatialObject

geo:Feature geo:hasGeometry geo:Geometry

geo:defaultGeometry

geo:asWKT / sf:wktLiteral for values

geo:asGML / gml:gmlLiteral for values

USGS

GeoSPARQL

- GeoSPARQL is an extension of SPARQL
- Associates a Geometry with a feature using geo:hasGeometry

<http://cegis.usgs.gov/rdf/nhd/Features/102204610> rdf:type nhd:flowline .

<http://cegis.usgs.gov/rdf/nhd/Features/102204610> geo:hasGeometry
<http://cegis.usgs.gov/rdf/nhd/Geometries/102204610> .

<http://cegis.usgs.gov/rdf/nhd/Geometries/102204610> rdf:type geo:Geometry .
<http://cegis.usgs.gov/rdf/nhd/Geometries/102204610> geo:asWKT
"LINESTRING (-93.387722032150236 38.166983407423857 0,-93.387682298816969
38.167539207422976 0,-93.388619432148857 38.168476474088209 0,-93.391319032144679
38.169734874086259 0,-93.396768432136241 38.171924274082869 0,-93.398635898799967
38.172490274081952 0,-93.398990298799447 38.17260060741512 0,-93.399145698799202
38.172711207414977 0,-93.399287298798981 38.172574207415153 0,-93.399409832132108
38.172571607415193 0)"^^<http://www.opengis.net/def/sf/wktLiteral> .

GeoSPARQL

A query for the geometries of counties from the USGS Pomme de Terre triplestore

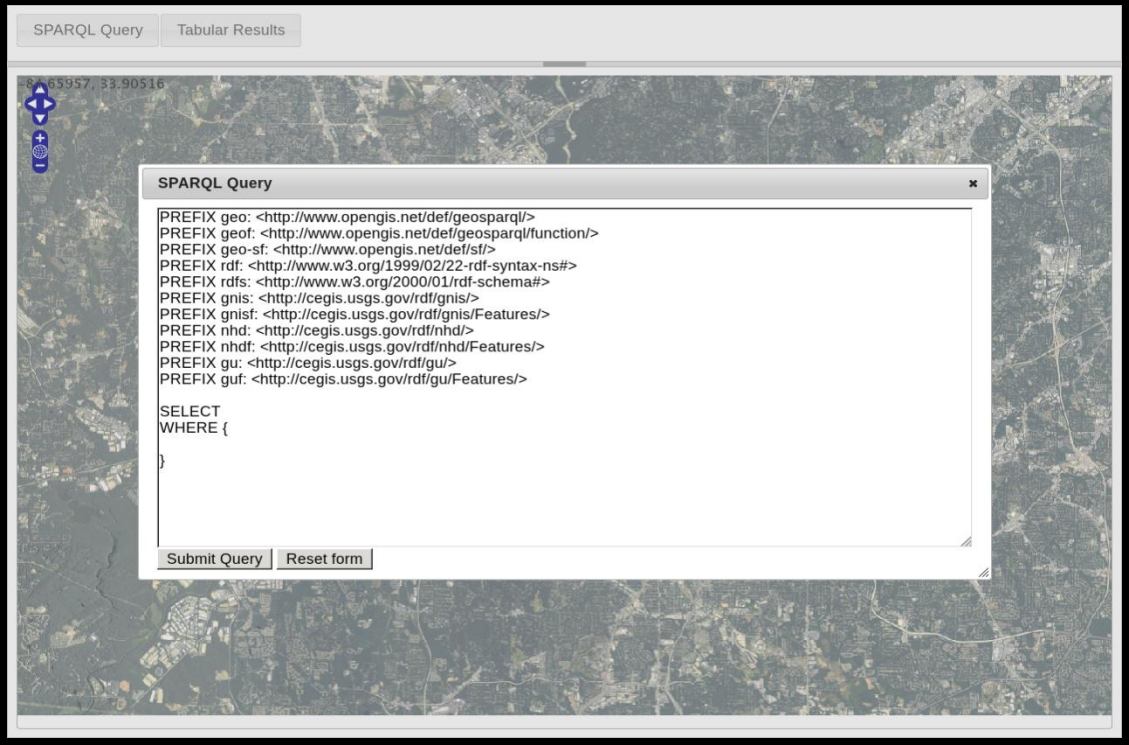
```
SELECT ?label ?wkt
WHERE {
  ?feature rdf:type       gu:countyOrEquivalent .
  ?feature rdfs:label     ?label .
  ?feature geo:hasGeometry ?g .
  ?g       geo:asWKT      ?wkt .
}
```

GeoSPARQL example

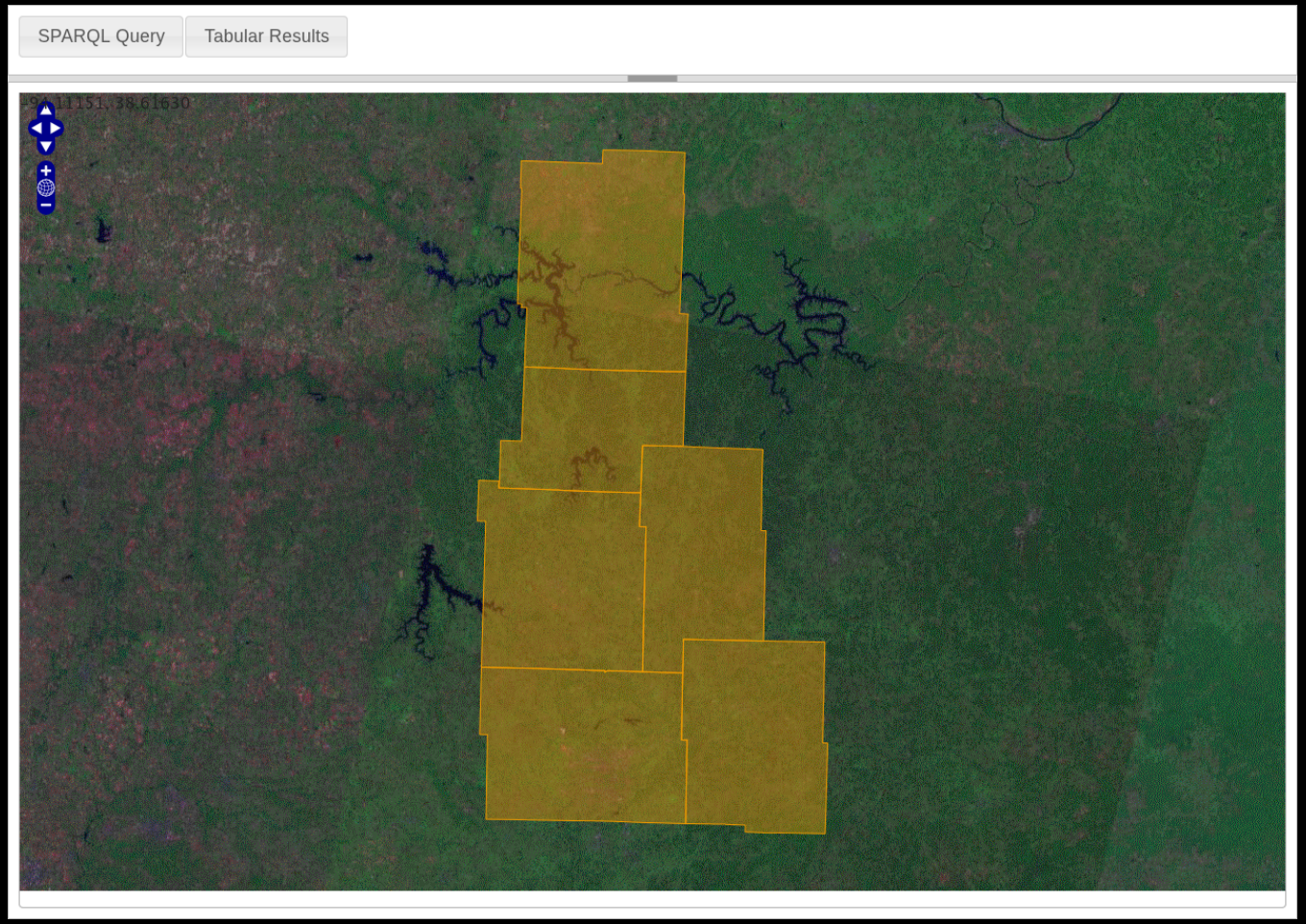
From a web browser we can connect to:

http://144.47.160.23:8000/viz/

And click on the “SPARQL Query” button



GeoSPARQL Result



USGS

GeoSPARQL Topological Query Functions

```
ogcf:sfEquals(geom1: ogc:WKTLiteral,
              geom2: ogc:WKTLiteral): xsd:boolean

ogcf:sfDisjoint(geom1: ogc:WKTLiteral,
                geom2: ogc:WKTLiteral): xsd:boolean

ogcf:sfIntersects(geom1: ogc:WKTLiteral,
                  geom2: ogc:WKTLiteral): xsd:boolean

ogcf:sfTouches(geom1: ogc:WKTLiteral,
               geom2: ogc:WKTLiteral): xsd:boolean

ogcf:sfCrosses(geom1: ogc:WKTLiteral,
               geom2: ogc:WKTLiteral): xsd:boolean

ogcf:sfWithin(geom1: ogc:WKTLiteral,
              geom2: ogc:WKTLiteral): xsd:boolean

ogcf:sfContains(geom1: ogc:WKTLiteral,
                geom2: ogc:WKTLiteral): xsd:boolean

ogcf:sfOverlaps(geom1: ogc:WKTLiteral,
                geom2: ogc:WKTLiteral): xsd:boolean
```

USGS

Assumes Simple Features Relation Family

FILTER statements

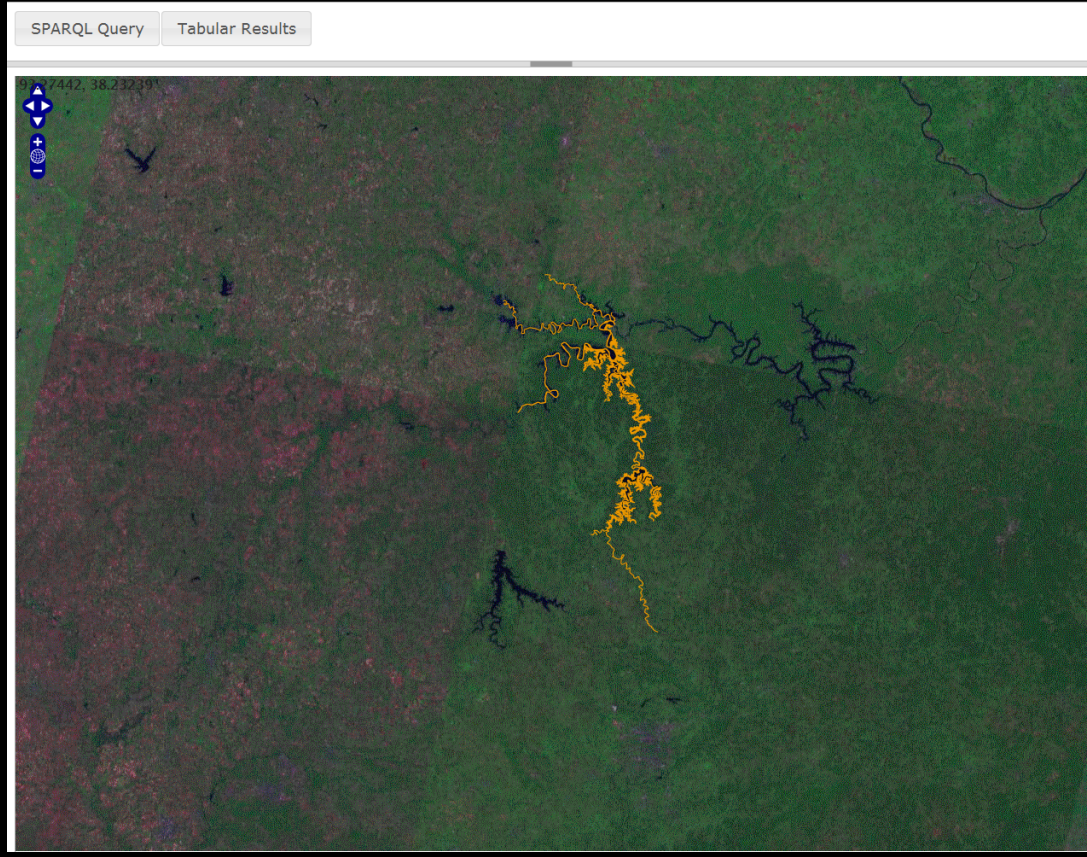
An example of theGeoSPARQL topological function contains

```
SELECT ?wkt
WHERE {
  ?feature rdf:type      gu:countyOrEquivalent .
  ?feature rdfs:label    "Polk" .
  ?feature geo:hasGeometry ?g .
  ?g       geo:asWKT      ?county_wkt .

  ?flowline rdf:type nhd:flowline .
  ?flowline  geo:hasGeometry ?g2 .
  ?g2        geo:asWKT       ?wkt .
  FILTER(geof:sfContains(?county_wkt, ?wkt))
}
```

USGS

Example of a filter function using an areal constraint




```
SELECT ?subject ?wkt
WHERE {
  ?subject rdf:type nhd:area .
  ?subject nhd:areaSqKM ?a .
  ?subject geo:hasGeometry ?geo .
  ?geo        geo:asWKT ?wkt .
   FILTER(?a > 1.0)
```

The same query with FILTER(?a > 10.0 retrieves fewer streams)

USGS

GeoSPARQL Query to Generate Data for US Topo

```
SELECT DISTINCT
?wkt
WHERE {
  GRAPH <http://cegis.usgs.gov/rdf/> {
 ?s rdfs:label "Sentinel" .
 ?s geo:hasGeometry ?g .
 ?g geo:asWKT ?quadwkt .

 ?feature geo:hasGeometry ?g2 .
 ?g2 geo:asWKT ?wkt .

  FILTER(geof:sfContains(?quadwkt, ?wkt))
}
}
```

This query selects all of the features that overlap the Sentinel quad, including itself.

USGS

GeoSparql Query visualization - Mozilla Firefox

File Edit View History Bookmarks Tools Help

GeoSparql Query visualization

usgs-ybother.srv.mst.edu/viz/

Google

SPARQL Query | Tabular Results

-93.21312, 37.89082

SPARQLer Query Results

Count: 2528

wkt
"POLYGON ((-93.25 37.75, -93.375 37.75, -93.375 37.875, -93.25 37.875, -93.25 37.75, -93.25 37.75))" ^^<http://www.opengis.net/sf#wktLiteral>
"LINESTRING(-93.270336 37.8732229995, -93.270702 37.8732289995, -93.271533 37.8732599995, -93.271962 37.8732919995)" ^^<http://www.opengis.net/sf#w
"LINESTRING(-93.267546 37.8616539996, -93.267178 37.8616509996, -93.266951 37.8617019996, -93.266683 37.8618279996, -93.26652 37.8619619996, -93.266 37.8621009996, -93.266003 37.8622769996)" ^^<http://www.opengis.net/sf#wktLiteral>
"LINESTRING(-93.3515209999 37.8520249996, -93.3515099999 37.8521829996, -93.3514499999 37.8524969996, -93.3514279999 37.8526159996)" ^^<http://www.opengis.net/sf#wktLiteral>
"LINESTRING(-93.3377209999 37.8434729996, -93.3371619999 37.8429829996, -93.3370049999 37.8427659996, -93.3368489999 37.8425009996, -93.336793999 37.8422259996, -93.3367429999 37.8418309996, -93.3367539999 37.8417399996)" ^^<http://www.opengis.net/sf#wktLiteral>
"LINESTRING(-93.3388519999 37.8350829996, -93.3388649999 37.8347199996)" ^^<http://www.opengis.net/sf#wktLiteral>
"LINESTRING(-93.3524489999 37.8125899996, -93.3520759999 37.8127499996, -93.3519489999 37.8127759996)" ^^<http://www.opengis.net/sf#wktLiteral>
"LINESTRING(-93.3371569999 37.8486239996, -93.3366689999 37.8492359996, -93.3365269999 37.8495479996)" ^^<http://www.opengis.net/sf#wktLiteral>
"LINESTRING(-93.3530679999 37.8593859996, -93.3531039999 37.8594659996)" ^^<http://www.opengis.net/sf#wktLiteral>
"LINESTRING(-93.317633 37.8665699996, -93.317701 37.8656159996)" ^^<http://www.opengis.net/sf#wktLiteral>
"LINESTRING(-93.297594 37.8375369996, -93.297689 37.8373349996, -93.297721 37.8372689996, -93.298094 37.8365359996)" ^^<http://www.opengis.net/sf#w
"LINESTRING(-93.312055 37.8637539996, -93.311964 37.8638669996, -93.311839 37.8641559996, -93.311751 37.8645539996, -93.311646 37.8648799996)" ^^<http://www.opengis.net/sf#wktLiteral>
"LINESTRING(-93.313546 37.8653059996, -93.313322 37.8652889996, -93.313131 37.8653649996)" ^^<http://www.opengis.net/sf#wktLiteral>
"LINESTRING(-93.2533730001 37.8582689996, -93.2534530001 37.8578299996, -93.2533200001 37.8574299996, -93.2532300001 37.8570669996, -93.253220000

Environmental and Other Thematic Maps

We will search for EPA sites within 5 km of Pittsburg Firehouse near Sentinel.

USGS

GeoSPARQL Query to Connect EPA Data to a USGS Quadrangle

First define the needed **prefixes**

```
PREFIX geo: <http://www.opengis.net/geosparql#>
PREFIX geof: <http://www.opengis.net/geosparql/function/>
PREFIX gml: <http://www.opengis.net/gml#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX gnis: <http://cegis.usgs.gov/rdf/gnis/>
PREFIX gnisf: <http://cegis.usgs.gov/rdf/gnis/Features/>
PREFIX nhd: <http://cegis.usgs.gov/rdf/nhd/>
PREFIX nhdf: <http://cegis.usgs.gov/rdf/nhd/Features/>
PREFIX gu: <http://cegis.usgs.gov/rdf/gu/>
PREFIX guf: <http://cegis.usgs.gov/rdf/gu/Features/>
PREFIX category: <http://dbpedia.org/class/yago/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX units: <http://www.opengis.net/def/uom/OGC/1.0/>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX dgtwc:    <http://www.data.gov/semantic/data/alpha/1050/dataset-1050.rdf#>
```

USGS

GeoSPARQL Query to Connect EPA Data to a USGS Quadrangle

Then enter the query and execute

```
SELECT DISTINCT
?name ?wkt1
WHERE {
GRAPH <http://cegis.usgs.gov/rdf/> {

  # Match features with type EPA DataEntry
  ?feature rdf:type   <http://data-gov.tw.rpi.edu/2009/data-gov-twc.rdf#DataEntry> .
  ?feature geo:asWKT ?wkt1 .
  ?feature dgtwc:primary_name ?name .

  # Get geometry of the firehouse
  <http://cegis.usgs.gov/rdf/struct/Features/10474482> geo:hasGeometry ?geo .
  ?geo geo:asWKT ?fire_wkt .

 # Create a 5km buffer around the firehouse
 BIND (geof:buffer(?fire_wkt, 5000, units:metre) AS ?fire_buff)

 # Restrict matches to the buffer
 FILTER(geof:sfContains(?fire_buff, ?wkt1))
}
}
```

USGS

Text result of query

name	wkt1
ASH GROVE AGGREGATES, INC	POINT(-93.304139 37.823306))
DALE & SHELLY WHITESIDE	POINT(-93.295654 37.858091))
MDNR, DIV OF STATE PARKS	POINT(-93.300556 37.833889))
ROYAL SCHOOL	POINT(-93.38 37.83611))

USGS

GeoSparql Query visualization - Mozilla Firefox

File Edit View History Bookmarks Tools Help

GeoSparql Query visualization

usgs-ybother.srv.mst.edu/viz/

Google

SPARQL Query | Tabular Results

Conclusions

Geospatial semantics offer potential to build semantic spatial relations to capture geographic feature characteristics and relations not available in current geospatial datasets and models, such as GIS.

The strength of the approach is in linking datasets for solutions requiring data from various sources and of disparate types.

Geometry is implemented in the RDF model and can be used for mapping and spatial analysis

GeoSPARQL provides an ontology that supports geometric and topological operations

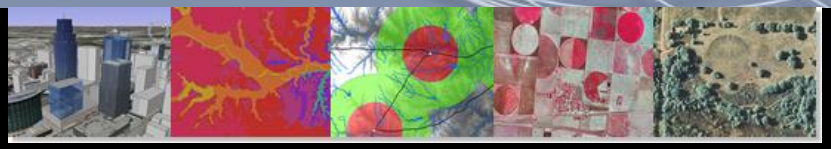
Creation of standard mapping products is possible with linked data

The RDF linked data process allows integrating data from multiple sources and organizations to create environmental and thematic maps and analyses to support decision-making requiring spatial data

USGS

USGS
science for a changing world

National Geospatial Program Office



11th Annual
GIS Day @ KU

Geospatial Semantics for Topographic Data

E. Lynn Usery

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CEGIS
Geospatial Information Science

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