The Wood River Valley Aquifer System Groundwater-Flow Model: Hydraulic conductivity

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These slides were presented at the Wood River Valley Modeling Technical Advisory Committee meeting Thursday, 04Jun15, 10am-2pm at the Nature Conservancy office in Hailey. Taken outside the context of the original presentation, these slides may not provide a complete or accurate representation of the speaker's intent.

Hydraulic conductivity (K)

- Hydraulic conductivity is a measure of the permeability of the geologic material
- Varies over 13 orders of magnitude
- Most methods of determination are probably ± 1 order of magnitude (at best)
- Can vary significantly over short distances
- Horizontal K is often greater than vertical K by an order of magnitude or more
- Scale dependent

Published ranges of horizontal K

Table 3.-- Published ranges for hydraulic conductivity of unconsolidated sediment and basalt.
[ft/d, feet per day]

Material	Hydraulic conductivity, ft/d Range			Source
Clay	2.8×10^{-6}	-	0.13	Spitz and Moreno (1996, p. 346)
Silt, sandy silts, clayey sands, till	2.8×10^{-3}	-	0.28	Fetter (2001, p. 85)
Silty sands, fine sands	0.028	-	2.8	Fetter (2001, p. 85)
Well-sorted sands, glacial outwash	2.8	-	280	Fetter (2001, p. 85)
Sand	1.3	-	2.8×10^{3}	Spitz and Moreno (1996, p. 348)
Sand and gravel	27	-	650	Spitz and Moreno (1996, p. 348)
Gravel	130	-	2.8×10^{5}	Spitz and Moreno (1996, p. 347)
Basalt	5.3×10^{-6}	-	0.13	Spitz and Moreno (1996, p. 346)
Basalt, permeable	0.13	-	1.3×10^{4}	Spitz and Moreno (1996, p. 346)
Basaltic lava and sediments	510	-	5.1×10^{4}	Spitz and Moreno (1996, p. 346)
Basalt, thin, fractured, sediment interbeds	0.01	-	2.4×10^{4}	Ackerman and others (2006, p. 19)
Basalt, massive, fractured, sediment interbeds	6.5	-	1.4×10^{4}	Ackerman and others (2006, p. 19)

Bartolino and Adkins (2012, p. 25)

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Horizontal K by layer

Horizontal K: Layer 1

	(ft/d)	
Min.	0.98	fine sand
1st Qu.	52	sand, gravel, outwash
Median	190	sand, gravel, outwash
Mean	950	sand, gravel
3rd Qu.	850	sand, gravel
Max.	200,000	gravel

Horizontal K: Layer 2

	(ft/d)	
Min.	0.001	clays, silts
1st Qu.	0.001	clays, silts
Median	46	basalts, sand, gravel
Mean	180	basalts, sand, gravel
3rd Qu.	59	basalts, sand, gravel
Max.	15,000	gravel

Horizontal K: Layer 3

	(ft/d)	
Min.	29	sand, gravel, outwash
1st Qu.	46	sand, gravel, outwash
Median	690	sand, gravel
Mean	1,900	sand, gravel
3rd Qu.	2,800	sand, gravel
Max.	43,000	gravel

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Horizontal K: specific-capacity vs model

Aquifer condition	Number of wells	Hydraulic conductivity (ft/d) High	Low	Mean	Median	Geometric mean
Theis/Thomasson						
Unconfined	78	1,900/2,300	0.33/1.2	250/300	71/97	69/100
Confined	3	52/84	32/34	42/52	43/37	42/47
Total	81	--	--	--	--	--
WRV Model calibration						
Layer 1	--	200,000	0.98	950	190	--
Layer 2	--	15,000	0.001	180	46	--
Layer 3	--	43,000	29	1,900	690	--

Bartolino and Adkins (2012) p. 25

Short tests

"Pumping depth"?

They're from drillers' logs

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Published ranges of vertical K

Table.-- Published values of vertical hydraulic conductivity [ft/d, feet per day]

Material	Hydraulic conductivity (ft/d)			Source
	Mean or specified	Range		
Limestone, fractured	2.5	--	--	Spitz and Moreno (1996, p. 351)
Sand, silt, and clay	14	--	--	Spitz and Moreno (1996, p. 351)
Santa Fe Group	0.059	0.00051	2.6	Reiter (2003, p. 22-23)
Ogallala Formation	--	0.00042	18	Davis and others (2015, p. 28-29)
Arikee Formation	--	0.000087	3.7	Davis and others (2015, p. 28-29)
SVRP, Layer 1; gravel	3,000	--	--	Hsieh and others (2007)
SVRP, Layer 2; clay	0.000000010	--	--	Hsieh and others (2007)
SVRP, Layer 3; gravel	3,000	--	--	Hsieh and others (2007)
gravel	--	2,800	28,000	Stephens (1996, p. 139)
sand	--	28	2,800	Stephens (1996, p. 139)
sandy clay	--	0.028	2.8	Stephens (1996, p. 139)
clay	--	0.0000028	0.00028	Stephens (1996, p. 139)
silt	--	0.0028	0.28	Stephens (1996, p. 139)
sand, silt, and clay	--	0.00028	2.8	Stephens (1996, p. 139)

Remember: The vertical K is controlled by the least permeable layers

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Vertical K by layer

Vertical K: Layer 1

	(ft/d)	
Min.	0.019	silt, sandy clay
1st Qu.	1.0	sandy clay; sand, silt, and clay
Median	3.9	sandy clay; sand, silt, and clay
Mean	19	sand; sand and gravel
3rd Qu.	16	sand; sand and gravel
Max.	3,900	gravel

Vertical K: Layer 2

	(ft/d)	
Min.	0.000019	clay
1st Qu.	0.000020	clay
Median	0.92	sandy clay; silt; sand, silt, and clay
Mean	3.6	sandy clay; sand, silt, and clay
3rd Qu.	1.2	sandy clay; sand, silt, and clay
Max.	290	sand; sand and gravel

Vertical K: Layer 3

	(ft/d)	
Min.	0.56	sandy clay; sand, silt, and clay
1st Qu.	0.89	sandy clay; sand, silt, and clay
Median	14	sand; sand and gravel
Mean	39	sand
3rd Qu.	56	sand
Max.	850	sand

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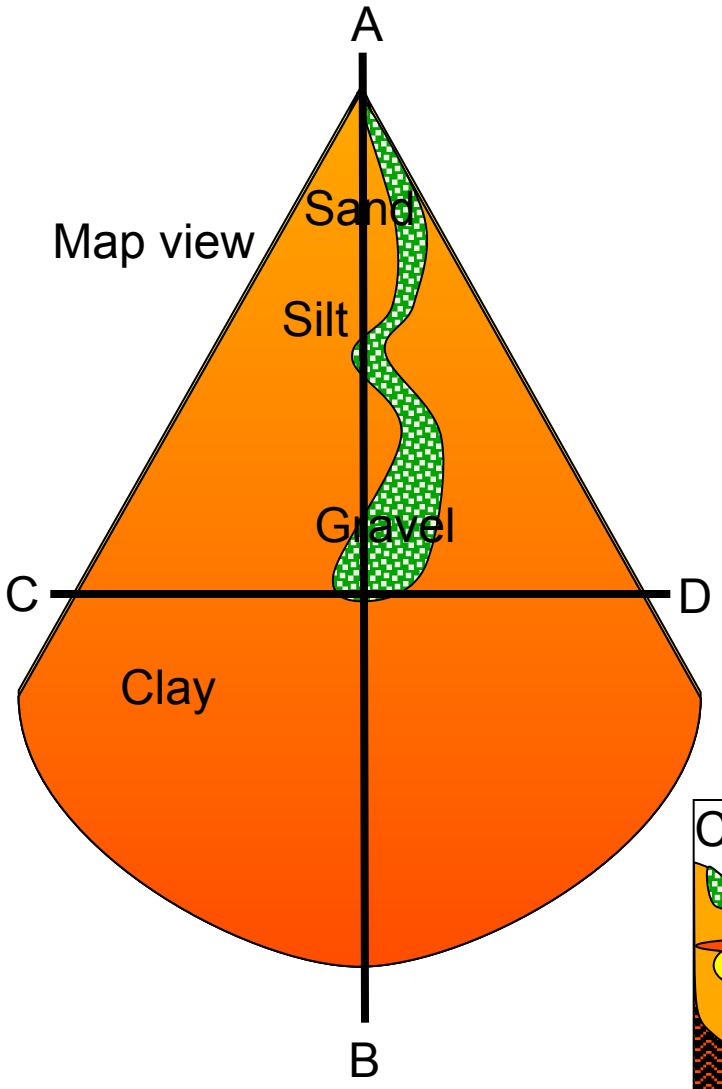
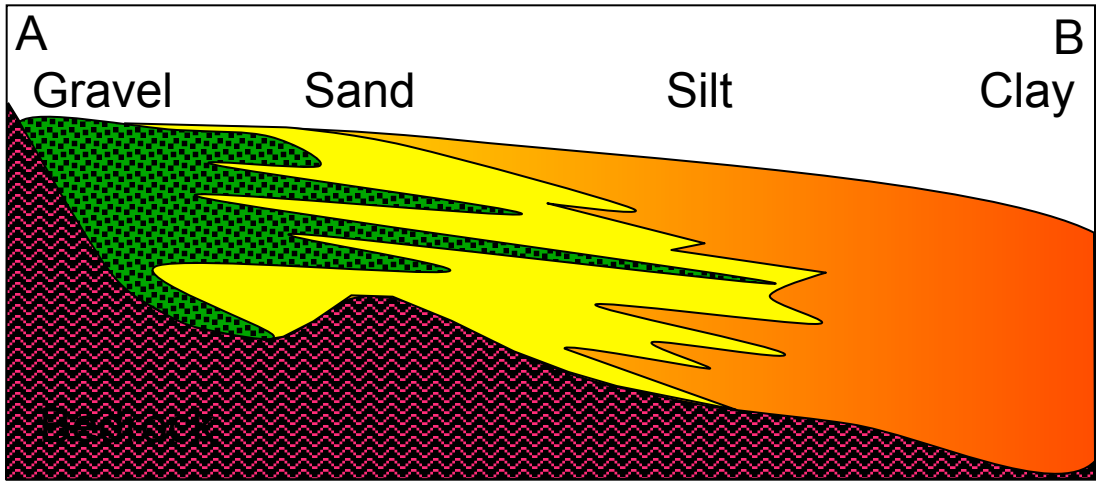
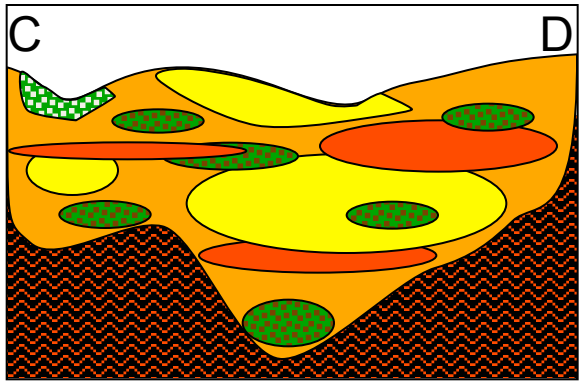
Textural variation in the aquifer







- The Bellevue Triangle and the tributary canyons are alluvial fans
- Basalt flows affected drainage

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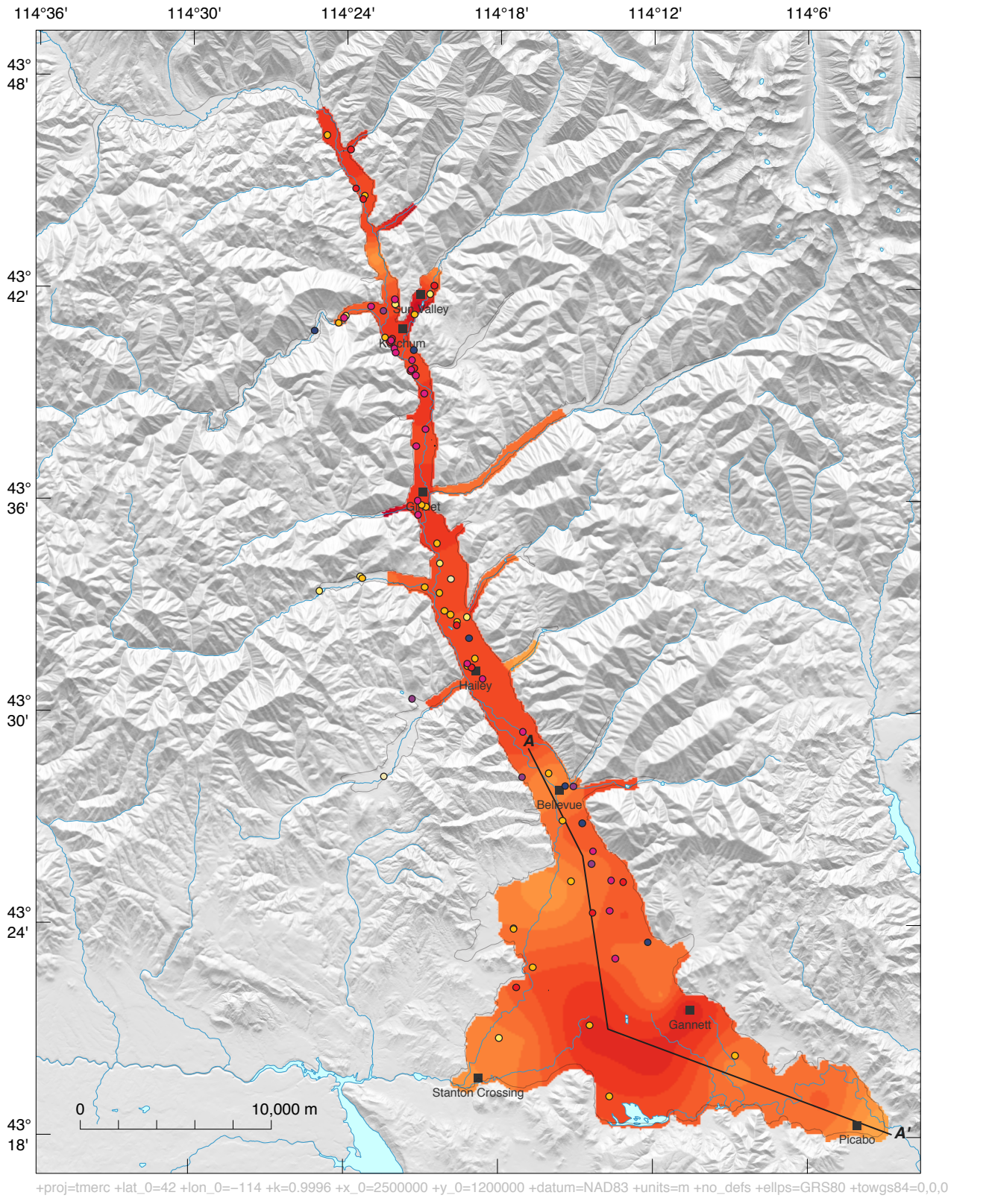
(a) model layer 1



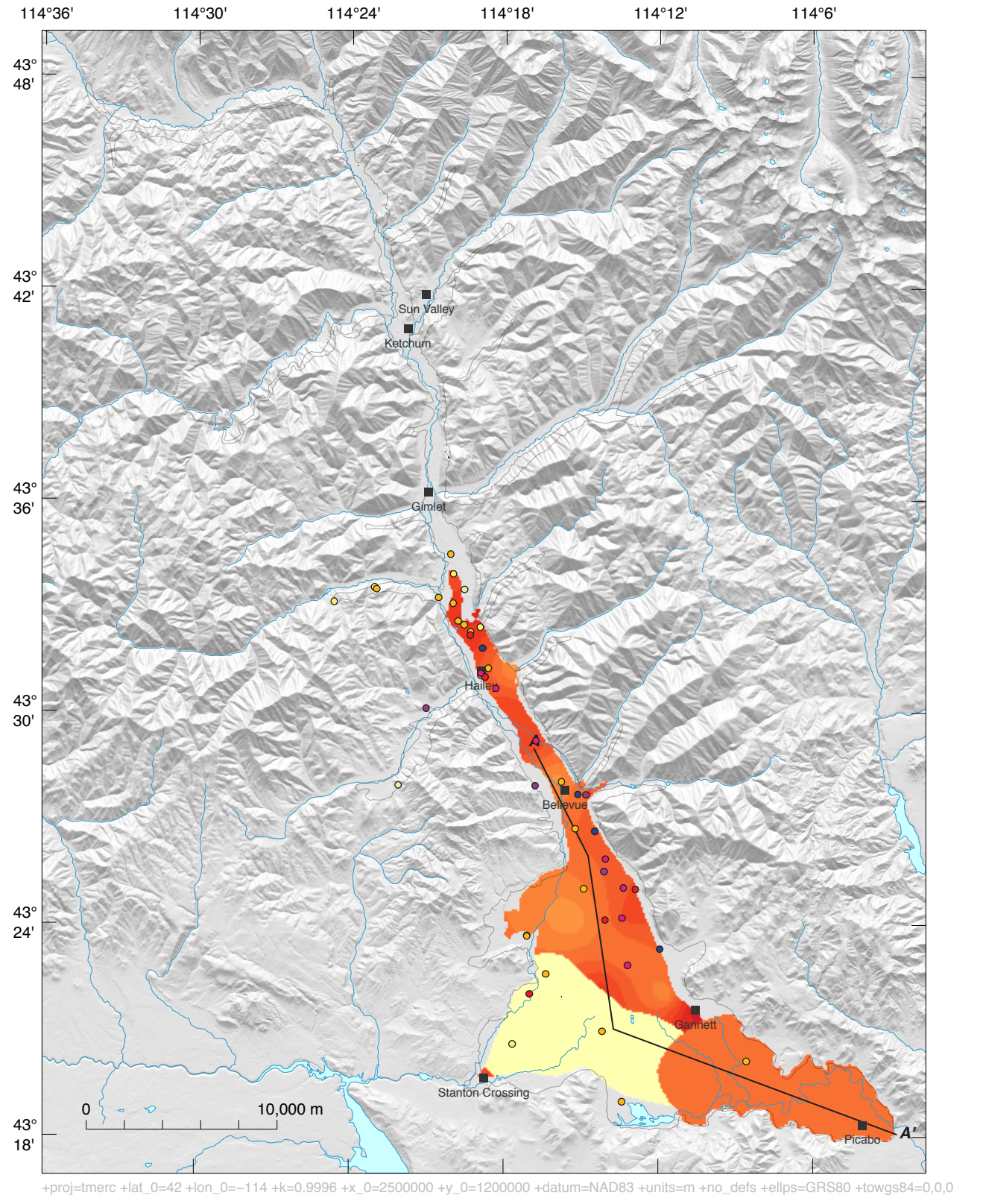
Horizontal hydraulic conductivity in meters per day, plotted on a logarithmic scale.

1e−04	1e−03	1e−02	1e−01	1e+00	1e+01	1e+02	1e+03	1e+04	1e+05
0.00033	0.0033	0.033	0.33	3.3	33	330	3,300	33,000	330,000 ft/d

Hydraulic conductivity, in feet per day (Theis method) Bartolino and Adkins (2012)

- 0.1 - 0.9
- 1.0 - 9
- 10 - 49
- 50 - 99
- 100 - 499
- 500 - 999
- 1,000 - 1,900

(b) model layer 2



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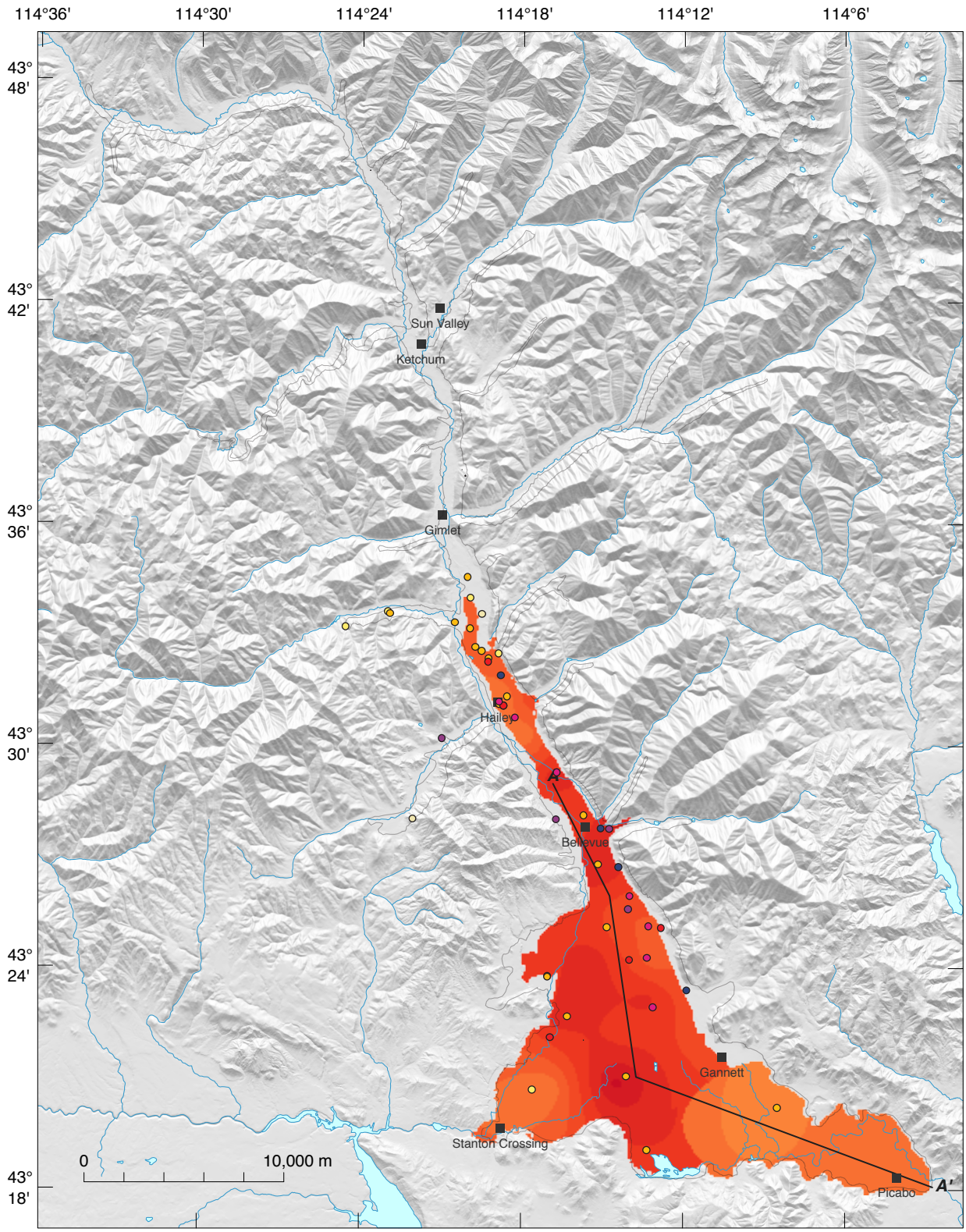
(c) model layer 3



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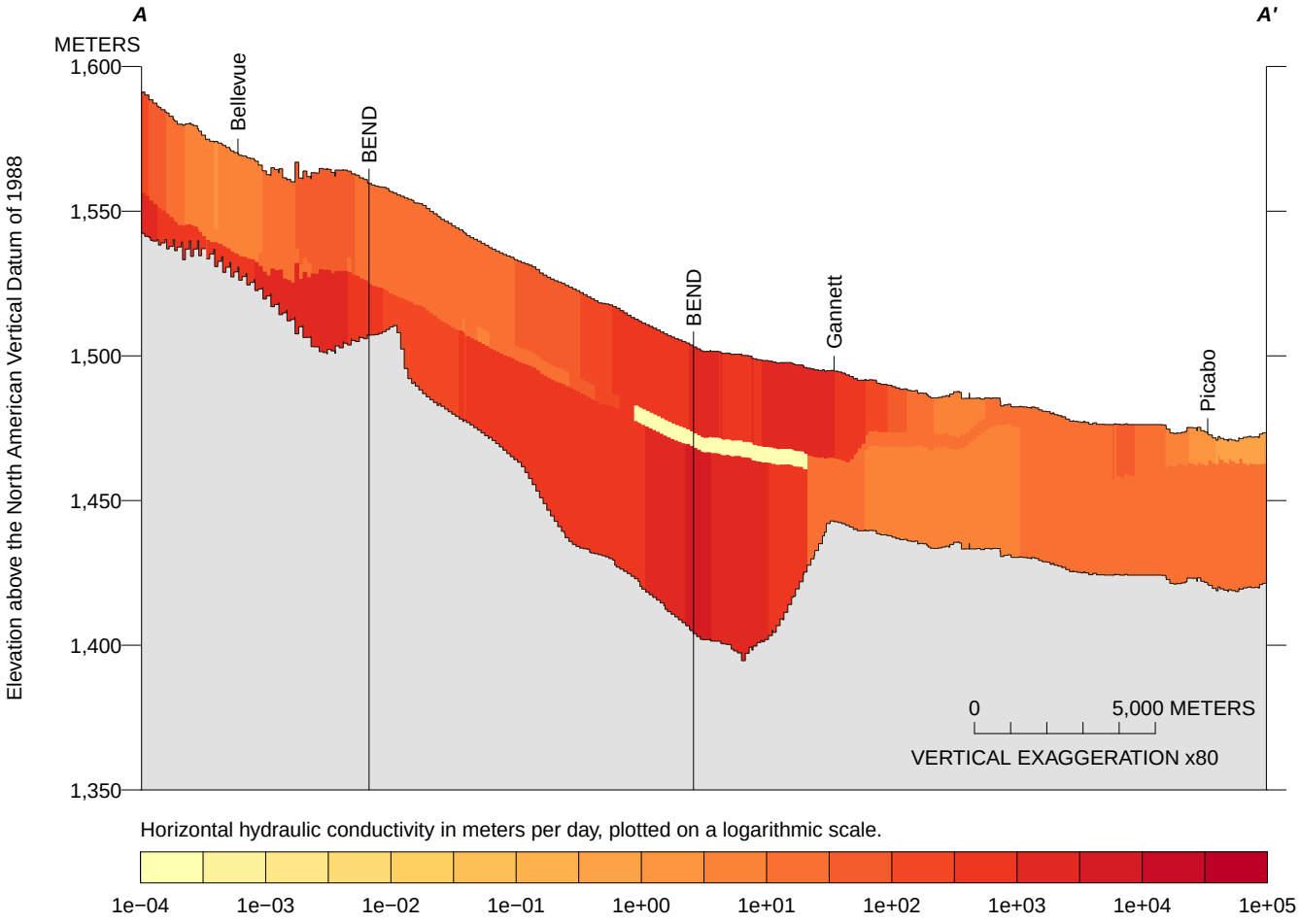

Figure 3: Vertical cross-section of horizontal hydraulic conductivities along transect line A-A′.