Aggregate Resource Mapping in Washington State

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GEOLOGIC MAPPING PROGRAM

WASHINGTON STATE DEPT OF NATURAL RESOURCES

WASHINGTON GEOLOGICAL SURVEY

What is Aggregate?

What is Aggregate used for?

Aggregate: Closer is better!

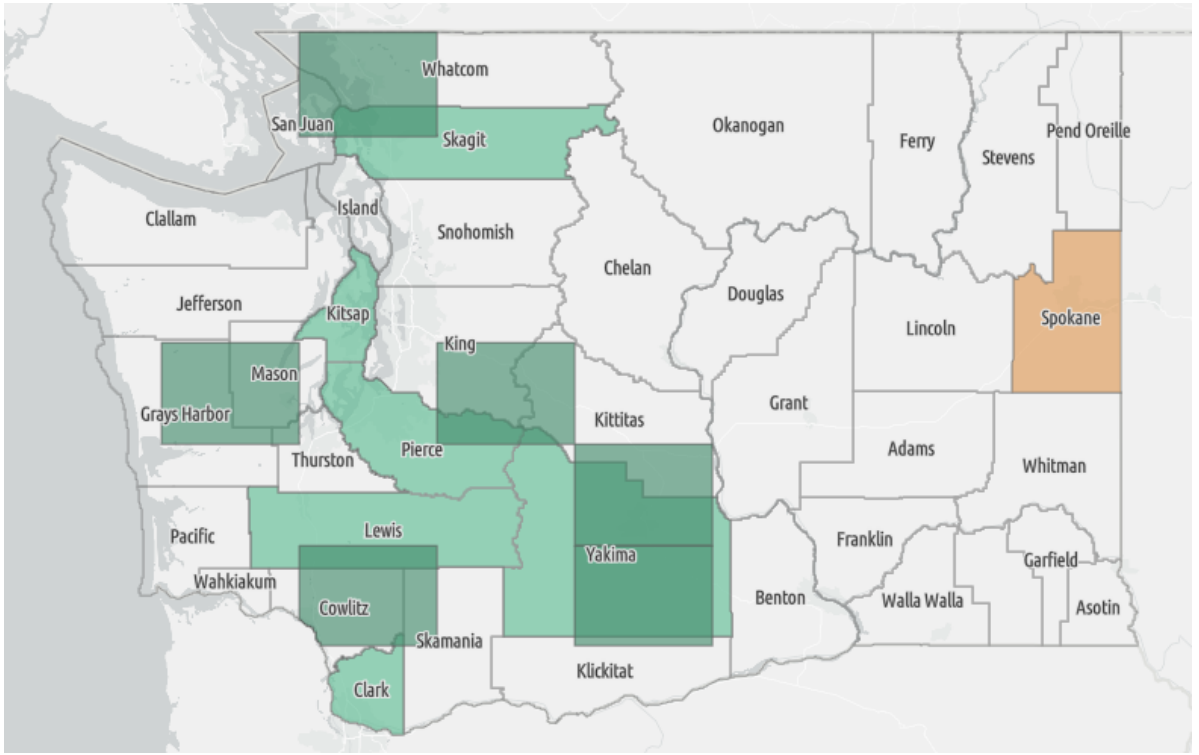
Aggregate Economic Impact and Importance report, Pacific Lutheran University School of Business, 2003

Why is WGS mapping Aggregate Resources?

Washington State's Growth Management Act requires that counties and cities base their land-use decisions related to Mineral Resource Lands on information provided by the Department of Natural Resources

Where has aggregate been mapped?

6 **1:100,000-scale quadrangle maps** **6** **county maps**



Making Aggregate Approachable

Identifying our audience

- ✓ Focused outreach with WGS's Geologic planning liaison
- x Avoid: Surprising counties with new data

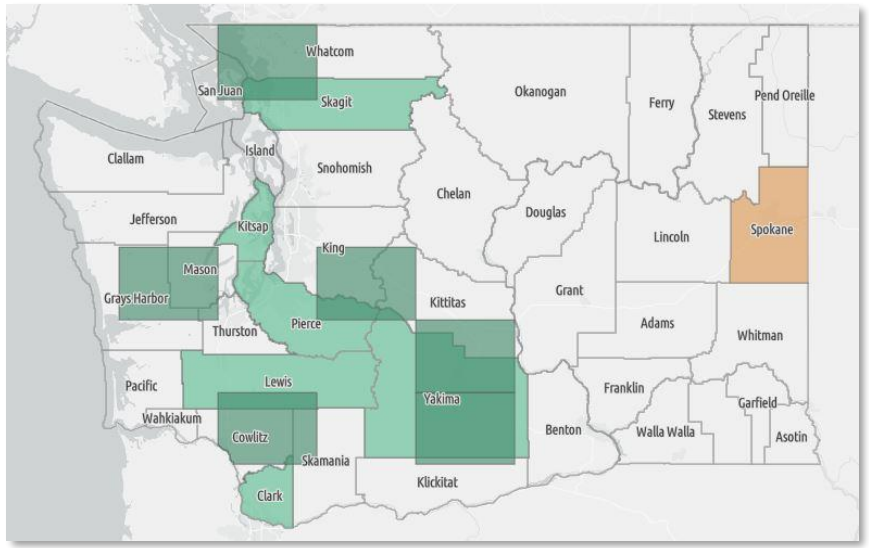
Maps are produced at a county scale

- ✓ Complete county coverage
- x Avoid: Less useful partial county maps

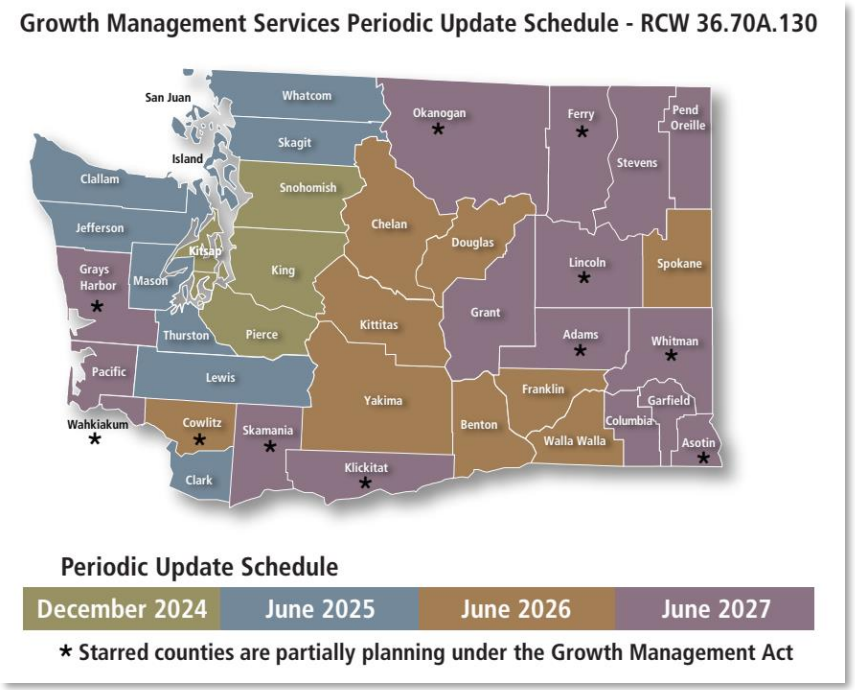
Approachable data

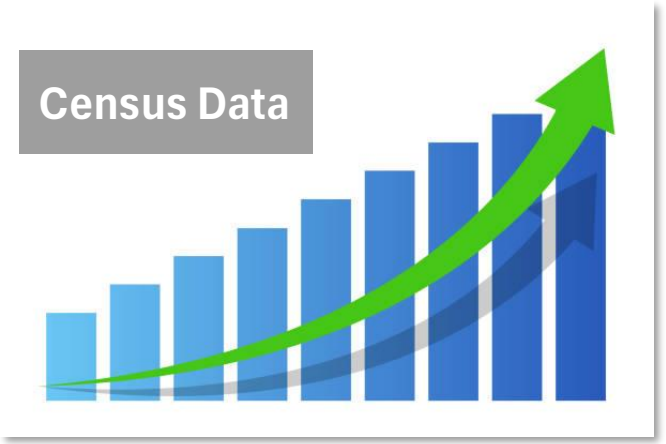
- ✓ Publish spatial data
- ✓ Generalized aggregate language
- ✓ Detailed metadata
- x Avoid: Audience not using or misusing our data

How do we prioritize where to map?

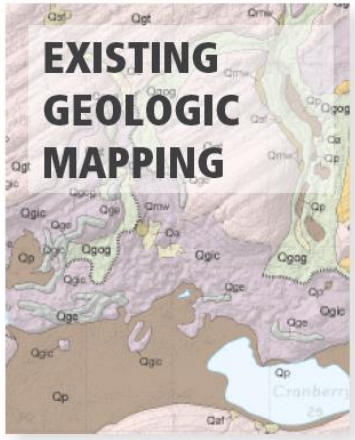


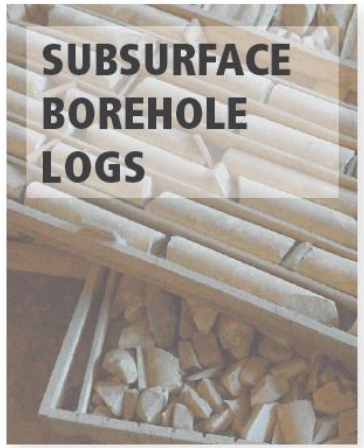
Areas in Washington State with WGS aggregate resource data

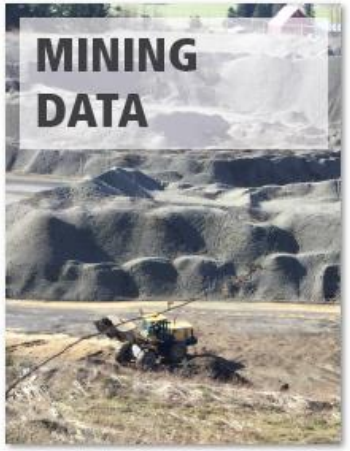


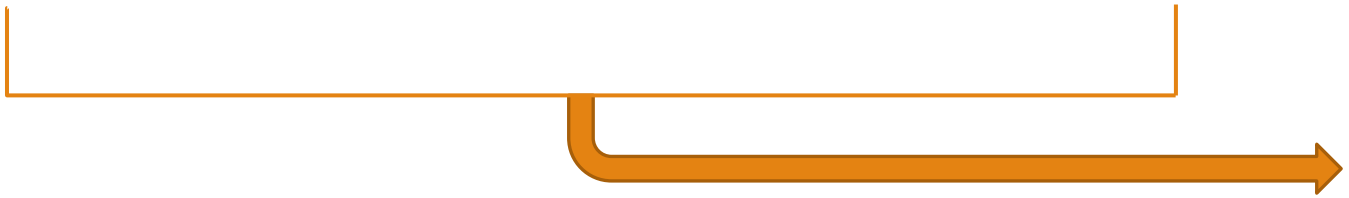


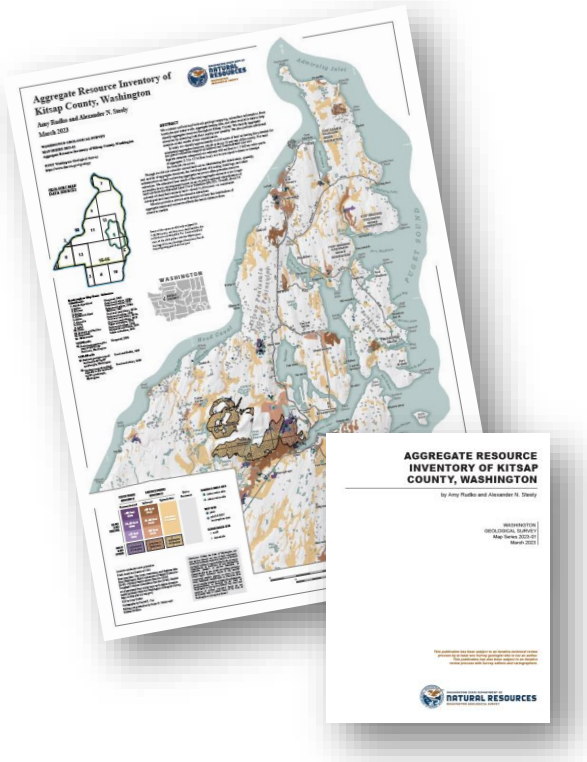
How is an Aggregate Resource map created?











Our Inspiration

TABLE 1: CLASSIFICATION OF SAND AND GRAVEL POTENTIAL

Characteristics	SIGNIFICANT RESOURCES		NONSIGNIFICANT[1] RESOURCES	
	High Potential	Moderate Potential	Low Potential	Limited Potential
Surficial Geology Landforms	Glacial stream valley; collapsed stream sediment; interlobate complex	Glacial stream valley; collapsed stream sediment; interlobate complex; collapsed channel; spillway terrace; delta or shallow lake	Add: alluvial valley; beach; ice-walled lake plain; lake plain; low-relief washed till plain	Add: channelized lake plain; dune or eolian feature; hummocky moraine; hummocky till; streamlined till
Predominant Sediment Description	Gravel, sand, with minor diamicton	Sand, gravel, diamicton with minor fine sediment (silt and clay)	Sand, fine sediment (silt and clay), gravel and diamicton	Diamicton, fine sediment (silt and clay), sand and
Probability[2]	High	Moderate to high	Very low to moderate	Very low to moderate
Sand and Gravel Thickness (in feet)	0-80+	0-40+	0-35+	0-15+
Overburden[3] Thickness (in feet)	0-15	15-25	25-40	>40
Sand and Gravel Deposit Size (areal extent[4])	Large (10-30+ acres)	Moderate to large (5-15+ acres)	Moderately small to small (3-10+ acres)	Very small to small (<1-5+ acres)
Sand and Gravel Textural Characteristics[5]	Moderate to good	Moderate to good	Very poor to good	Very poor to moderate
Sand and Gravel Quality[6]	Moderate to high	Moderate to high	Low to high	Low to high

FOOTNOTES ASSOCIATED WITH SAND AND GRAVEL POTENTIAL

[1]Nonsignificant: Aggregate resources that do not meet the criteria for high or moderate aggregate potential according to the characteristics listed in Table 1. This is a relative classification that changes from one mapping region to another.
[2]Probability: The degree of certainty that aggregate exists within a mapping unit largely defined by the amount of available information. Many gravel pits verify the certainty for many map units classified as high potential.
[3]Overburden: The material that lies above the sand and gravel that must be removed to access a deposit.
[4]Areal Extent: The size, horizontal extent, or distribution of a unit (e.g., area in acres). This attribute does not necessarily reflect the size of an individual polygon but the size of a deposit found within that polygon.
[5]Textural Characteristics: Particle size distribution, defined as the percentage of gravel or sand vs. silt or clay (e.g., sieve analysis).
[6]Quality: The physical characteristics of the material, such as soundness (e.g., magnesium sulfate test), durability (Los Angeles Rattler test), and percent of deleterious rock types such as iron oxide, disintegrating rock, or unsound chert. Field observations supplement historic data.

Minnesota Department of Natural Resources, 2014

WGS, 2015

Table B1. Listing of resource classification types and criteria.

Discovered resource	Definition
Indicated	Indicated resources are gravel or bedrock aggregate for which specific geologic evidence, limited sampling, and laboratory analysis provide confident estimation of distribution, grade, and quality. Indicated resources may include economic, marginally economic, and sub-economic components that reflect various degrees of geologic certainty. We map an indicated resource where available data appear to satisfy all of the elements of our threshold criteria (listed below).
Undiscovered resource	**Definition**
Hypothetical	Hypothetical resources are aggregate resources postulated to exist on the basis of general geologic information, aggregate test data, and production history. We map hypothetical resources where available data appear to satisfy most of the elements of our threshold criteria (listed below).
Speculative	Speculative resources are aggregate resources for which there is sparse geologic and production information and where indeterminate or no aggregate testing exists. Nevertheless, existing geologic mapping and data suggest that these rock units may have the potential for meeting the threshold criteria established for this study and possibly contain aggregate resources.

Associated Earth Sciences, Inc., 2017

Table 2
Thurston County Mineral Resource Lands Aggregate Quarry Rock Classification System

Sand and Gravel (Aggregate)		Resource Strata decreasing resource quality →			Non-Resource
		Quality Type A[1]	Quality Type B[2]	Quality Type C[3]	Quality Type D[4]
Decreasing resource thickness and volume	Quantity Type 1	• <5 percent fines[5] • 70:30 to 30:70 sand and gravel ratio • >25 years' life expectancy • Minimum 240,000 yd³/acre • >100 feet thick • Minimum overburden	• Up to 15 percent fines[5] • 70:30 to 30:70 sand and gravel ratio • >25 years' life expectancy • Minimum 240,000 yd³/acre • >100 feet thick • Minimum overburden	• Up to 25 percent fines[5] • 70:30 to 30:70 sand and gravel ratio • >25 years' life expectancy • Minimum 240,000 yd³/acre • >100 feet thick • Minimum overburden	• Generally unsuitable for extraction • >25 percent fines[5], may have high organic content • Out of 70:30 to 30:70 sand and gravel range • No life expectancy • <15,000 yd³/acre • Limited depth
	Quantity Type 2	• <5 percent fines • 70:30 to 30:70 sand and gravel ratio • 10 to 25 years' life expectancy • Average 80,000 to 240,000 yd³/acre • 50 to 100 feet thick • Overburden <15 feet thick	• Up to 15 percent fines • 70:30 to 30:70 sand and gravel ratio • 10 to 25 years' life expectancy • Average 80,000 to 240,000 yd³/acre • 50 to 100 feet thick • Overburden <15 feet thick	• Up to 25 percent fines • 70:30 to 30:70 sand and gravel ratio • 10 to 25 years' life expectancy • Average 80,000 to 240,000 yd³/acre • 50 to 100 feet thick • Overburden <15 feet thick	
	Quantity Type 3	• <5 percent fines • 70:30 to 30:70 sand and gravel ratio • Life expectancy variable, generally <10 years • Average 15,000 to 80,000 yd³/acre • Thickness varies, typically <50 feet	• Up to 15 percent fines • 70:30 to 30:70 sand and gravel ratio • Life expectancy variable, generally <10 years • Average 15,000 to 80,000 yd³/acre • Thickness varies, typically <50 feet	• Up to 25 percent fines • 70:30 to 30:70 sand and gravel ratio • Life expectancy variable, generally <10 years • Average 15,000 to 80,000 yd³/acre • Thickness varies, typically <50 feet	
Quarry Rock[6] (Bedrock)		Quality Type A	Quality Type B[13]	Quality Type C[7]	Quality Type D[8]
Decreasing interbedded resource strata	Type 1[10]	• Formation generally well mapped and (or) high percentage of formation contains resource strata of type A • Meets or exceeds WSDOT specs for all rock products • Minimal amount of fractures[9] • Minimal percent waste rock • 20 percent or more rockery-size material produced	• Formation mostly divided locally and contains a high percentage of resource strata of Type B • Meets WSDOT specs for some rock products • Fractures vary from minor to very prevalent[9] • Up to 10 percent waste rock • 20 percent or less rockery-size material produced[10]	• Formation mostly divided locally and contains a high percentage of resource strata of Type C • Rock will not meet WSDOT specs • Highly fractured[9] • 10 to 30 percent waste rock • Minimal rockery-size material produced[10]	• Generally unsuitable for extraction[8] • >30 percent waste rock • Highly to very highly fractured[9] and (or) weathered and (or) poorly lithified • No rockery-size material produced
	Type 2[11]	None	• Formation undivided[12] and >50% of formation contains mostly resource strata of Type B as defined for Type 1 bedrock	• Formation undivided[12] and >50% of formation contains mostly resource strata of type C as defined for Type 1 bedrock	
	Type 3[11]		• Formation undivided[12] and <50% formation contains mostly resource strata of Type B as defined for Type 1	• Formation undivided[12] and <50% of formation contains mostly resource strata of Type C as defined for Type 1[14]	

1 Type A sand and gravel is generally suitable for use in concrete. Aggregate meets or exceeds Washington State Department of Transportation (WSDOT) specs for all products.
2 Because of variability of grain size and fines content, Type B sand and gravel is less likely to be utilized in concrete and is generally considered to be a borrow source. Aggregate meets WSDOT specs for most or all products.
3 Type C sand and gravel is highly variable in grain size, generally sound, and *is* suitable for roadway fill and small borrow pits; not suitable for concrete. Aggregate is near or below WSDOT specs for most or all products.
4 Type D deposits may include fine sand, silt, clay, or lodgement till.
5 Fines are defined as percent material passing through a No. 200 sieve size.

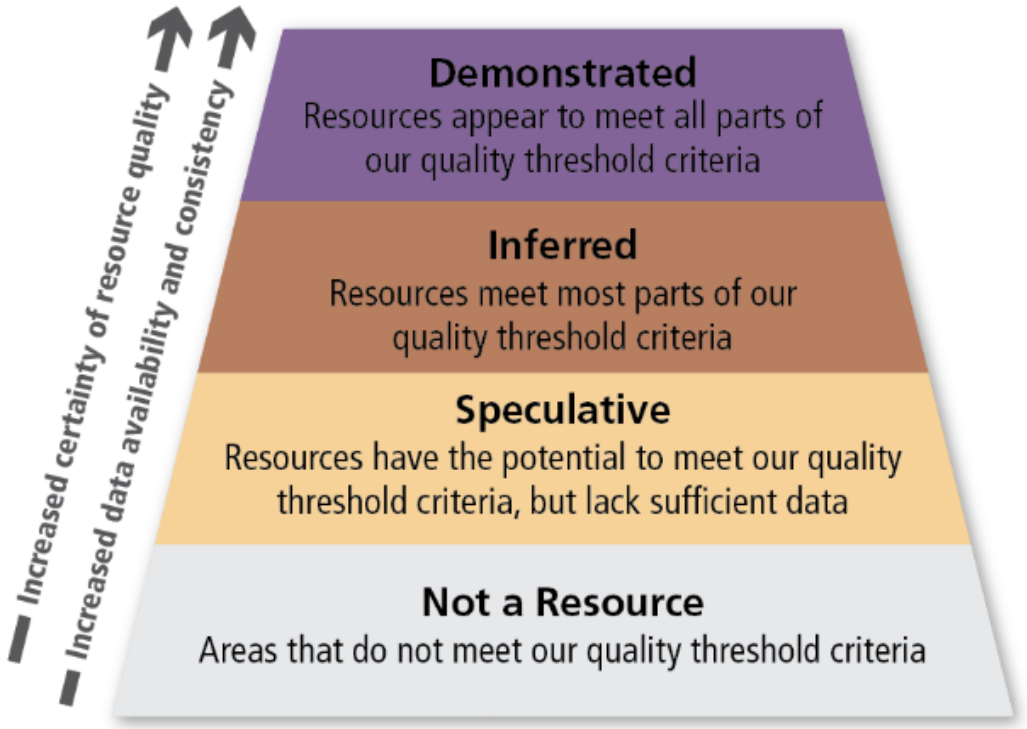
Our Classification Scheme

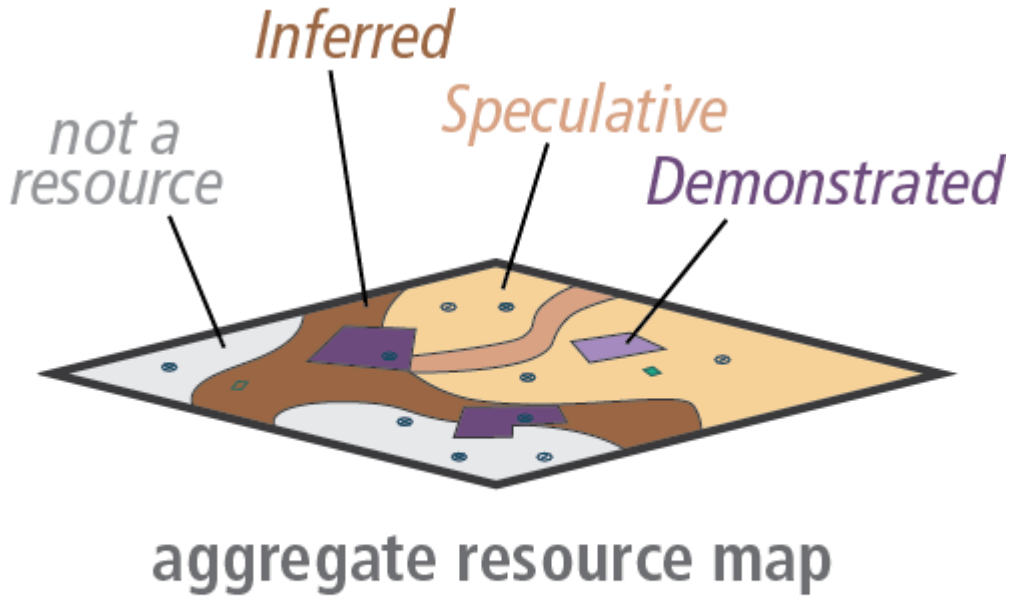
	Resource-quality input data	*More data available, data more consistent* ⟷ *Less data available, data less consistent*			
		Demonstrated	**Inferred**	**Speculative**	**Not a Resource**
Higher priority evidence	**Material description of sand and gravel or bedrock** Sources: Geologic and geomorphic maps (1:24,000 to 1:100,000 scale), subsurface data, and other geologic descriptions when available	Material descriptions are typically consistent and indicate a good-quality resource* with minor, if any, material of lesser quality. Example: A 1:24,000-scale geologic map describes in detail a well-sorted gravelly glacial outwash deposit.	Material descriptions vary in level of detail and (or) indicate the resource quality varies and may include some minor material that is not of good quality.* Examples: A 1:24,000-scale geologic map describes in detail a unit that contains mostly sand and gravel but also lenses of till, or a 1:100,000-scale geologic map describes a unit that generally contains sand and gravel.	Material descriptions vary in level of detail and (or) indicate the resource may include minor to moderate amounts of lower-quality material.* Example: A 1:100,000-scale geologic map describes a glacial ice-contact unit which may contain a mixture of good material (esker gravels) and low-quality material (clayey till).	Material descriptions available indicate material does not meet our aggregate resource material requirements.* Example: A 1:24,000-scale geologic map describes a poorly sorted glacial till with significant clay content.
	Active permitted mining activity Sources: SMRP records of active mines	Typically intersects with or adjacent to active (permitted) aggregate mines or quarries.	Sometimes adjacent to active (permitted) aggregate mines or quarries.	Rarely near or adjacent to active (permitted) aggregate mines or quarries.	Rarely near or adjacent to active (permitted) aggregate mines or quarries.
	Subsurface data (where available) Sources: Water-well logs, geotechnical borings	Subsurface data are typically available, well-located, evenly distributed, and indicate good-quality aggregate material throughout the resource area.	Subsurface data are typically available, but may be located less precisely. Generally indicates good-quality aggregate material. Some records may indicate lower-quality material.	Subsurface data are sometimes available, located with variable precision, have uneven distribution, and (or) indicate variable quality aggregate material.	Subsurface data may or may not be available. Where available, data generally indicate material does not meet our aggregate resource material requirements.*
	Other Mining activity (if available) Sources: SMRP records of inactive mines, USGS topo maps	Typically intersect with or adjacent to small mining operations, inactive (cancelled or terminated permit) aggregate mines or quarries, or historical mining activity.	Sometimes intersect with or adjacent to small mining operations, inactive (cancelled or terminated permit) aggregate mines or quarries, or historical mining activity.	Sometimes intersect with or adjacent to small mining operations, inactive (cancelled or terminated permit) aggregate mines or quarries, or historical mining activity.	Rarely intersects with or adjacent to historical or small mining operations. OR Sometimes intersects with or adjacent to previously reclaimed or cancelled permitted mines.
Lower priority evidence	**Aggregate testing data** (where available)	Test results are sometimes available. Available results typically pass our testing thresholds.†	Test results are sometimes available, but may be inconsistent. Available results sometimes pass our testing thresholds.†	Test results are rarely available and often inconsistent. Available results sometimes pass our testing thresholds.†	Test results are rarely available and often inconsistent. Available results typically fail our testing thresholds† or are incomplete.
	Consistency of evidence	Most to all data indicate a good-quality resource; rarely data may indicate lower quality material.	Most to some data indicate a good-quality resource; some data may indicate lower-quality material.	At least some data indicate a good-quality resource; some data may indicate lower-quality material.	Most to all data indicate that the material is not a good aggregate resource; rarely data may indicate a good-quality resource.
	Criteria that all resource polygons must meet (Demonstrated, Inferred, and Speculative polygons)	(1) When subsurface data are available and indicate the presence of an overburden, it is typically <10 feet thick with a stripping ratio of 1:3 or better (the overburden should be no more than a third of the resource thickness). (2) Mapped polygon is larger than 1 acre and not too narrow (generally >200 feet across at its narrowest dimension).			Criteria (1) or (2) are not met.

* Good-quality sand and gravel resource: Material description indicates sand and gravel with little to no organic material, silt, or clay. These deposits are typically unweathered, generally stratified, moderately to well rounded, and well sorted. Good-quality bedrock resource: Material description indicates little to no weathering, little indication of physical or chemical alteration, and other details that correspond with strong and durable rock.

† We adopt the 2023 specifications for Hot Mix Asphalt (HMA) as our aggregate testing threshold: LA abrasion values of <30% and Washington Degradation values of >30%.

What is represented on an Aggregate Resource Map?

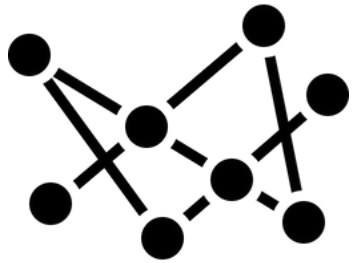




Aggregate Analyses

Sand and gravel reserves volume estimate

Undeveloped aggregate area and volume estimate



Distance to market network analyses

Thank you!

Special Thanks:

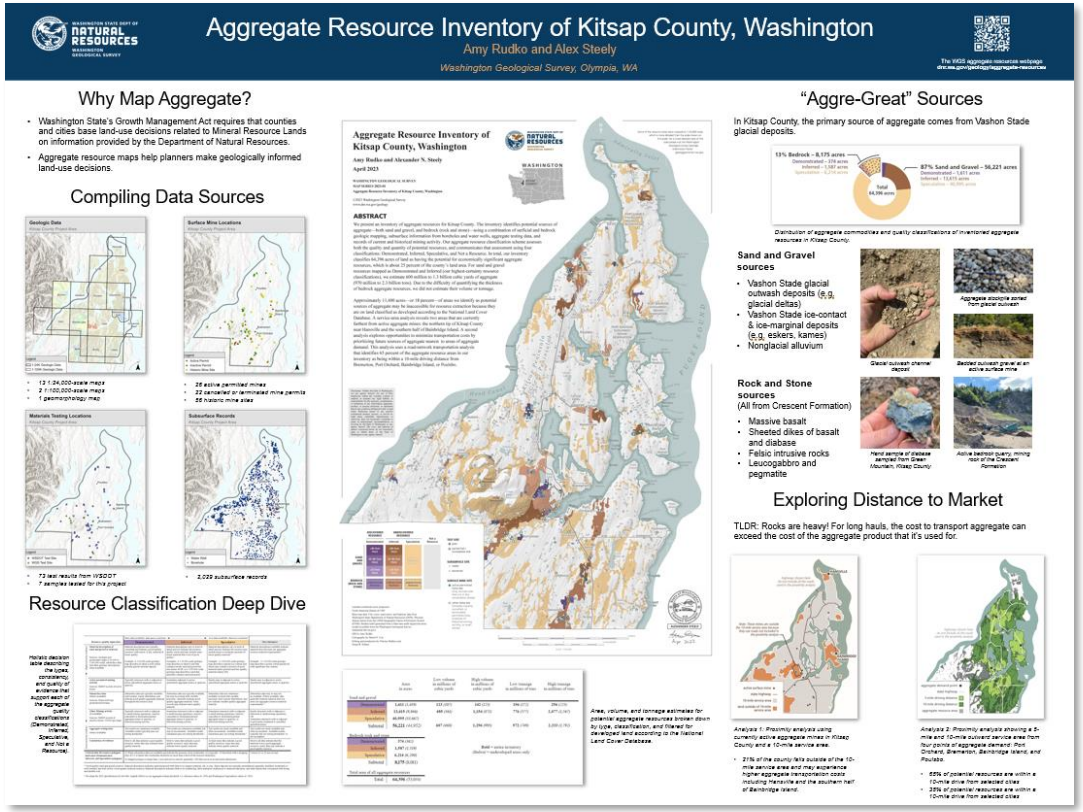
Alex Steely

WGS's Assistant Director of Geologic Hazards and Mapping

Tricia Sears

WGS's Geologic Planning Liaison

Rian Skov and the whole Surface Mine Reclamation team



Check out the Kitsap County Aggregate mapping poster!