

Attachment I-8: Revised In-Town Levee Analyses



Fargo-Moorhead Metro Feasibility Study

Assumptions used in GeoStudio Cross-sections for Revised Analysis

Low Head Dam Crest Elevations and Location

1) North Dar	871.38 ft	12th Avenue N, Fargo OR 15th Avenue, Moorhead
2) Midtown D	876.2 ft	Dike East
3) South Dar	878.4 ft	32nd Avenue S, Fargo OR River Oaks Park, Moorhead

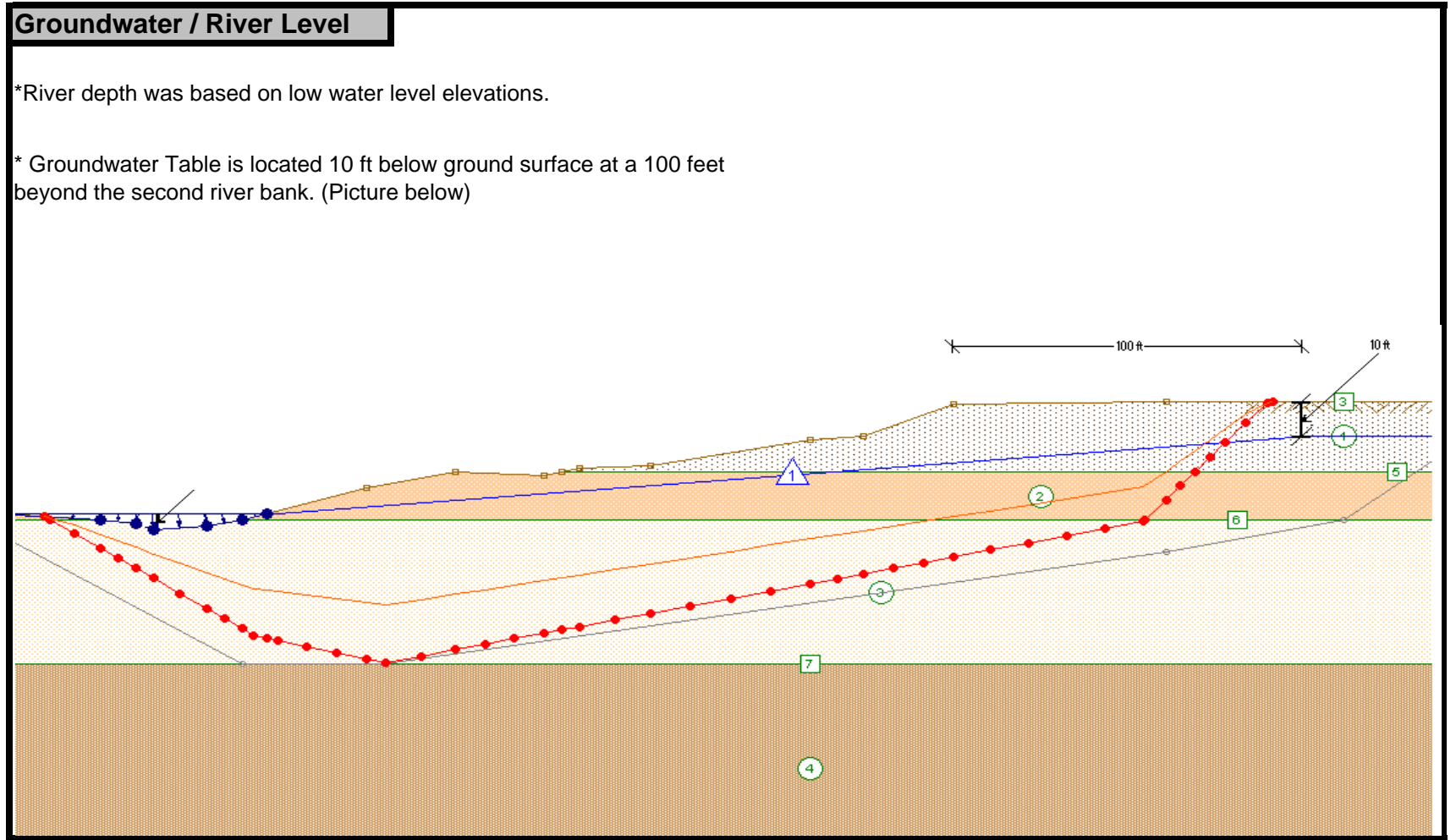
Material	Unit Weight [pcf]	Drained		Residual	Undrained	
		Friction Angle [Deg] ϕ'	Cohesion [psf] c'		Friction Angle [Deg] ϕ	Cohesion [Psf] c
Alluvium / Fluvial	119	31	0	20		1400
Sherack	118	28	0	13	0	1400
PL Sherack	112	19	0	6	0	1150
Poplar River West Fargo	123	34	0	20	0	1900
Poplar River Harwood	116	26	0	20	0	1450
Brenna	103	13	0	9*	0	650
Argusville	106	15	0	11	0	825
Sand	128	30	0		30	0
Sand Delta	128	25	0		25	0
Till	122	31	0		0	1900
Levee Fill	118	28	250		0	1400
Sand Drain	128	30	0		30	0
Fill (Spoil Area)	118	28	0		0	1400
Riprap	120	32	0		32	0

* Actual value used to compute levee setback was backcalculated from assumed failures.

Groundwater / River Level

*River depth was based on low water level elevations.

* Groundwater Table is located 10 ft below ground surface at a 100 feet beyond the second river bank. (Picture below)





Fargo-Moorhead Metro Feasibility Study

Revised Setback Distances for Earthen Levees: MVP's 0.2-percent annual chance event (500-year) level plus superiority

Computed By: RWP, JF
Date: Dec-09

Revised By:
Date:

Setback Distances for Earthen Levees MVP's 0.2-percent annual chance event (500-year) level plus superiority

- Measured from center of river channel to center of the levee
- Required Factor of Safety of 1.4 (EM 1110-2-1913)

Top Elevations for Earthen Levees

- The elevations were determined by USACE based on a risk and uncertainty analysis
- Level of Protection provided to be determined based on R&U analysis
- Elevations in NAVD 1988

Levee Embankment Geometry

- Earthen levee section assumed to have a top width of 10 feet and a side slope of 1:3 (Vert:Horz).

Stratigraphy

- Stratigraphy is based on the soil exploration completed and developed stratigraphy'
- A residual zone was assumed to occur from the secondary bank to the river

Slope Stability Analysis

- Analyzed using GeoStudio (Slope/W)
- Entry/Exit Slip Surface with Optimization
- Two slip surfaces were analyzed:
 - (1) Front toe of the levee
 - (2) At or beyond the back toe of the levee



Fargo-Moorhead Metro Feasibility Study

Revised Setback Distances for Earthen Levees: MVP's 0.2-percent annual chance event (500-year) level plus superiority

Fargo, North Dakota										Drained Strengths		Undrained Strengths		Brenna Residual Friction Angle (Backcalculated)	Notes
Cross-Section	HEC Ras Section	HEC Ras TOL	Low Water Profile	Height of Levee [ft]	Preliminary Setback Distance [ft]	Revised Setback Dist. W/ Low Flow Elev. [ft]	Setback Difference	Setback Used	Description	Front Toe FS	Back Toe FS	Front Toe FS	Back Toe FS		
FAR-01	(1/3) from 316 to 315	898	861	2	520	415	-105	520	10th St N, north end	1.219	1.319	1.409	1.404		
FAR-02	(1/2) from 321 to 320	899	862	0	555	545	-10	555	10th St N, south end	1.529		1.304			Undrained Analysis Controls
FAR-03	326/325/324/322	899	862	5	480	443	-37	480	Fargo WWTP	1.326	1.321	1.321	1.363		Undrained Analysis Controls
FAR-04	327	900	863	3	490	487	-3	495	Golf course north	1.207	1.278	1.360	1.417	12.25	1 foot tension crack in drained analysis
FAR-05	(2/3) from 334 to 333	901	865	1	510	454	-56	500	South of Seminary	1.201	1.260	1.346	1.363	10.3	
FAR-06	(2/3) from 339 to 338	902	865	12	385	362	-23	660	Lilac Lane	1.201	1.379	1.628	1.680		
FAR-07	339	902	865	9	355	345	-10	380	Woodcrest Drive	1.209	1.295	1.673	1.655		tension in drained analysis - increased FS when a tension crack was added.
FAR-08	351	905	872	5	410	415	5	420	The Shrine	1.206	1.283	1.439	1.448	11.6	
FAR-09	355	906	872	7	450	360	-90	Oakgrove	Oakgrove School	1.219	1.350	1.475	1.506		
FAR-10	359	907	872	4	470	453	-17	450	Downtown, north	1.216	1.298	1.498	1.521		
FAR-11	(1/3) from 361 to 360	907	872	13	365	263	-102	520	Downtown, City Hall	1.204	1.663	1.443	1.513	10.7	
FAR-12	391	911	877	7	485	489	4	485	Elmwood Ave S (Lindenwood Area)	1.209	1.430	1.631	1.648	10.4	3' tension crack in drained analysis
FAR-13	(7/8) from 406 to 405	912	877	6	380	516	136	340	Fargo Country Club	1.203	1.325	1.747	1.769		2.5' tension crack in drained analysis
FAR-14	(1/2) 408 to 407	913	877	8	410	483	73	365	Southwood Drive	1.204	1.358	1.690	1.725		
FAR-15	414	913	879	9	425	448	23	420	River Drive, north end	1.212	1.442	1.609	1.692		
FAR-16	(1/3) from 415 to 414	914	879	9	400	440	40	430	River Drive, south end	1.2	1.397	1.665	1.736	9.6	1' tension crack in drained analysis
FAR-17	(2/3) from 461.3 to 460.72	915	880	12	385	405	20	505	University Dr, golf course	1.199	1.507	1.757	1.779		3' tension crack in drained analysis
FAR-18	(1/3) from 462.03 to 461.3	916	880	10	445	453	8	410	University Dr, cemetery	1.201	1.541	1.614	1.702		7' tension crack in drained analysis - couldn't get rid of tension. Checked w/ UT4
FAR-19	462.7	916	880	10	500	458	-42	470	University Dr, south end	1.204	1.562	1.598	1.644		5' tension crack in drained analysis - couldn't get rid of tension. Checked w/ UT4.
FAR-20	(1/5) from 465.1 to 464.6	917	880	14	450	406	-44	415	University Dr, south end tie-back	1.209	1.518	1.635	1.713		5' tension crack in drained analysis

Pink indicates location that setback could potentially seen bigger difference

- Setback distances decreased less than 50 ft 8
- Setback distances decreased between 50 - 100 ft 2
- Setback distances decreased more than 100 ft 2
- Setback distances increased less than 50 ft 6
- Setback distances increased between 50 - 100 ft 1
- Setback distances increased more than 100 ft 1
- 20



Fargo-Moorhead Metro Feasibility Study

Revised Setback Distances for Earthen Levees: MVP's 0.2-percent annual chance event (500-year) level plus superiority

Moorhead, Minnesota														
Cross-Section	HEC Ras	HEC Ras TOL	Low Water Profile	Levee Height [ft]	Preliminary Setback Distance [ft]	Revised Setback Dist. W/ Low Flow Elev. [ft]	Setback Difference	Setback Used	Description	Drained Strengths		Undrained Strengths		Notes
										Front Toe FS	Back Toe FS	Front Toe FS	Back Toe FS	
MOOR-01	(1/3) from 330 to 329	901	864	5	470	431	-39	415	North Moorhead	1.2	1.313	1.517	1.541	--
MOOR-02	332	901	864	13	435	442	7	430	North Moorhead	1.209	1.578	1.307	1.434	Small Tension (<10lbs) Ignored
MOOR-03	(3/5) from 337 to 336	902	865	4	435	476	41	425	North Moorhead	1.227	1.288	1.514	1.511	--
MOOR-04	(1/4) from 340 to 339	903	865	6	445	458	13	450	Crystal Sugar	1.205	1.321	1.407	1.471	Small Tension (<10lbs) Ignored
MOOR-05	(1/2) from 343 to 342	904	866	8	495	442	-53	485	North of golf course	1.203	1.32	1.383	1.421	--
MOOR-06	(2/5) from 345 to 344	905	867	7	415	336	-79	400	south of golf course	1.263	1.303	1.522	1.536	--
MOOR-07	(1/5) from 345 to 344	905	867	3	485	483	-2	660	Municipe building	1.205	1.285	1.408	1.423	2' Tension Crack in Drained Front of Toe
MOOR-08	(2/3) from 354 to 353	906	872	3	465	462	-3	455	S Homestead park	1.206	1.296	1.412	1.43	Small Tension (<105lbs) Ignored
MOOR-09	(1/6) from 354 to 353	906	872	3	435	488	53	430	Moorhead Jail	1.229	1.303	1.487	1.508	Small Tension (<10lbs) Ignored
MOOR-10	356	907	872	2	470	498	28	470	Moorhead City Hall	1.224	1.285	1.455	1.453	2' Tension Crack in Drained Front of Toe
MOOR-11	(1/2) from 371 to 370	909	872	5	485	540	55	475	S City Hall	1.203	1.318	1.515	1.536	4' Tension Crack in Drained Front of Toe
MOOR-12	(1/4) from 387 to 386	910	877	6	440	472	32	570	Old Plant	1.212	1.384	1.58	1.618	3' Tension Crack in Drained Front of Toe
MOOR-13	(1/3) from 391 to 390	911	877	6	395	475	80	385	N Gooseberry Park	1.204	1.355	1.628	1.679	2' Tension Crack in Drained Front of Toe
MOOR-14	(1/2) from 393/394 to 392	911	877	6	420	466	46	415	Gooseberry Park	1.207	1.355	1.658	1.691	4' Tension Crack in Drained Front of Toe
MOOR-15	395	911	877	5	370	470	100	380	Rivershore Dr, north	1.209	1.342	1.671	1.682	--
MOOR-16	(1/2) from 405 to 404	912	877	6	410	471	61	405	Rivershore Dr, south	1.201	1.374	1.909	1.987	5' Tension Crack in Drained Front of Toe
MOOR-17	(1/3) from 407 to 406	913	877	8	440	492	52	435	River Oak Circle	1.205	1.342	1.624	1.694	1' Tension Crack in Drained Front of Toe
MOOR-18	414	913	879	6	515	502	-13	530	south subdivision	1.201	1.367	1.679	1.727	4' Tension Crack in Drained Front of Toe
MOOR-19	415	914	879	10	405	446	41	435	south subdivision	1.203	1.474	1.672	1.754	5' Tension Crack in Drained Front of Toe (Some Difficulties)
MOOR-20	(1/2) from 460.72 to 460.28	915	880				0	495	Art center					

Pink indicates location that setback could potentially seen bigger difference

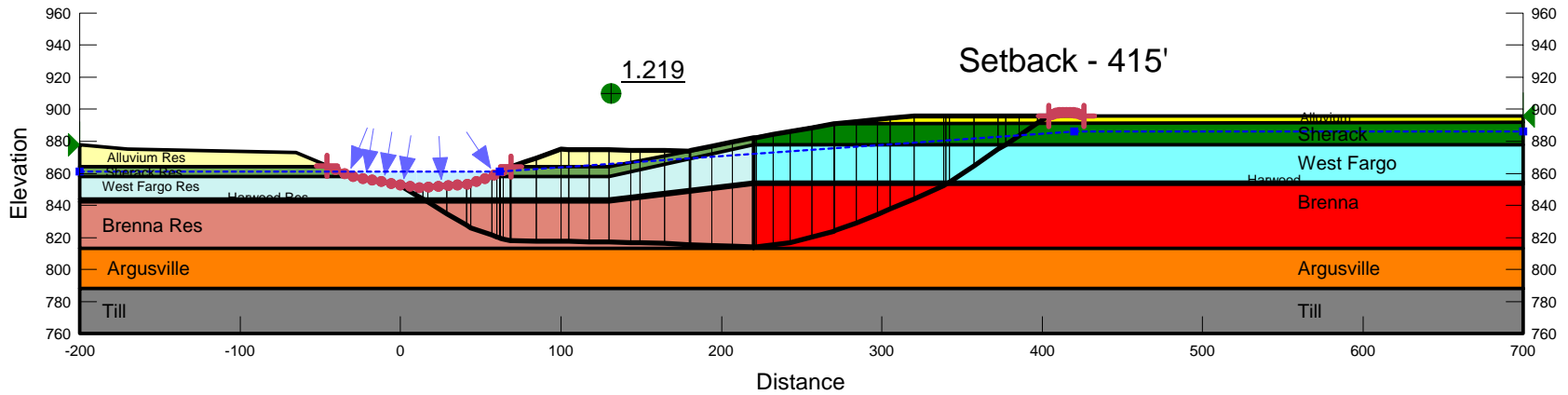
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- Setback distances decreased between 50 - 100 ft 2
- Setback distances decreased more than 100 ft 0
- Setback distances increased less than 50 ft 8
- Setback distances increased between 50 - 100 ft 6
- Setback distances increased more than 100 ft 20

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 1

Level of Protection: 898 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	
Sherack Res 118 pcf 0 psf 13 °	Levee Fill 118 pcf 250 psf 28 °	Harwood 116 pcf 0 psf 26 °	
West Fargo Res 123 pcf 0 psf 25 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °	
Harwood Res 116 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °	Till 122 pcf 0 psf 31 °

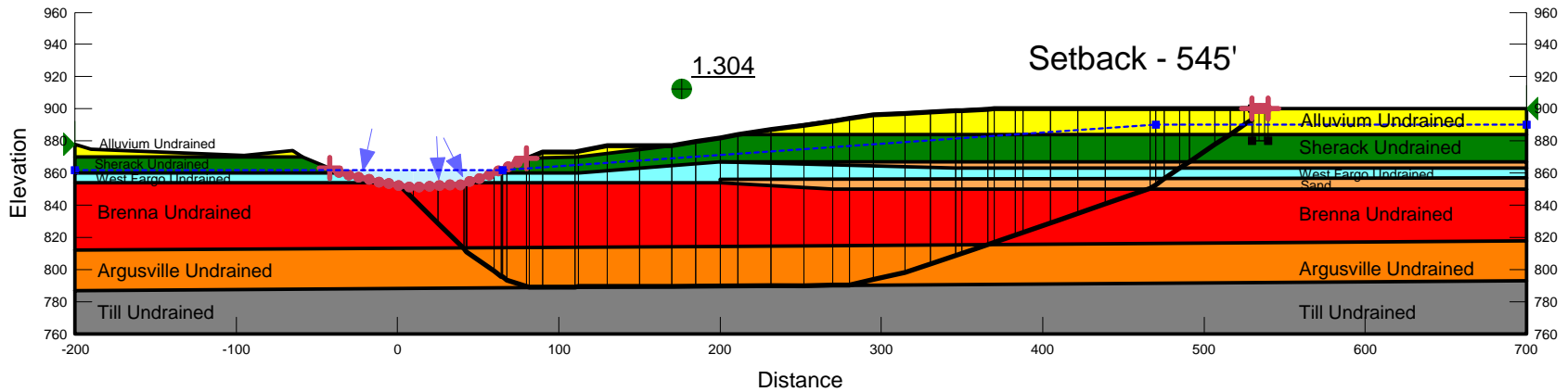


Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 2

Level of Protection: 899 ft

Undrained Strengths

Soil Properties		
Alluvium Undrained 119 pcf 1400 psf	Alluvium Undrained 119 pcf 1400 psf	
Sherack Undrained 118 pcf 1400 psf	Sherack Undrained 118 pcf 1400 psf	Brenna Undrained 103 pcf 650 psf
West Fargo Undrained 123 pcf 1900 psf	Sand 125 pcf 0 psf	Argusville Undrained 106 pcf 825 psf
Brenna Undrained 103 pcf 650 psf	West Fargo Undrained 123 pcf 1900 psf	Till Undrained 122 pcf 1900 psf



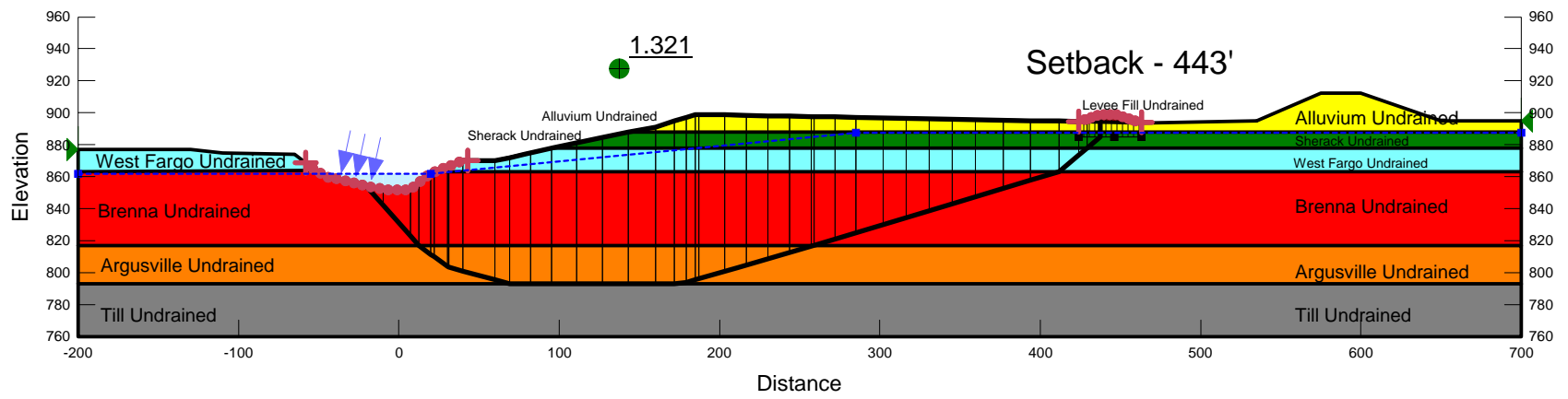
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Date: 12/16/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 3

Level of Protection: 899 ft

Undrained Strengths

Soil Properties		
Alluvium Undrained 119 pcf 1400 psf Sherack Undrained 118 pcf 1400 psf West Fargo Undrained 123 pcf 1900 psf Brenna Undrained 103 pcf 650 psf	Levee Fill Undrained 118 pcf 1400 psf Alluvium Undrained 119 pcf 1400 psf Sherack Undrained 118 pcf 1400 psf West Fargo Undrained 123 pcf 1900 psf	Brenna Undrained 103 pcf 650 psf Argusville Undrained 106 pcf 825 psf Till Undrained 122 pcf 1900 psf

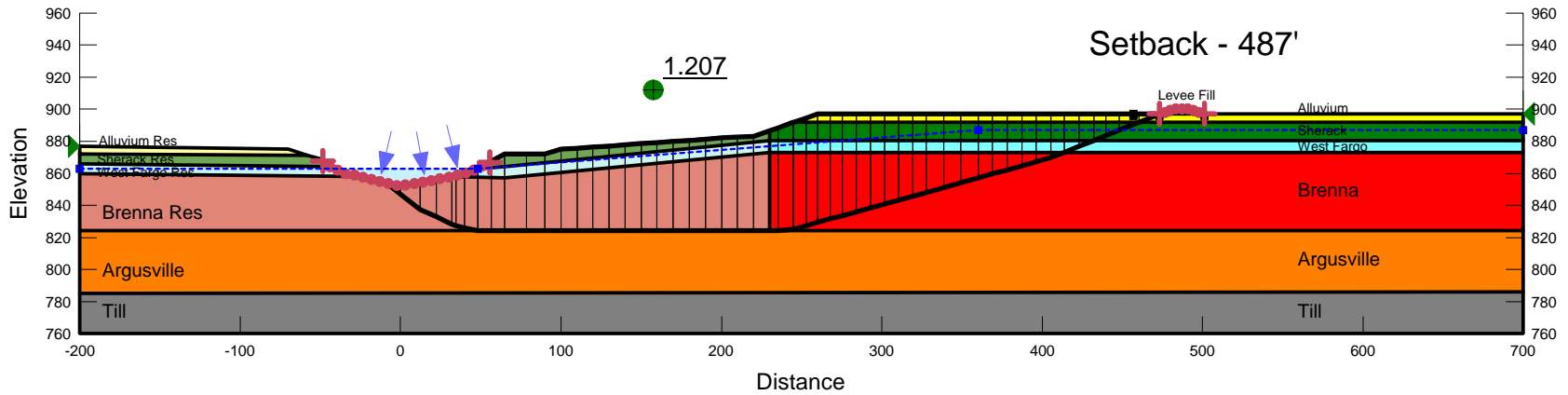


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Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 4

Level of Protection: 900 ft

Soil Properties		
Alluvium Res 119 pcf 0 psf 20 °	Levee Fill 118 pcf 250 psf 28 °	
Sherack Res 118 pcf 0 psf 13 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
West Fargo Res 123 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	Till 122 pcf 0 psf 31 °

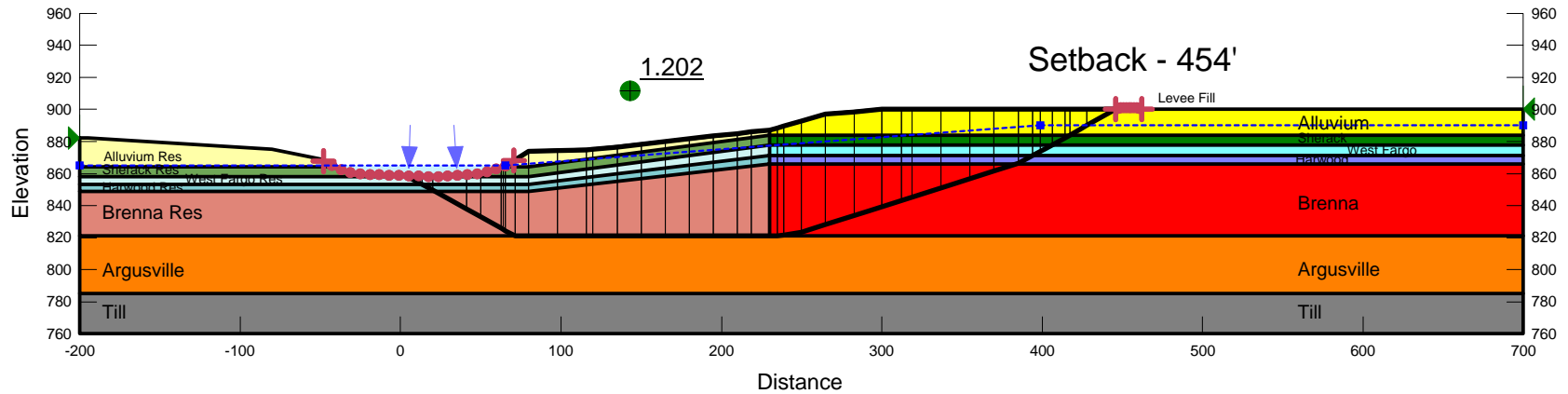


Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 5

Level of Protection: 901 ft

Soil Properties

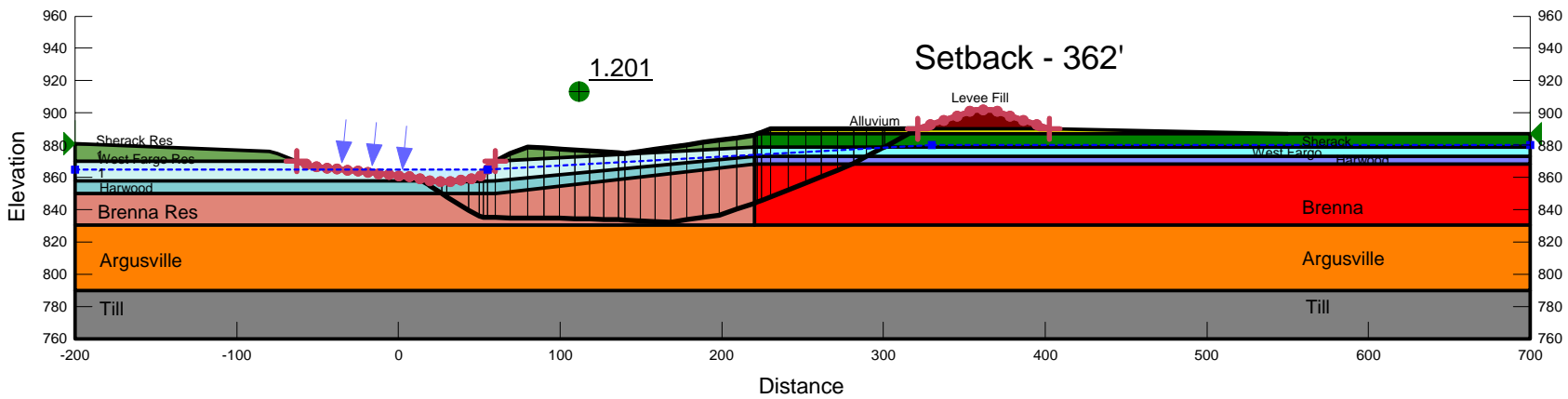
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Sherack Res 118 pcf 0 psf 13 °	Levee Fill 118 pcf 250 psf 28 °	Harwood 116 pcf 0 psf 26 °	
West Fargo Res 123 pcf 0 psf 25 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °	
Harwood Res 116 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °	Till 122 pcf 0 psf 31 °



Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 6

Level of Protection: 902 ft

Soil Properties		
Sherack Res 118 pcf 0 psf 13 °	Levee Fill 118 pcf 250 psf 28 °	Harwood 116 pcf 0 psf 26 °
West Fargo Res 123 pcf 0 psf 25 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
Harwood Res 116 pcf 0 psf 25 °	Sherack 118 pcf 106 pcf 15 °	Argusville 106 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	Till 122 pcf 0 psf 31 °

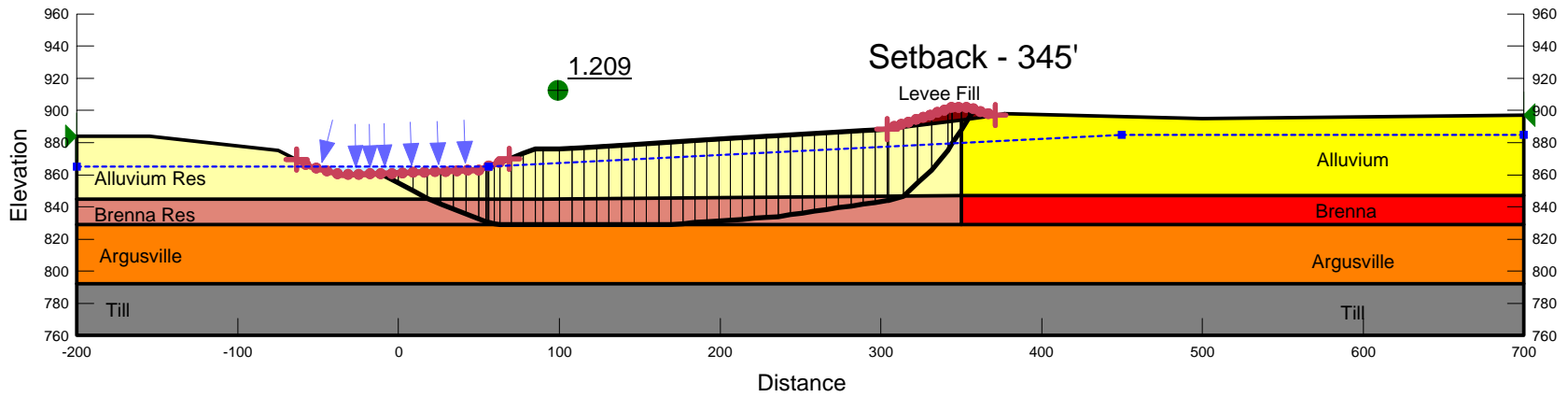


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Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 7

Level of Protection: 902 ft

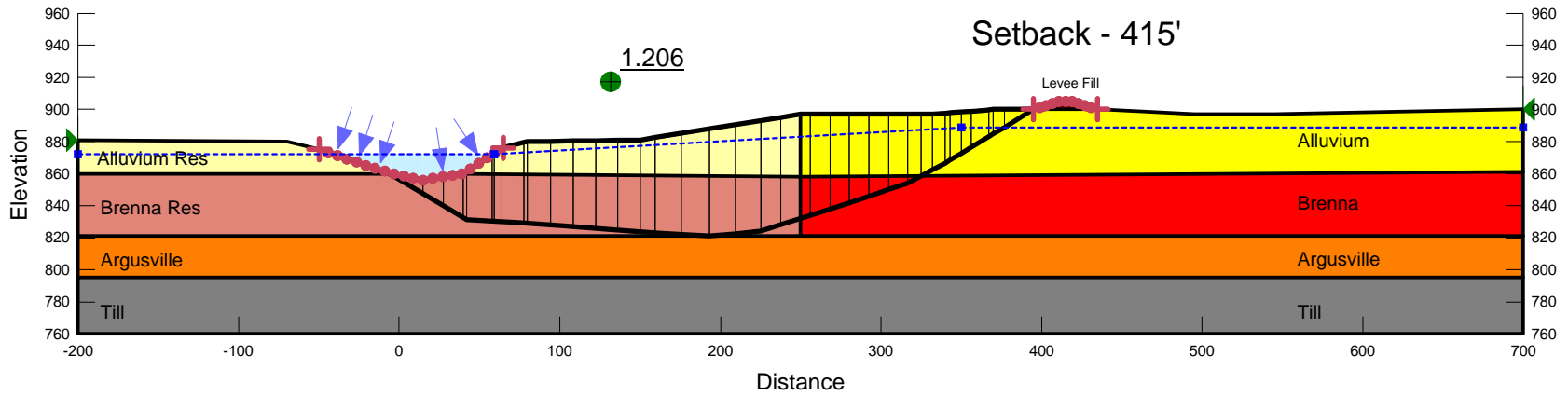
Soil Properties	
Alluvium Res	Brenna
119 pcf	103 pcf
0 psf	0 psf
20 °	13 °
Brenna Res	Argusville
103 pcf	106 pcf
0 psf	0 psf
9 °	15 °
Levee Fill	Till
118 pcf	122 pcf
250 psf	0 psf
28 °	31 °
Alluvium	
119 pcf	
0 psf	
31 °	



Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 8

Level of Protection: 905 ft

Soil Properties		
Alluvium Res	Alluvium	
119 pcf	119 pcf	
0 psf	0 psf	
20 °	31 °	
Brenna Res	Brenna	
103 pcf	103 pcf	
0 psf	0 psf	
9 °	13 °	
Levee Fill	Argusville	Till
118 pcf	106 pcf	122 pcf
250 psf	0 psf	0 psf
28 °	15 °	31 °

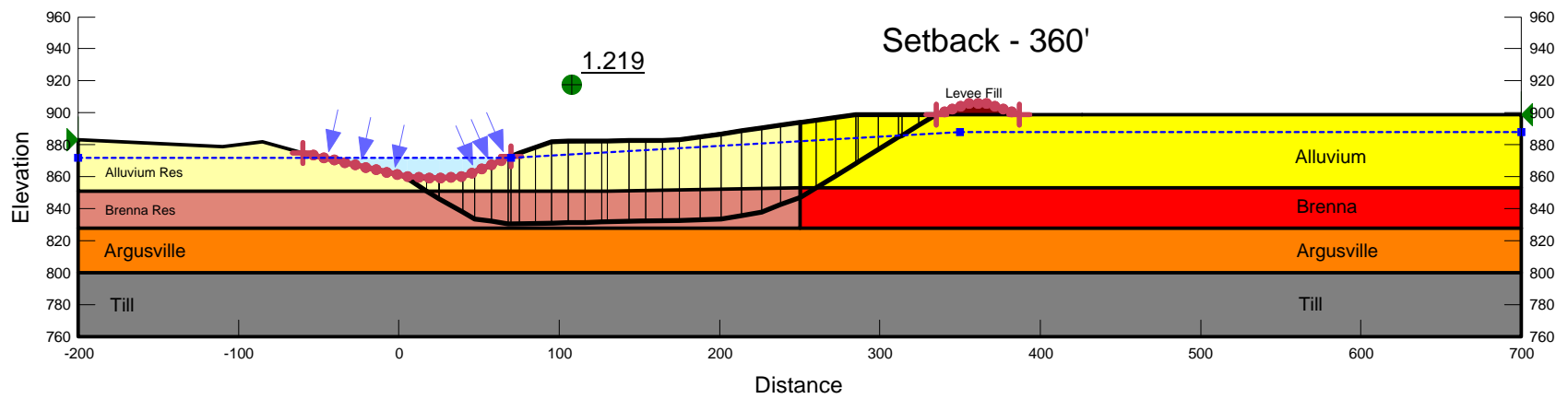


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Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 9

Level of Protection: 906 ft

Soil Properties	
Alluvium Res	
119 pcf	
0 psf	
20 °	
Brenna Res	Brenna
103 pcf	103 pcf
0 psf	0 psf
9 °	13 °
Alluvium	Argusville
119 pcf	106 pcf
0 psf	0 psf
31 °	15 °
Levee Fill	Till
118 pcf	122 pcf
250 psf	0 psf
28 °	31 °

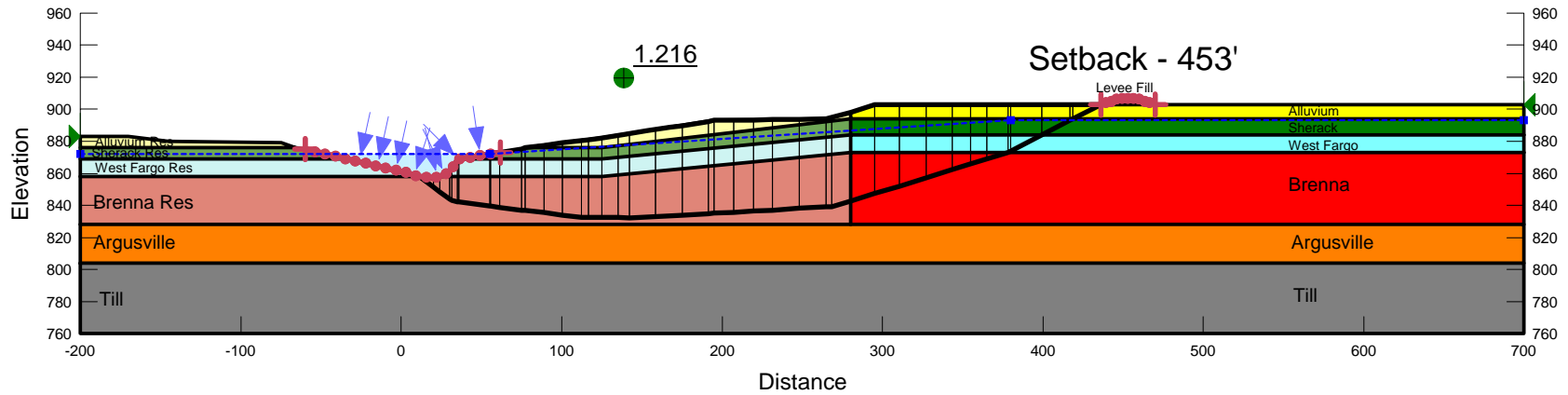


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Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 10

Level of Protection: 907 ft

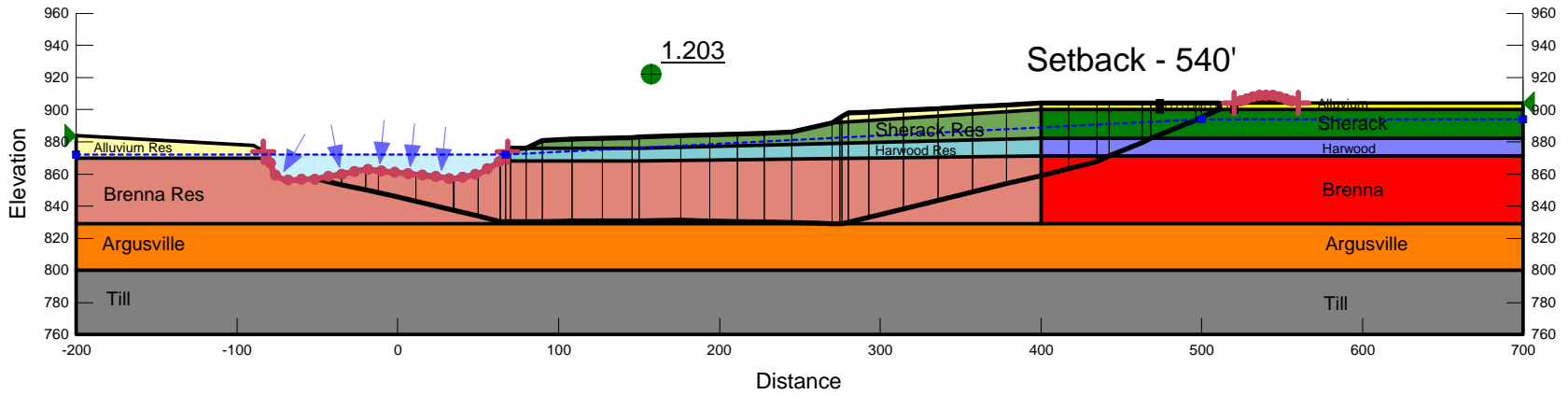
Soil Properties		
Alluvium Res 119 pcf 0 psf 20 ° Sherack Res 118 pcf 0 psf 13 ° West Fargo Res 123 pcf 0 psf 25 ° Brenna Res 103 pcf 0 psf 9 °	Levee Fill 118 pcf 250 psf 28 ° Alluvium 119 pcf 0 psf 31 ° Sherack 118 pcf 0 psf 28 ° West Fargo Res 123 pcf 0 psf 25 °	Brenna 103 pcf 0 psf 13 ° Argusville 106 pcf 0 psf 15 ° Till 122 pcf 0 psf 31 °



Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 11

Level of Protection: 909 ft

Soil Properties		
Alluvium Res 119 pcf 0 psf 20 °	Levee Fill 118 pcf 250 psf 28 °	
Brenna Res 103 pcf 0 psf 9 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
Sherack Res 118 pcf 0 psf 13 °	Sherack 118 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °
Harwood Res 116 pcf 0 psf 25 °	Harwood 116 pcf 0 psf 26 °	Till 122 pcf 0 psf 31 °

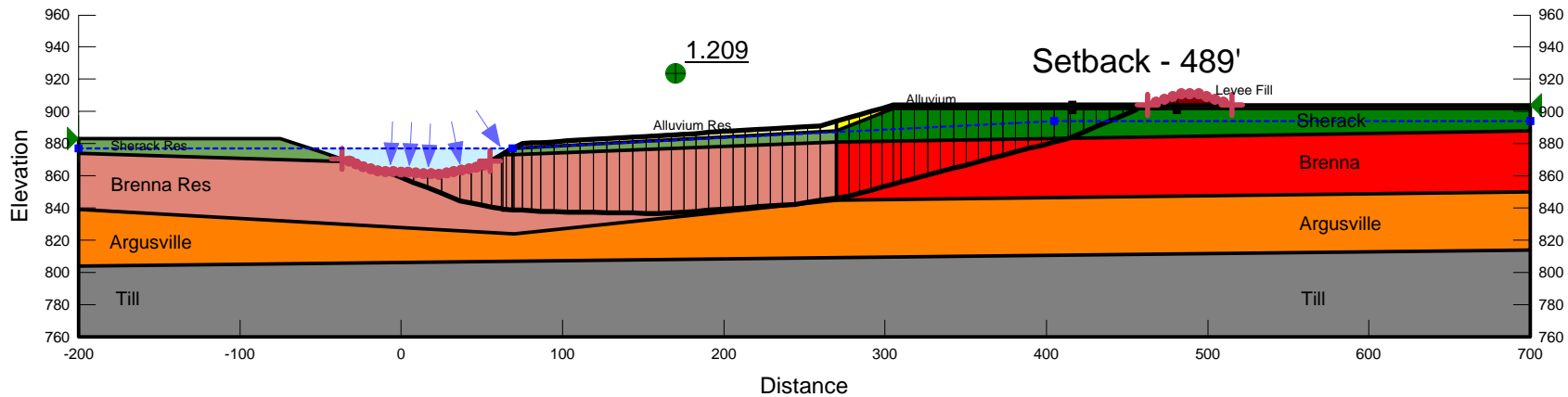


Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 12

Level of Protection: 911 ft

Soil Properties

Alluvium Res 119 pcf 0 psf 20 °	Levee Fill 118 pcf 250 psf 28 °	Brenna 103 pcf 0 psf 13 °
Sherack Res 118 pcf 0 psf 13 °	Alluvium 119 pcf 0 psf 31 °	Argusville 106 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	Sherack 118 pcf 0 psf 28 °	Till 122 pcf 0 psf 31 °

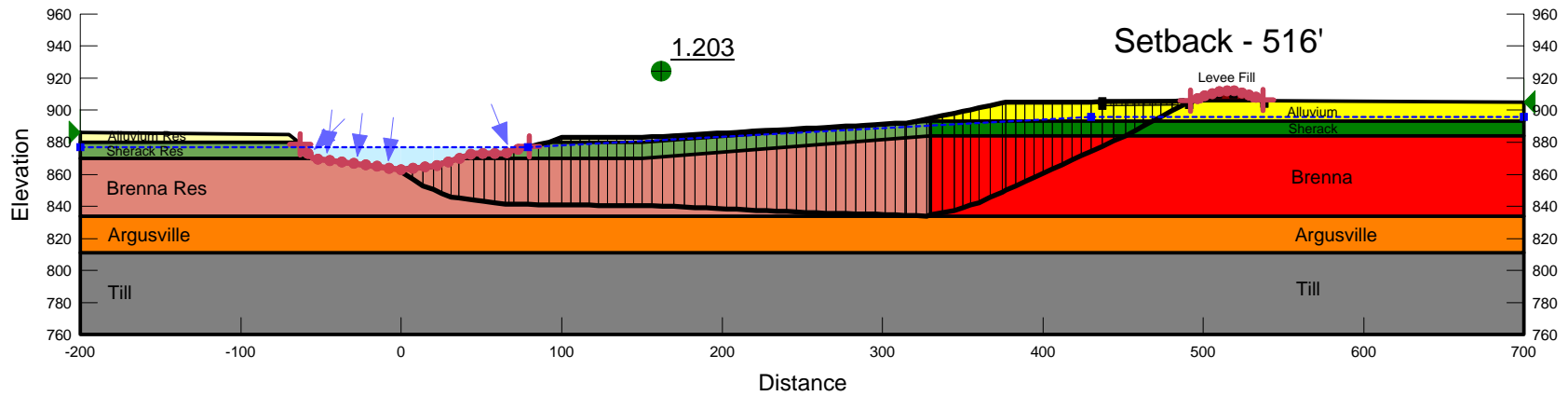


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Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 13

Level of Protection: 912 ft

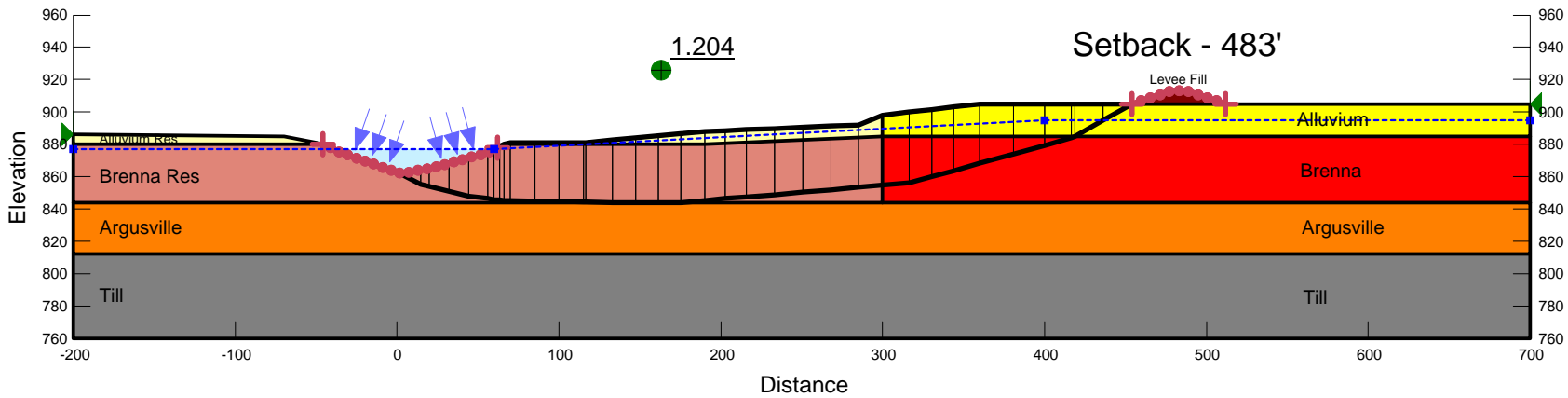
Soil Properties		
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Sherack Res 118 pcf 0 psf 13 °	Sherack 118 pcf 0 psf 28 °	
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °	
Levee Fill 118 pcf 250 psf 28 °	Argusville 106 pcf 0 psf 15 °	Till 122 pcf 0 psf 31 °



Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 14

Level of Protection: 913 ft

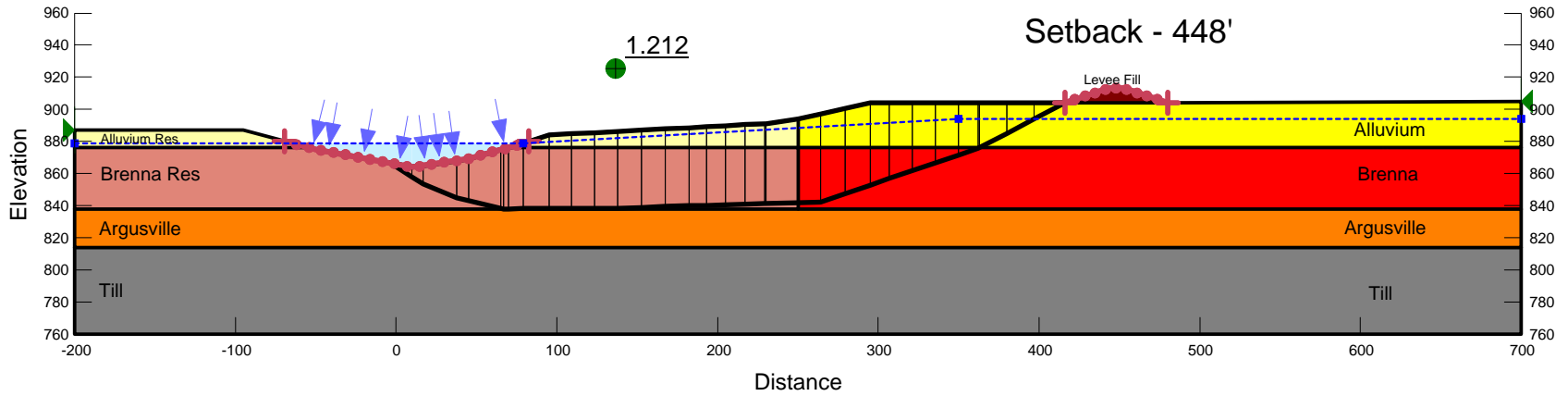
Soil Properties	
Alluvium Res	
119 pcf	
0 psf	
20 °	
Brenna Res	Brenna
103 pcf	103 pcf
0 psf	0 psf
9 °	13 °
Levee Fill	Argusville
118 pcf	106 pcf
250 psf	0 psf
28 °	15 °
Alluvium	Till
119 pcf	122 pcf
0 psf	0 psf
31 °	31 °



Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 15

Level of Protection: 913 ft

Soil Properties	
Alluvium Res 119 pcf 0 psf 20 °	
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °
Levee Fill 118 pcf 250 psf 28 °	Argusville 106 pcf 0 psf 15 °
Alluvium 119 pcf 0 psf 31 °	Till 122 pcf 0 psf 31 °

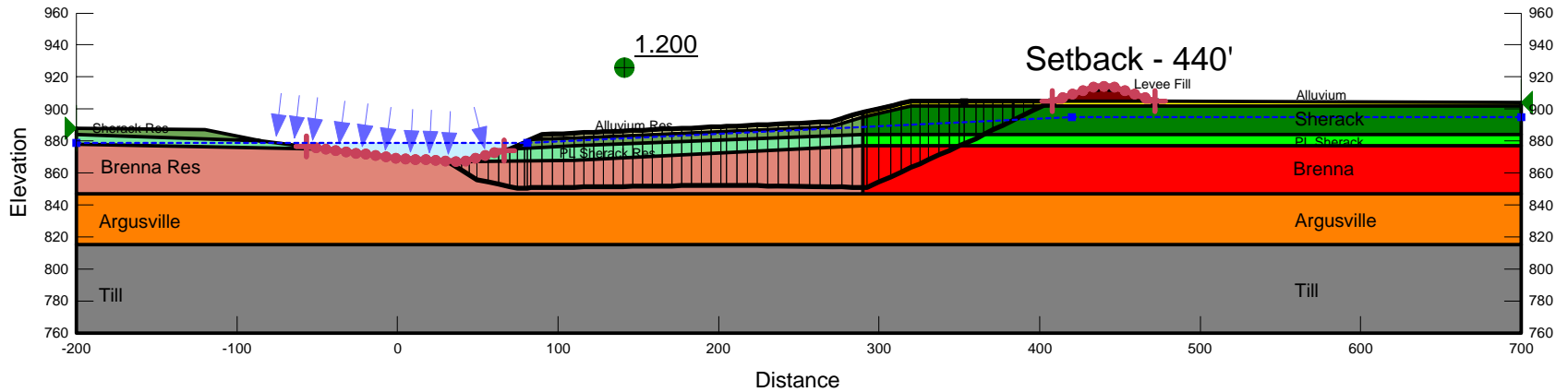


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Date: 12/14/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 16

Level of Protection: 914 ft

Soil Properties		
Alluvium Res 119 pcf 0 psf 20 °	Levee Fill 118 pcf 250 psf 28 °	
Sherack Res 118 pcf 0 psf 13 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
PL Sherack Res 112 pcf 0 psf 7 °	Sherack 118 pcf 28 °	Argusville 106 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	PL Sherack 112 pcf 0 psf 19 °	Till 122 pcf 0 psf 31 °

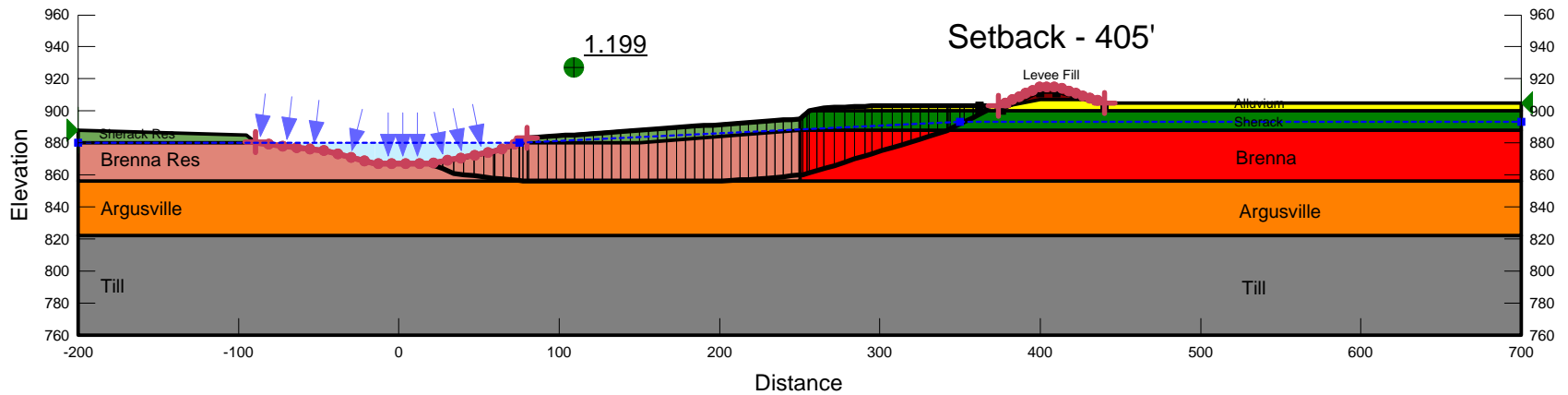


Created By: Schmidt, Luke L MVP
Last Edited By: Foss, Jason MVP
Date: 12/18/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 17

Level of Protection: 915 ft

Soil Properties	
Sherack Res 118 pcf 0 psf 13 °	Sherack 118 pcf 0 psf 28 °
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °
Levee Fill 118 pcf 250 psf 28 °	Argusville 106 pcf 0 psf 15 °
Alluvium 119 pcf 0 psf 31 °	Till 122 pcf 0 psf 31 °

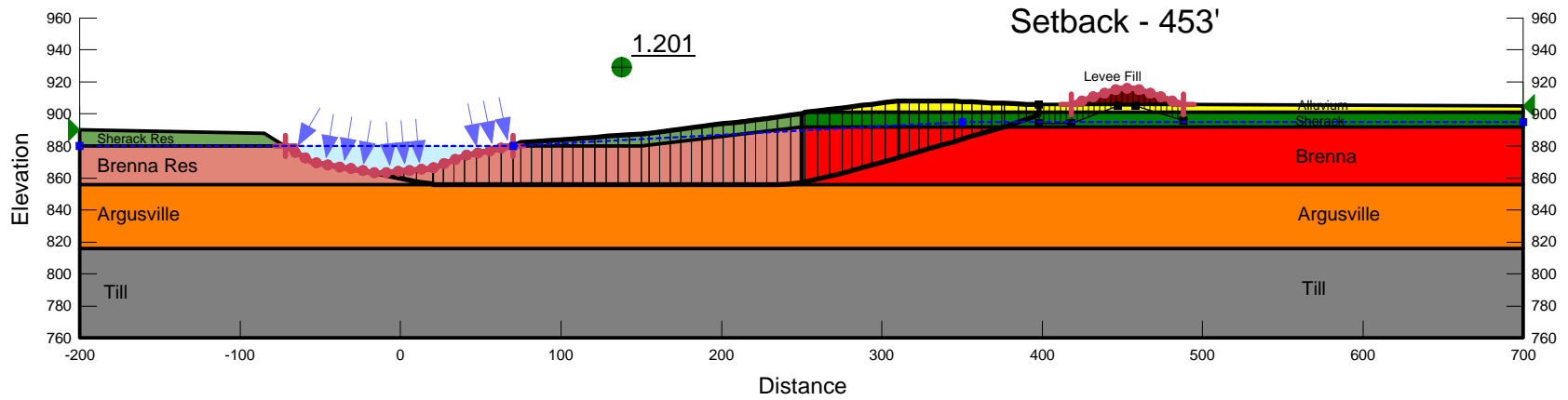


Created By: Schmidt, Luke L MVP
Last Edited By: Price, Ryan W MVP
Date: 12/18/2009

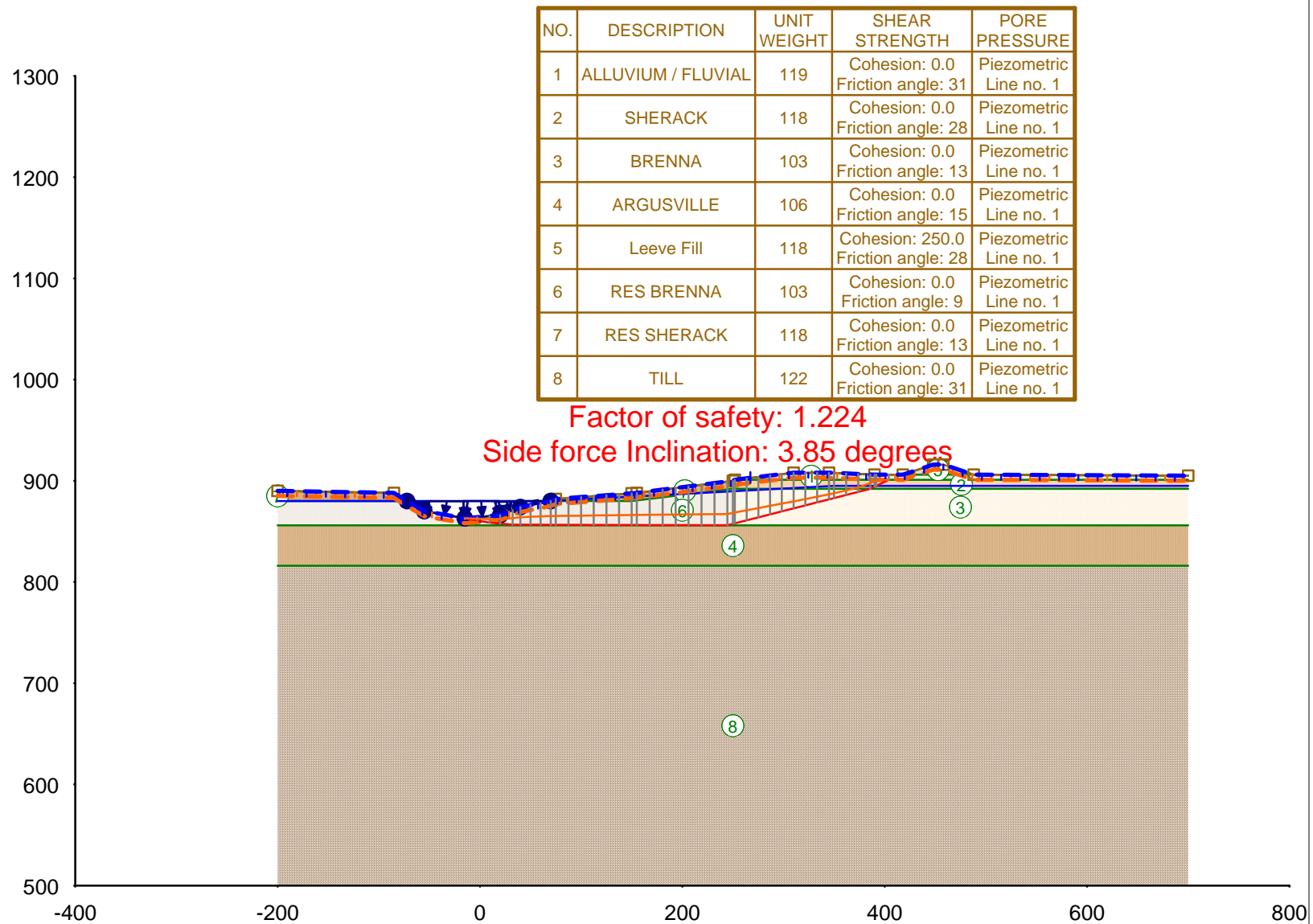
Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 18

Level of Protection: 916 ft

Soil Properties	
Sherack Res	Sherack
118 pcf	118 pcf
0 psf	0 psf
13 °	28 °
Brenna Res	Brenna
103 pcf	103 pcf
0 psf	0 psf
9 °	13 °
Levee Fill	Argusville
118 pcf	106 pcf
250 psf	0 psf
28 °	15 °
Alluvium	Till
119 pcf	122 pcf
0 psf	0 psf
31 °	31 °



FARGO-MOORHEAD METRO FEASIBILITY STUDY, PHASE 2

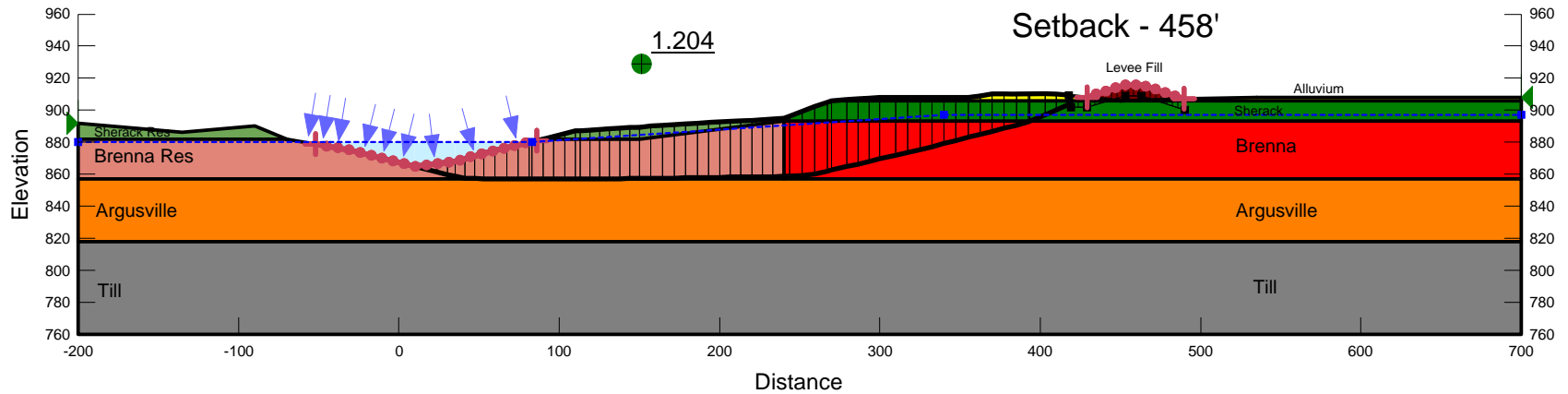


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Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 19

Level of Protection: 916 ft

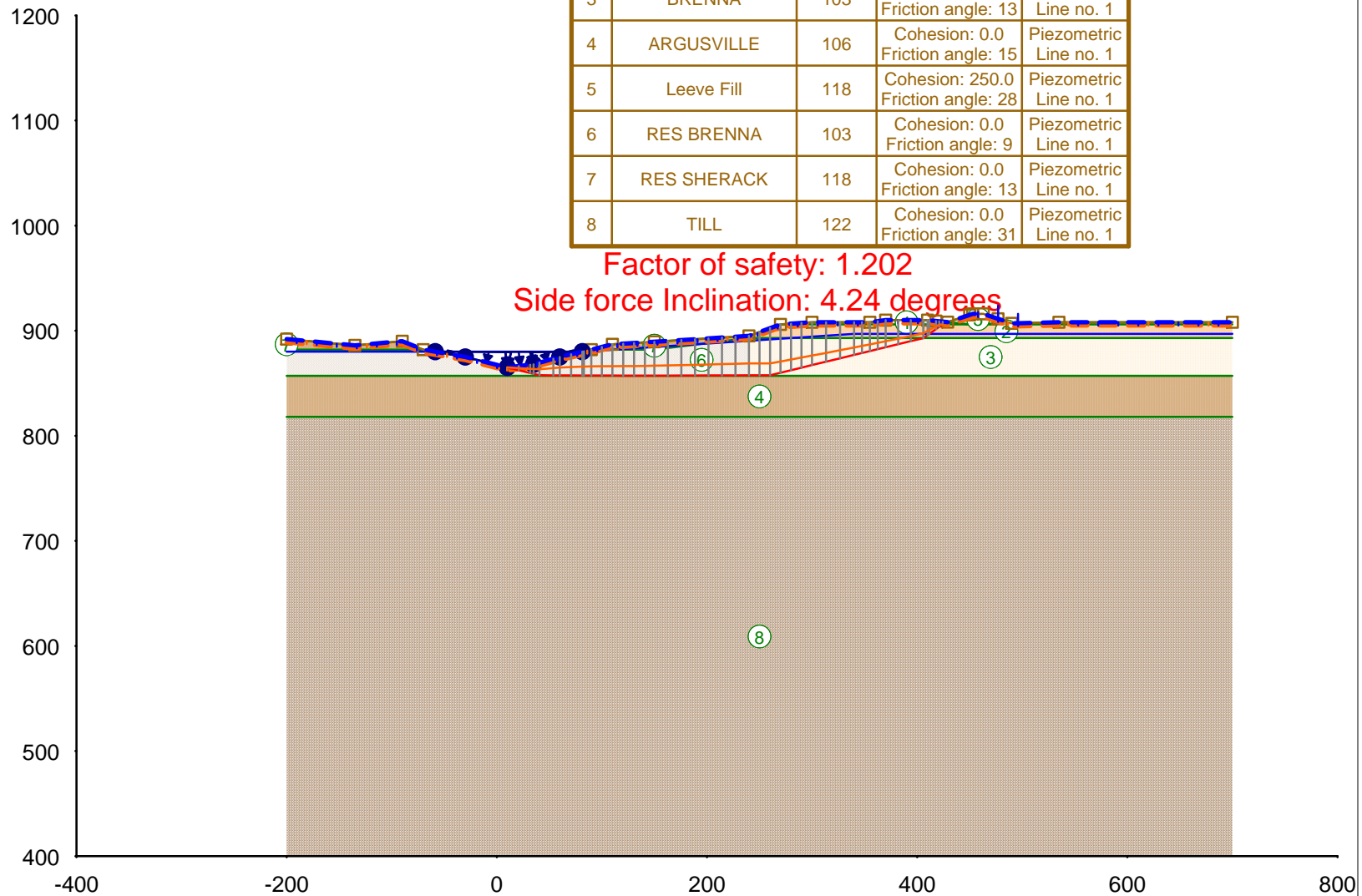
Soil Properties	
Sherack Res 118 pcf 0 psf 13 °	Sherack 118 pcf 0 psf 28 °
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °
Levee Fill 118 pcf 250 psf 28 °	Argusville 106 pcf 0 psf 15 °
Alluvium 119 pcf 0 psf 31 °	Till 122 pcf 0 psf 31 °



Created By: Schmidt, Luke L MVP
Last Edited By: Price, Ryan W MVP
Date: 12/16/2009

FARGO-MOORHEAD METRO FEASIBILITY STUDY, PHASE 2

2	SHERACK	118	Cohesion: 0.0 Friction angle: 28	Piezometric Line no. 1
3	BRENNA	103	Cohesion: 0.0 Friction angle: 13	Piezometric Line no. 1
4	ARGUSVILLE	106	Cohesion: 0.0 Friction angle: 15	Piezometric Line no. 1
5	Leeve Fill	118	Cohesion: 250.0 Friction angle: 28	Piezometric Line no. 1
6	RES BRENNA	103	Cohesion: 0.0 Friction angle: 9	Piezometric Line no. 1
7	RES SHERACK	118	Cohesion: 0.0 Friction angle: 13	Piezometric Line no. 1
8	TILL	122	Cohesion: 0.0 Friction angle: 31	Piezometric Line no. 1

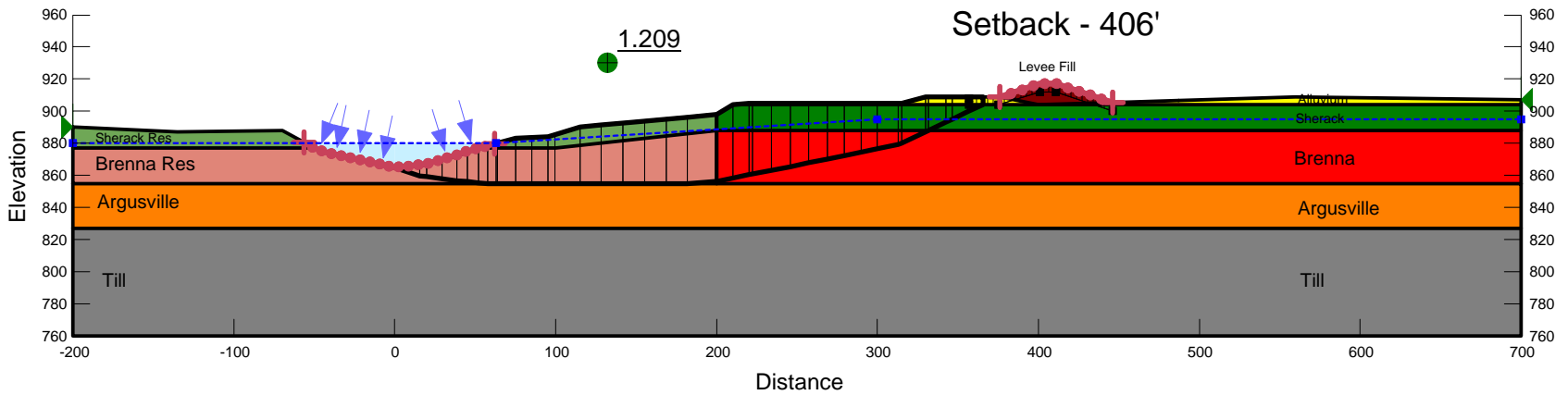


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Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Fargo Section 20

Level of Protection: 917 ft

Soil Properties	
Sherack Res 118 pcf 0 psf 13 °	Sherack 118 pcf 0 psf 28 °
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °
Levee Fill 118 pcf 250 psf 28 °	Argusville 106 pcf 0 psf 15 °
Alluvium 119 pcf 0 psf 31 °	Till 122 pcf 0 psf 31 °

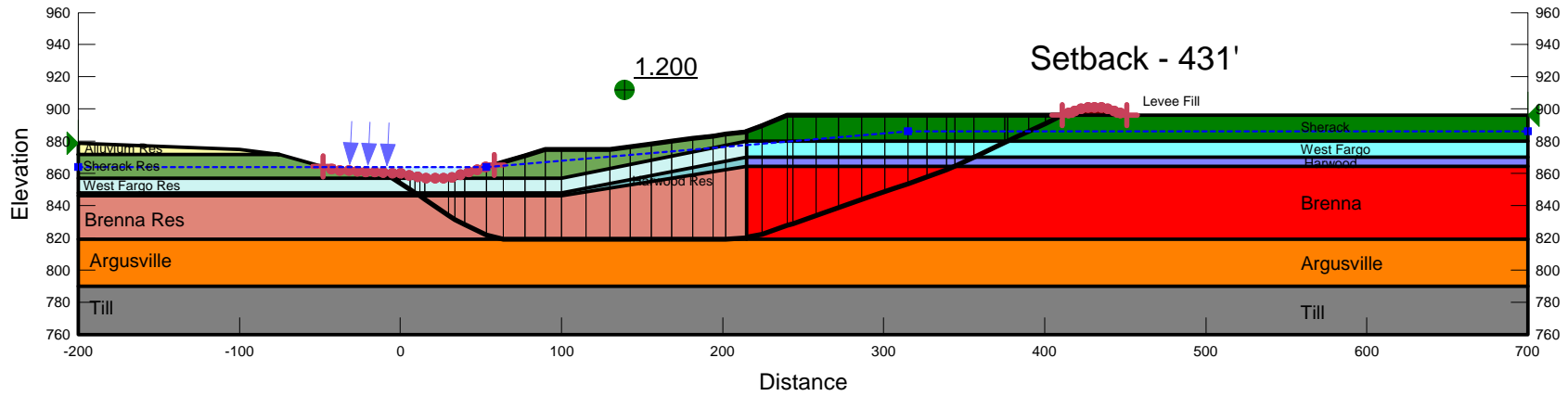


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Last Edited By: Price, Ryan W MVP
Date: 12/16/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 1

Level of Protection: 901 ft

Soil Properties		
Alluvium Res	Brenna Res	Harwood
119 pcf	103 pcf	116 pcf
0 psf	0 psf	0 psf
20 °	9 °	26 °
Sherack Res	Levee Fill	Brenna
118 pcf	118 pcf	103 pcf
0 psf	250 psf	0 psf
13 °	28 °	13 °
West Fargo Res	Sherack	Argusville
123 pcf	118 pcf	106 pcf
0 psf	0 psf	0 psf
25 °	28 °	15 °
Harwood Res	West Fargo	Till
116 pcf	123 pcf	122 pcf
0 psf	0 psf	0 psf
25 °	34 °	31 °

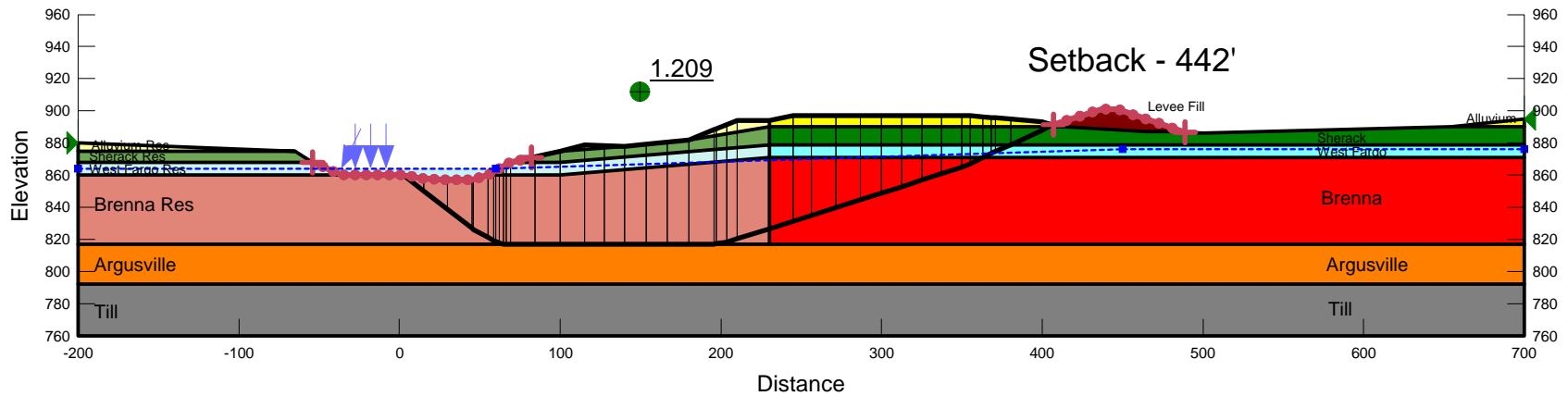


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Last Edited By: Foss, Jason MVP
Date: 12/15/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 2

Level of Protection: 901 ft

Soil Properties		
Alluvium Res 119 pcf 0 psf 20 °	Levee Fill 118 pcf 250 psf 28 °	Brenna 103 pcf 0 psf 13 °
Sherack Res 118 pcf 0 psf 13 °	Alluvium 119 pcf 0 psf 31 °	Argusville 106 pcf 0 psf 15 °
West Fargo Res 123 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	Till 122 pcf 0 psf 31 °
Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	

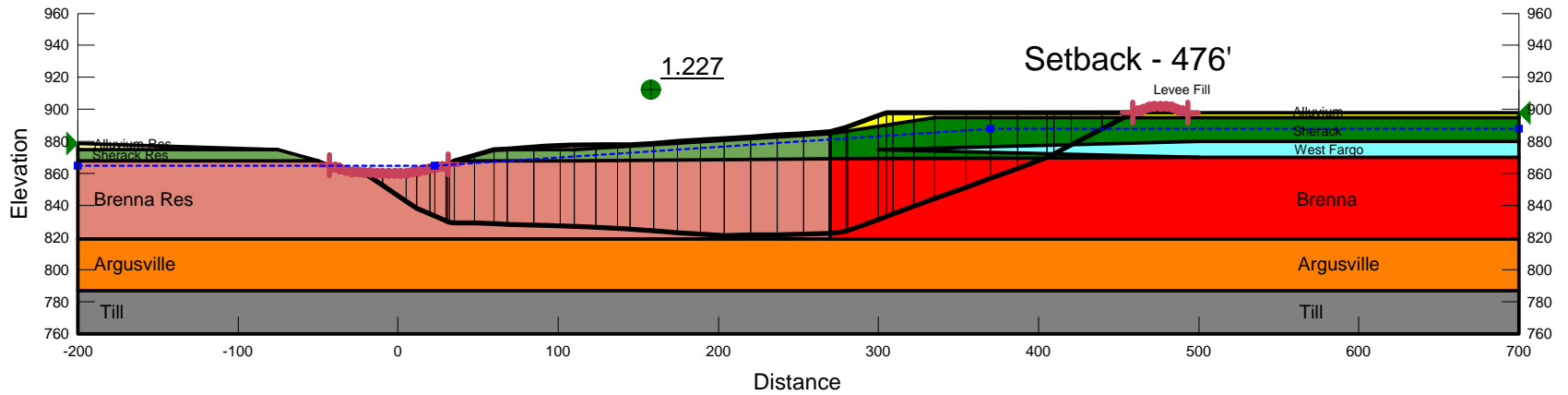


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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 3

Level of Protection: 902 ft

Soil Properties		
Alluvium Res 119 pcf 0 psf 20 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
Sherack Res 118 pcf 0 psf 13 °	Sherack 118 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	Till 122 pcf 0 psf 31 °
Levee Fill 118 pcf 250 psf 28 °		

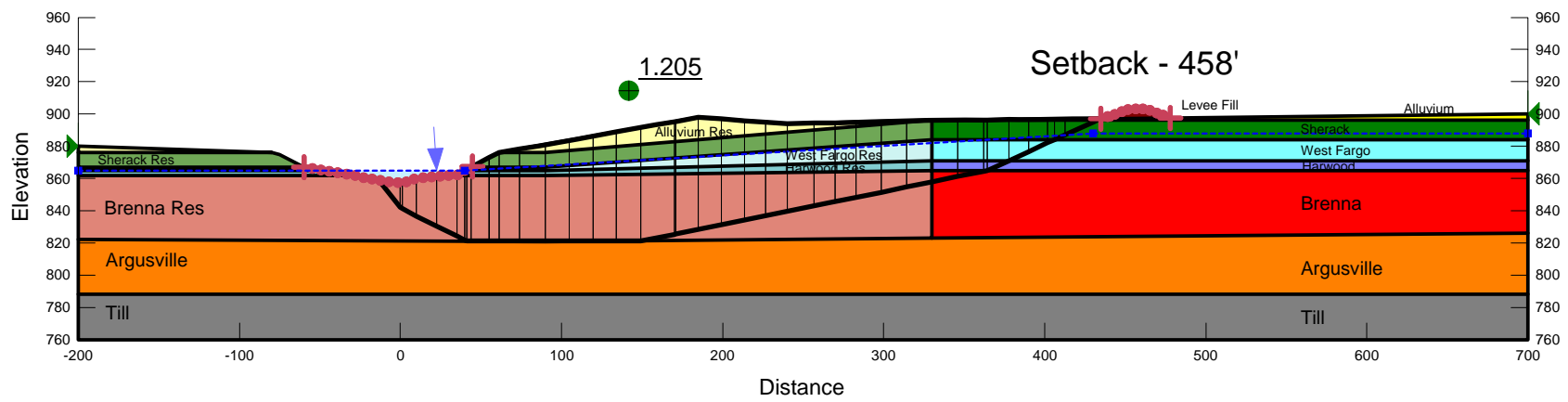


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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 4

Level of Protection: 903 ft

Soil Properties				
Alluvium Res	Brenna Res	West Fargo		
119 pcf	103 pcf	123 pcf		
0 psf	0 psf	0 psf		
20 °	9 °	34 °		
Sherack Res	Levee Fill	Harwood		
118 pcf	250 psf	116 pcf		
0 psf	28 °	0 psf		
13 °	Alluvium	Brenna		
West Fargo Res	119 pcf	103 pcf		
123 pcf	0 psf	0 psf		
0 psf	31 °	13 °		
25 °	Sherack	Argusville		
Harwood Res	118 pcf	106 pcf		Till
116 pcf	0 psf	0 psf		122 pcf
0 psf	28 °	15 °		0 psf
25 °				31 °

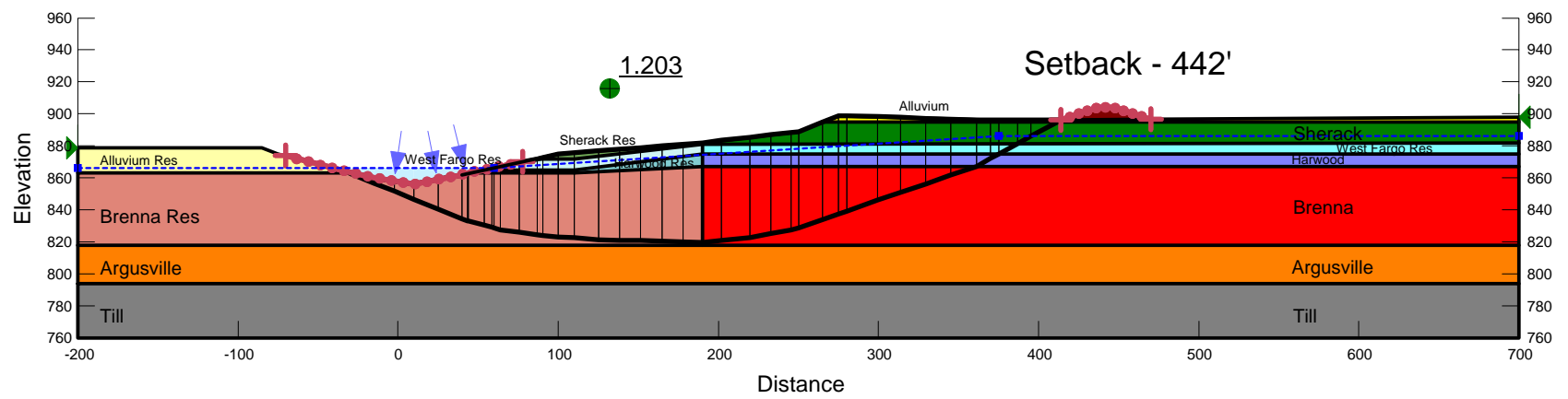


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Last Edited By: Foss, Jason MVP
Date: 12/14/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 5

Level of Protection: 901 ft

Soil Properties		
Alluvium Res	Brenna Res	Harwood
119 pcf	103 pcf	116 pcf
0 psf	0 psf	0 psf
20 °	9 °	26 °
Sherack Res	Levee Fill	Brenna
118 pcf	118 pcf	103 pcf
0 psf	250 psf	0 psf
13 °	28 °	13 °
West Fargo Res	Sherack	Argusville
123 pcf	118 pcf	106 pcf
0 psf	0 psf	0 psf
25 °	28 °	15 °
Harwood Res	West Fargo	Till
116 pcf	123 pcf	122 pcf
0 psf	0 psf	0 psf
25 °	34 °	31 °

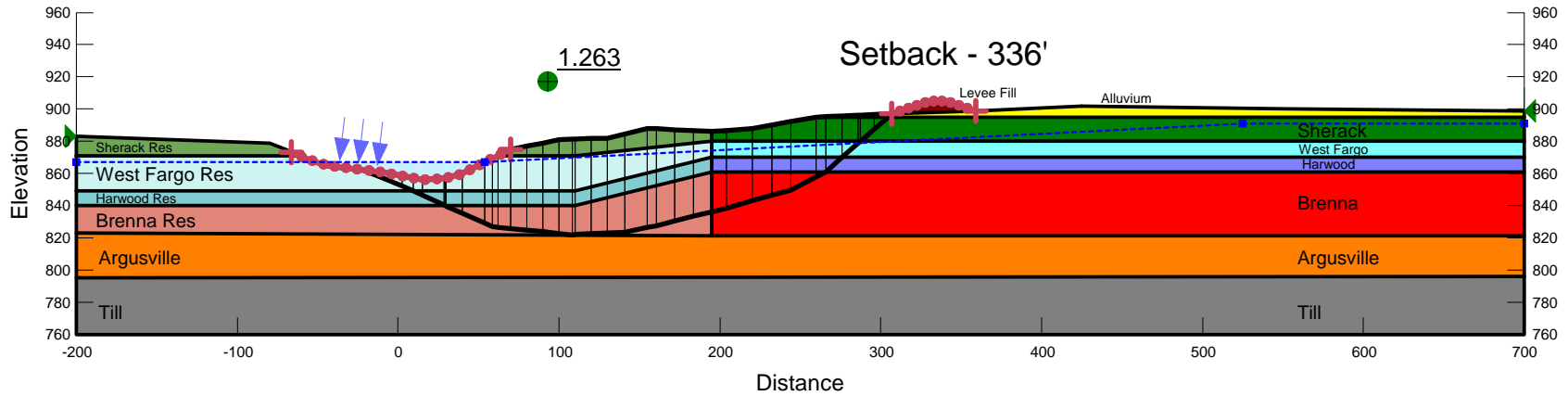


Created By: Schmidt, Luke L MVP
Last Edited By: Price, Ryan W MVP
Date: 12/9/2009

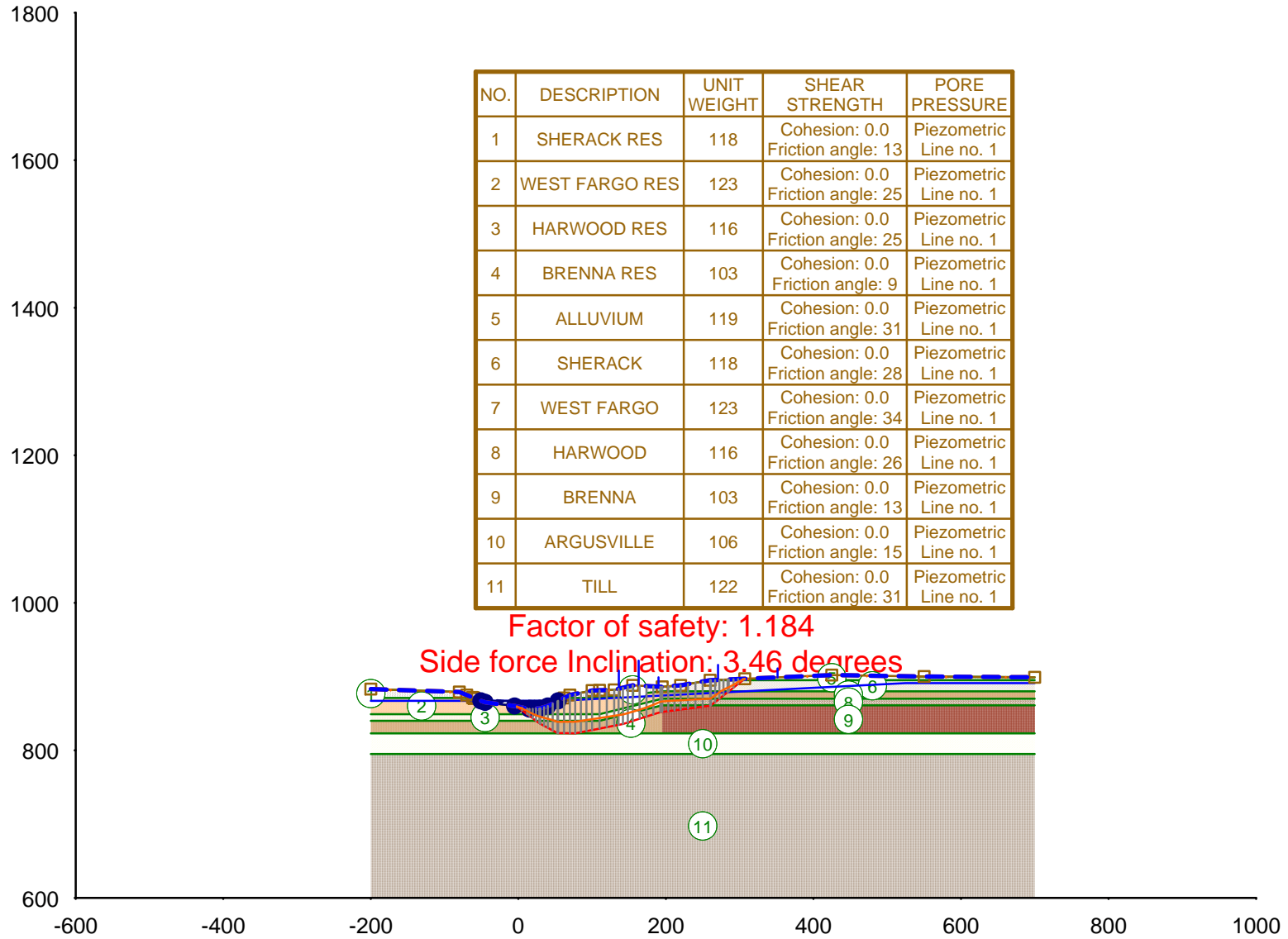
Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 6

Level of Protection: 905 ft

Soil Properties		
Sherack Res 118 pcf 0 psf 13 °	Levee Fill 118 pcf 250 psf 28 °	Harwood 116 pcf 0 psf 26 °
West Fargo Res 123 pcf 0 psf 25 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
Harwood Res 116 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	Till 122 pcf 0 psf 31 °



FARGO-MOORHEAD METRO FEASIBILITY STUDY, PHASE 2

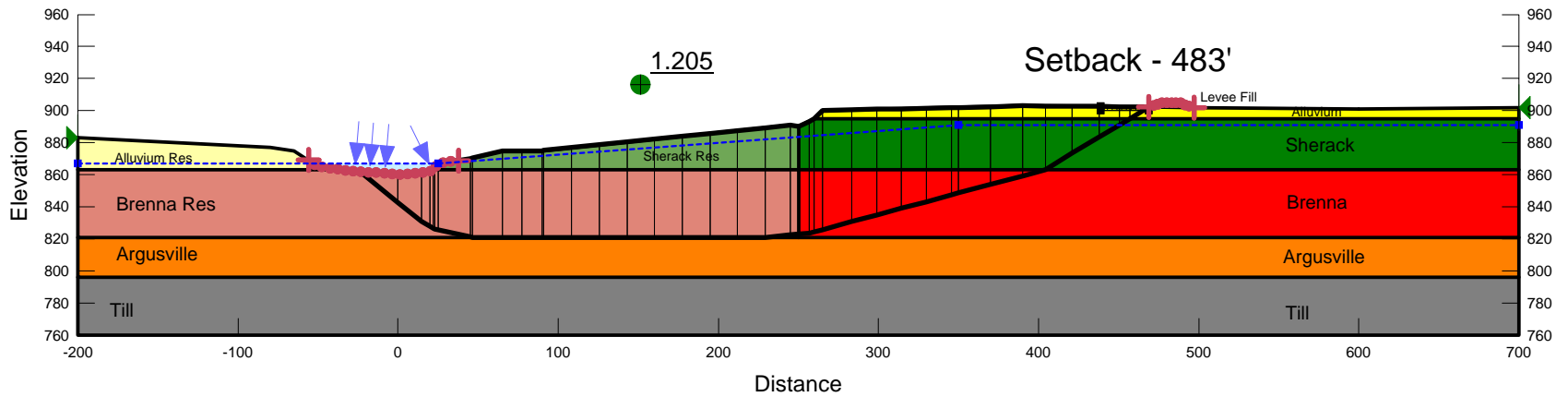


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Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 7

Level of Protection: 905 ft

Soil Properties		
Alluvium Res	Levee Fill	Brenna
119 pcf	118 pcf	103 pcf
0 psf	250 psf	0 psf
20 °	28 °	13 °
Sherack Res	Alluvium	Argusville
118 pcf	119 pcf	106 pcf
0 psf	0 psf	0 psf
13 °	31 °	15 °
Brenna Res	Sherack	Till
103 pcf	118 pcf	122 pcf
0 psf	0 psf	0 psf
9 °	28 °	31 °

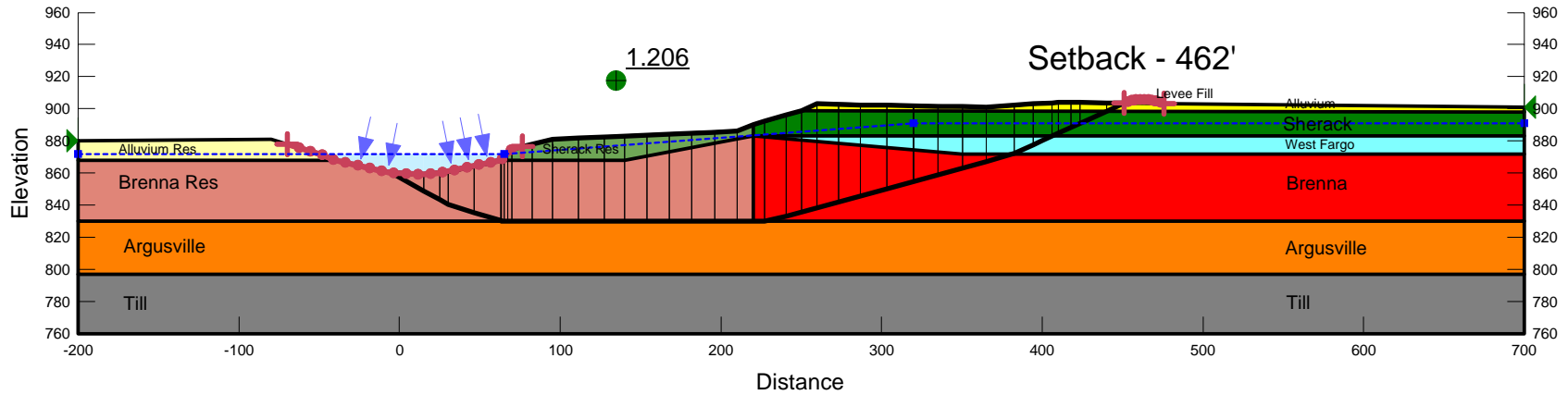


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Date: 12/16/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 8

Level of Protection: 906 ft

Soil Properties		
Alluvium Res 119 pcf 0 psf 20 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
Sherack Res 118 pcf 0 psf 13 °	Sherack 118 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °
Brenna Res 103 pcf 0 psf 9 °	West Fargo 123 pcf 0 psf 34 °	Till 122 pcf 0 psf 31 °
Levee Fill 118 pcf 250 psf 28 °		

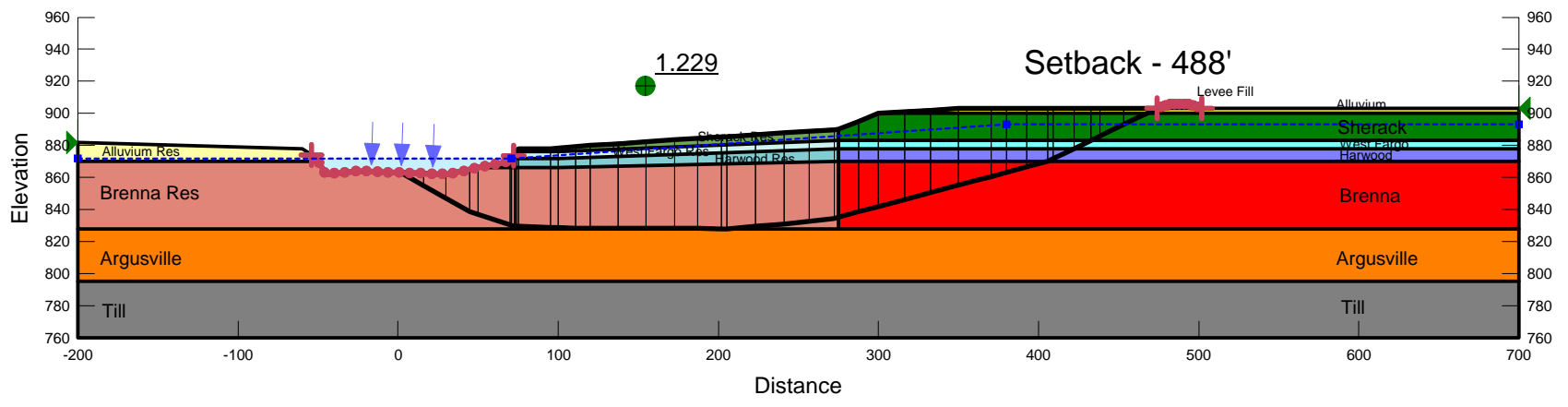


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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 9

Level of Protection: 906 ft

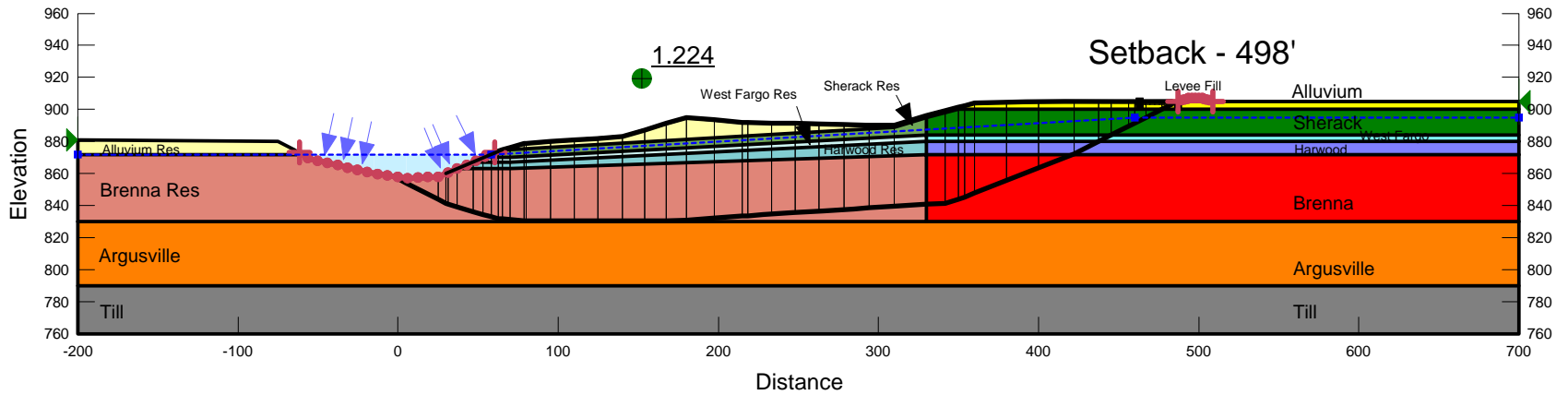
Soil Properties			
Alluvium Res 119 pcf 0 psf 20 ° Sherack Res 118 pcf 0 psf 13 ° West Fargo Res 123 pcf 0 psf 25 ° Harwood Res 116 pcf 0 psf 25 °	Brenna Res 103 pcf 0 psf 9 ° Levee Fill 250 psf 28 ° Alluvium 119 pcf 0 psf 31 ° Sherack 118 pcf 0 psf 28 °	West Fargo 123 pcf 0 psf 34 ° Harwood 116 pcf 0 psf 26 ° Brenna 103 pcf 0 psf 13 ° Argusville 106 pcf 0 psf 15 °	Till 122 pcf 0 psf 31 °



Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 10

Level of Protection: 907 ft

Soil Properties			
Alluvium Res 119 pcf 0 psf 20 ° Sherack Res 118 pcf 0 psf 13 ° West Fargo Res 123 pcf 0 psf 25 ° Harwood Res 116 pcf 0 psf 25 °	Brenna Res 103 pcf 0 psf 9 ° Levee Fill 118 pcf 250 psf 28 ° Alluvium 119 pcf 0 psf 31 ° Sherack 118 pcf 0 psf 28 °	West Fargo 123 pcf 0 psf 34 ° Harwood 116 pcf 0 psf 26 ° Brenna 103 pcf 0 psf 13 ° Argusville 106 pcf 0 psf 15 °	Till 122 pcf 0 psf 31 °

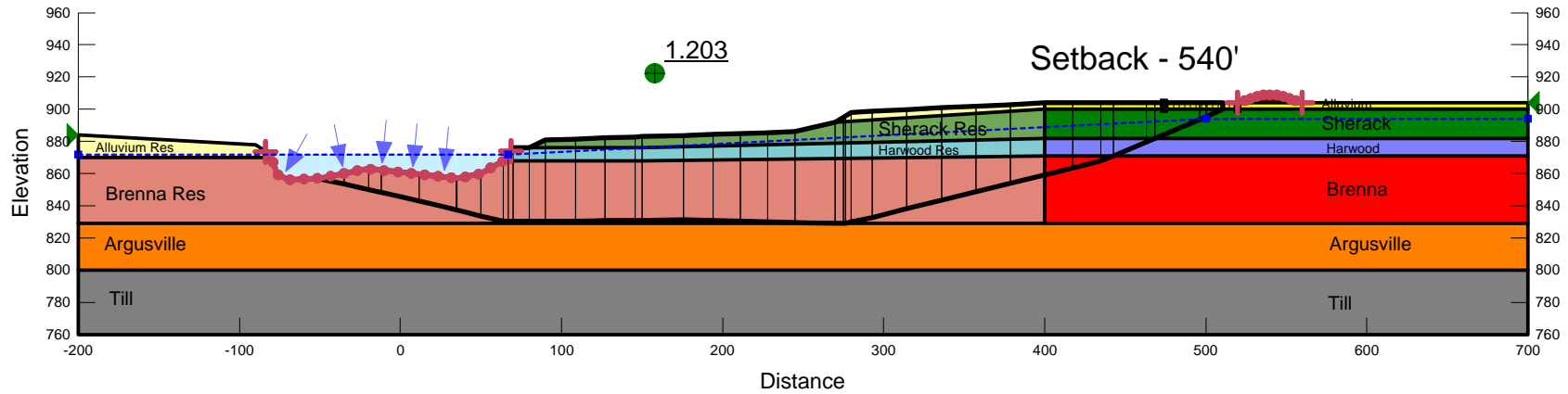


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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 11

Level of Protection: 909 ft

Soil Properties		
Alluvium Res 119 pcf 0 psf 20 °	Alluvium 119 pcf 0 psf 31 °	Brenna 103 pcf 0 psf 13 °
Brenna Res 103 pcf 0 psf 9 °	Sherack 118 pcf 0 psf 28 °	Argusville 106 pcf 0 psf 15 °
Sherack Res 118 pcf 0 psf 13 °	Harwood 116 pcf 0 psf 26 °	Till 122 pcf 0 psf 31 °
Harwood Res 116 pcf 0 psf 25 °		

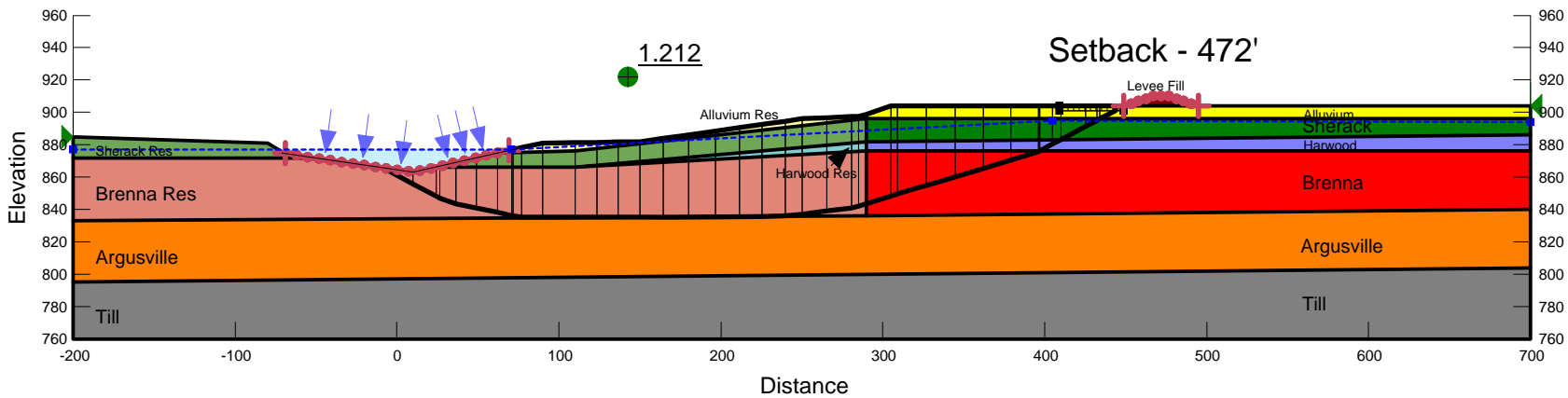


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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 12

Level of Protection: 910 ft

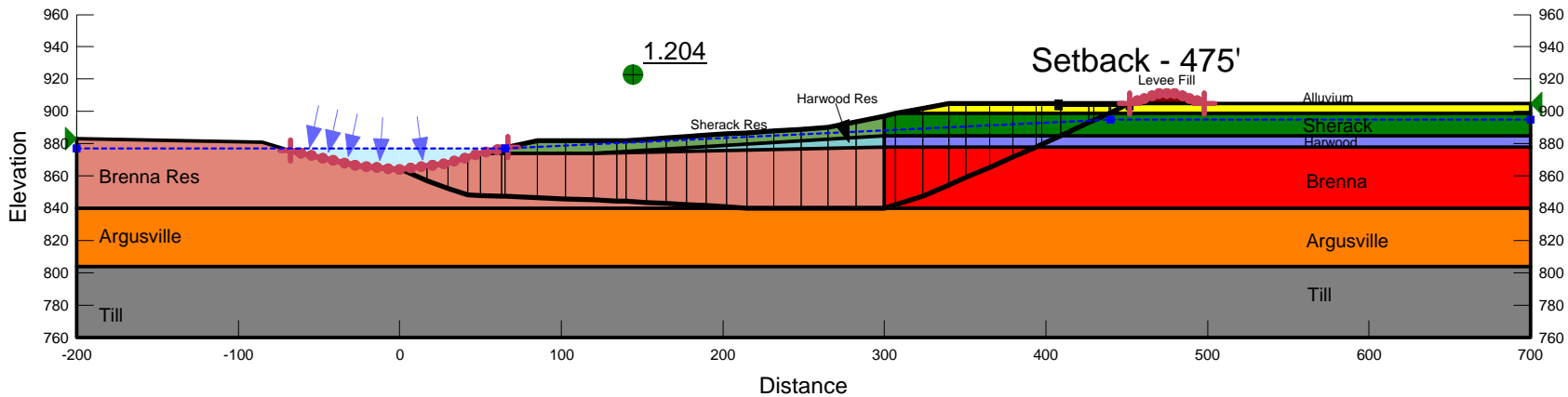
Soil Properties		
Alluvium Res 119 pcf 0 psf 20 °	Levee Fill 118 pcf 250 psf 28 °	Brenna 103 pcf 0 psf 13 °
Sherack Res 118 pcf 0 psf 13 °	Alluvium 119 pcf 0 psf 31 °	Argusville 106 pcf 0 psf 15 °
Harwood Res 116 pcf 0 psf 25 °	Sherack 28 °	Till 122 pcf 0 psf 31 °
Brenna Res 103 pcf 0 psf 9 °	Harwood 116 pcf 26 °	



Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 13

Level of Protection: 911 ft

Soil Properties		
Sherack Res 118 pcf 0 psf 13 °	Alluvium 119 pcf 0 psf 31 °	
Harwood Res 116 pcf 0 psf 25 °	Sherack 118 pcf 0 psf 28 °	
Brenna Res 103 pcf 0 psf 9 °	Harwood 116 pcf 0 psf 26 °	Argusville 106 pcf 0 psf 15 °
Levee Fill 118 pcf 250 psf 28 °	Brenna 103 pcf 0 psf 13 °	Till 122 pcf 0 psf 31 °

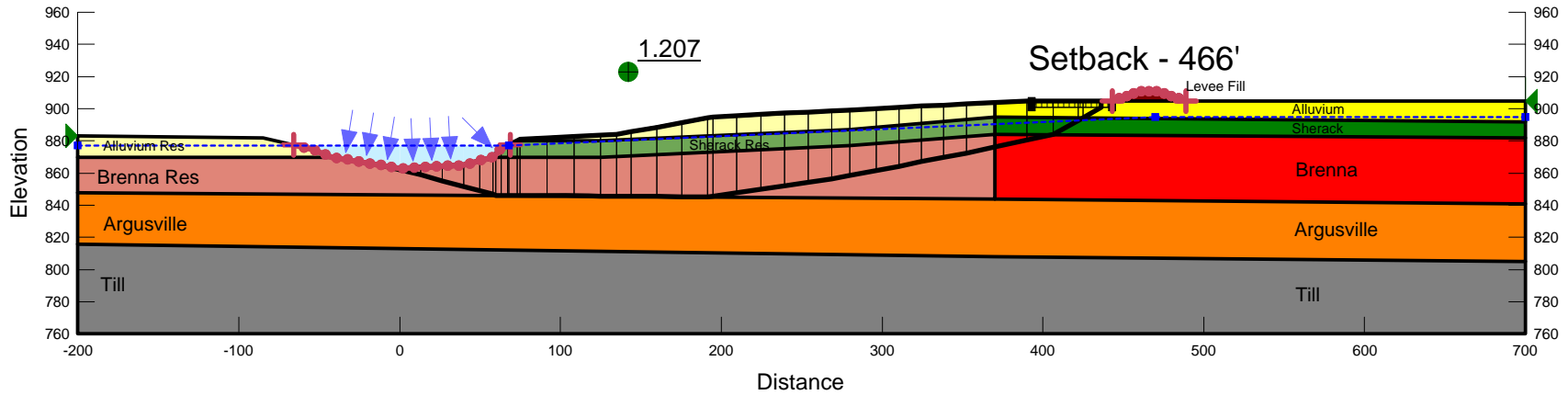


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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 14

Level of Protection: 911 ft

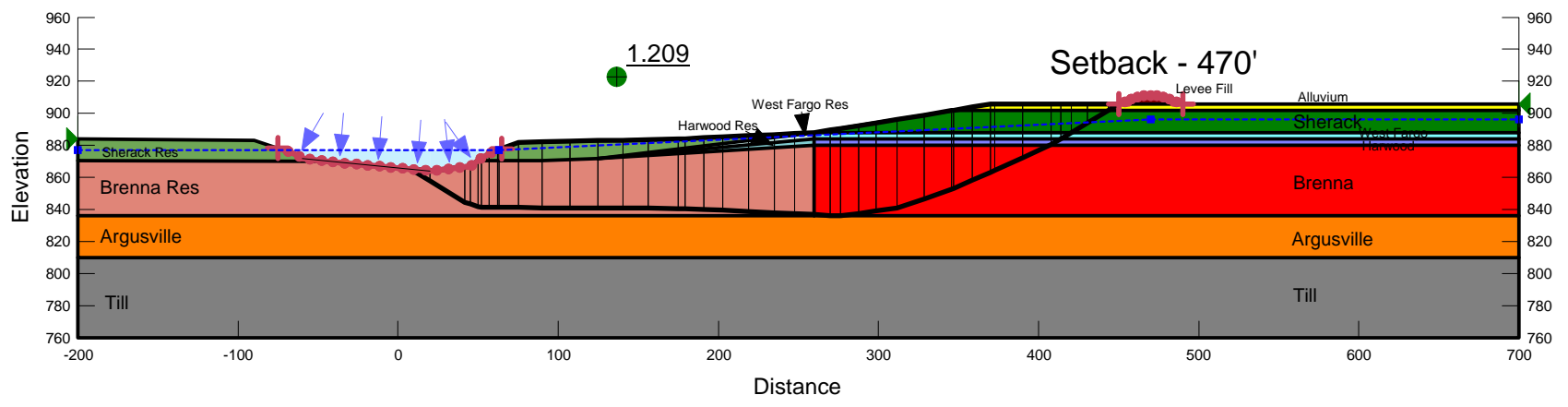
Soil Properties		
Alluvium Res	Levee Fill	Brenna
119 pcf	118 pcf	103 pcf
0 psf	250 psf	0 psf
20 °	28 °	13 °
Sherack Res	Alluvium	Argusville
118 pcf	119 pcf	106 pcf
0 psf	0 psf	0 psf
13 °	31 °	15 °
Brenna Res	Sherack	Till
103 pcf	118 pcf	122 pcf
0 psf	0 psf	0 psf
9 °	28 °	31 °



Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 15

Level of Protection: 911 ft

Soil Properties		
Sherack Res	Levee Fill	Harwood
118 pcf	118 pcf	116 pcf
0 psf	250 psf	0 psf
13 °	28 °	26 °
West Fargo Res	Alluvium	Brenna
123 pcf	119 pcf	103 pcf
0 psf	0 psf	0 psf
25 °	31 °	13 °
Harwood Res	Sherack	Argusville
116 pcf	118 pcf	106 pcf
0 psf	0 psf	0 psf
25 °	28 °	15 °
Brenna Res	West Fargo	Till
103 pcf	123 pcf	122 pcf
0 psf	0 psf	0 psf
9 °	34 °	31 °

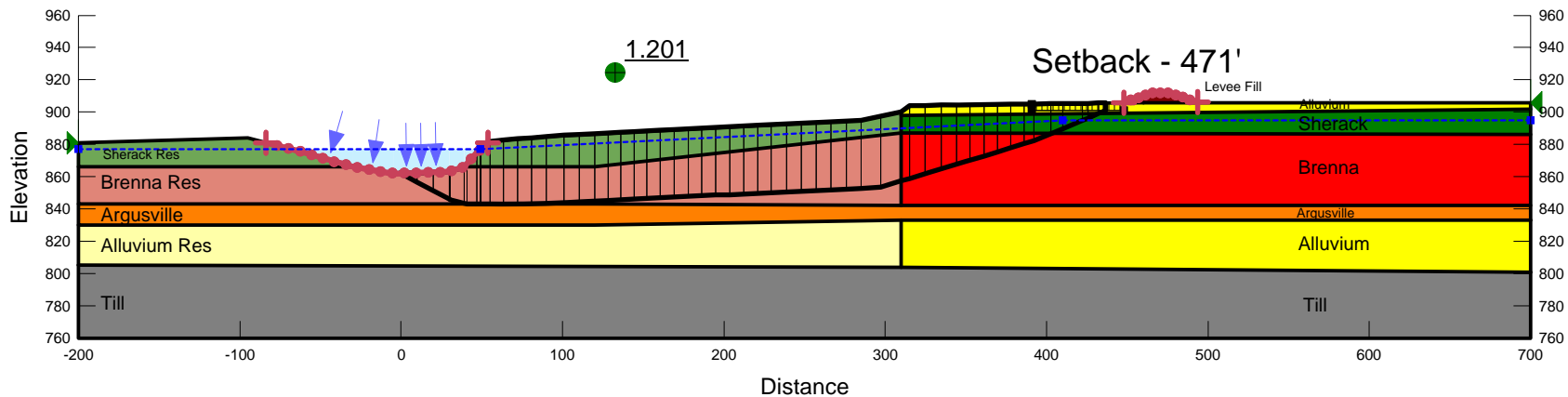


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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 16

Level of Protection: 912 ft

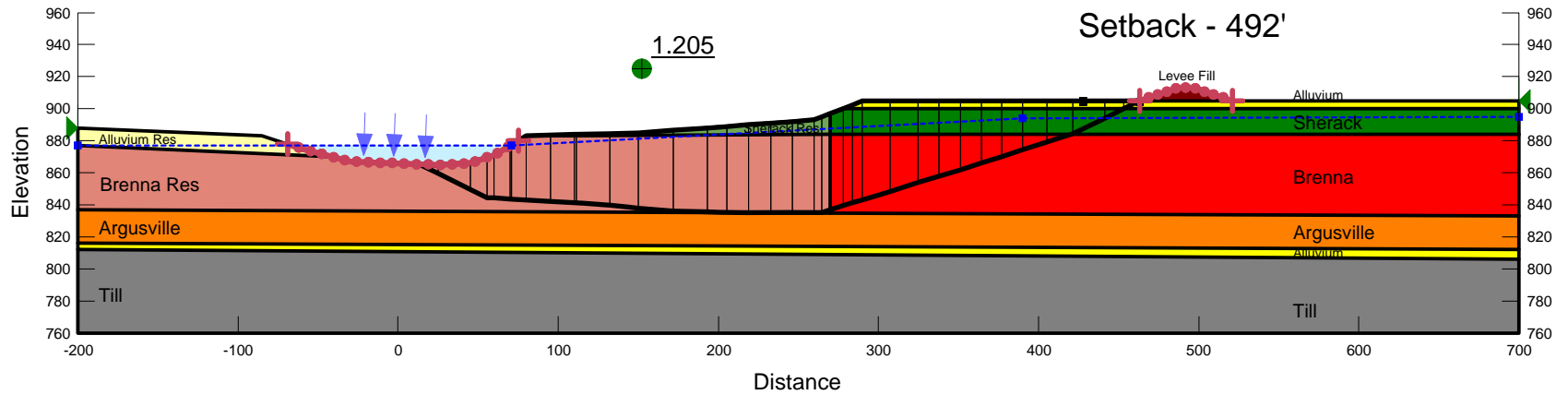
Soil Properties		
Sherack Res 118 pcf 0 psf 13 °	Sherack 118 pcf 0 psf 28 °	Alluvium 119 pcf 0 psf 31 °
Brenna Res 103 pcf 0 psf 9 °	Brenna 103 pcf 0 psf 13 °	Alluvium Res 119 pcf 0 psf 20 °
Levee Fill 118 pcf 250 psf 28 °	Argusville 106 pcf 0 psf 15 °	Till 122 pcf 0 psf 31 °
Alluvium 119 pcf 0 psf 31 °		



Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 17

Level of Protection: 913 ft

Soil Properties		
Alluvium Res	Alluvium	
119 pcf	119 pcf	
0 psf	0 psf	
20 °	31 °	
Sherack Res	Sherack	
118 pcf	118 pcf	
0 psf	0 psf	
13 °	28 °	
Brenna Res	Brenna	
103 pcf	103 pcf	
0 psf	0 psf	
9 °	13 °	
Levee Fill	Argusville	Till
118 pcf	106 pcf	122 pcf
250 psf	0 psf	0 psf
28 °	15 °	31 °

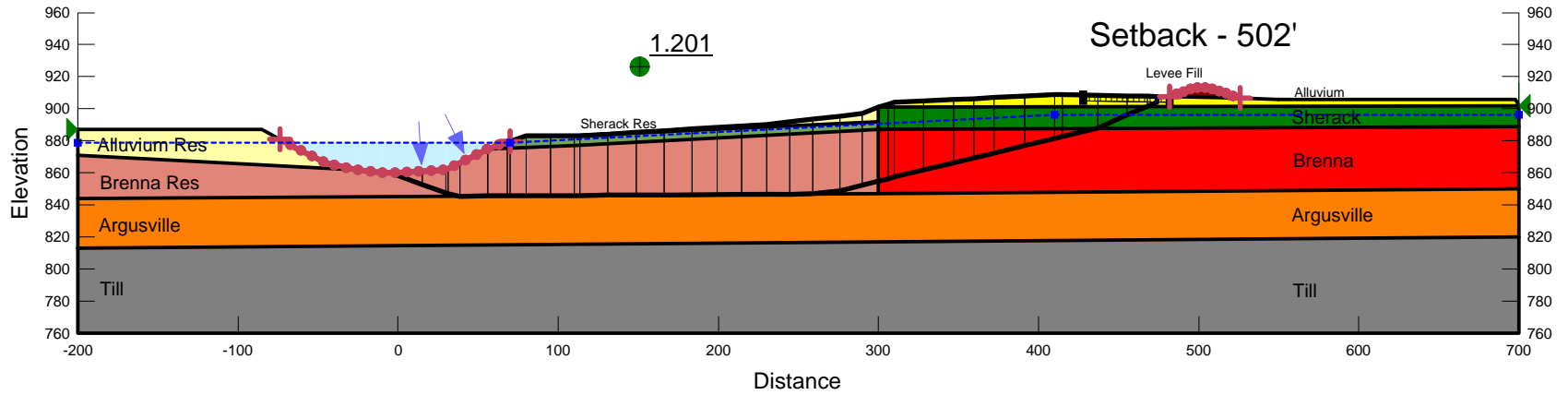


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Last Edited By: Foss, Jason MVP
Date: 12/16/2009

Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 18

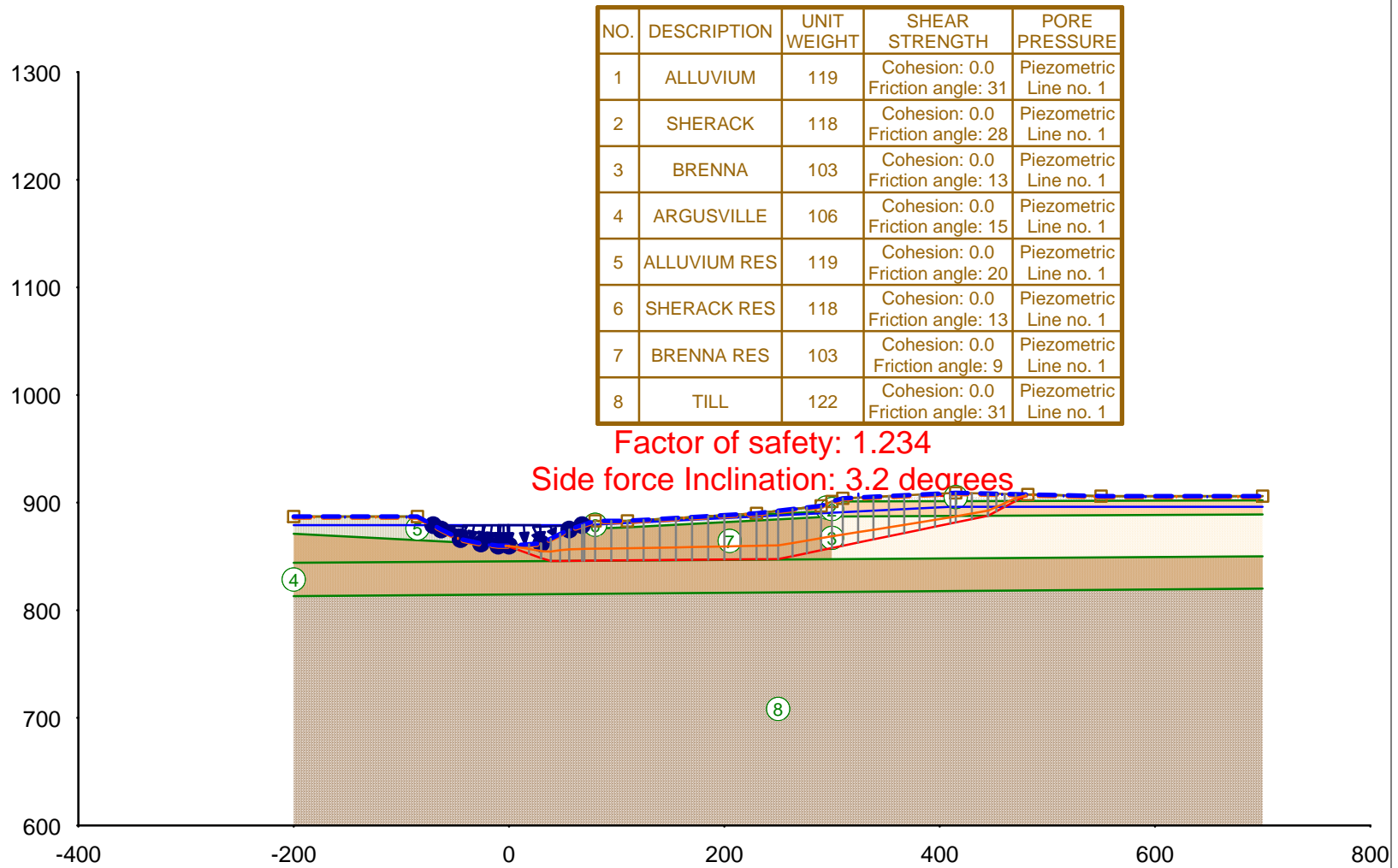
Level of Protection: 913 ft

Soil Properties		
Alluvium Res	Levee Fill	Brenna
119 pcf	118 pcf	103 pcf
0 psf	250 psf	0 psf
20 °	28 °	13 °
Sherack Res	Alluvium	Argusville
118 pcf	119 pcf	106 pcf
0 psf	0 psf	0 psf
13 °	31 °	15 °
Brenna Res	Sherack	Till
103 pcf	118 pcf	122 pcf
0 psf	0 psf	0 psf
9 °	28 °	31 °



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Date: 12/16/2009

FARGO-MOORHEAD METRO FEASIBILITY STUDY, PHASE 2

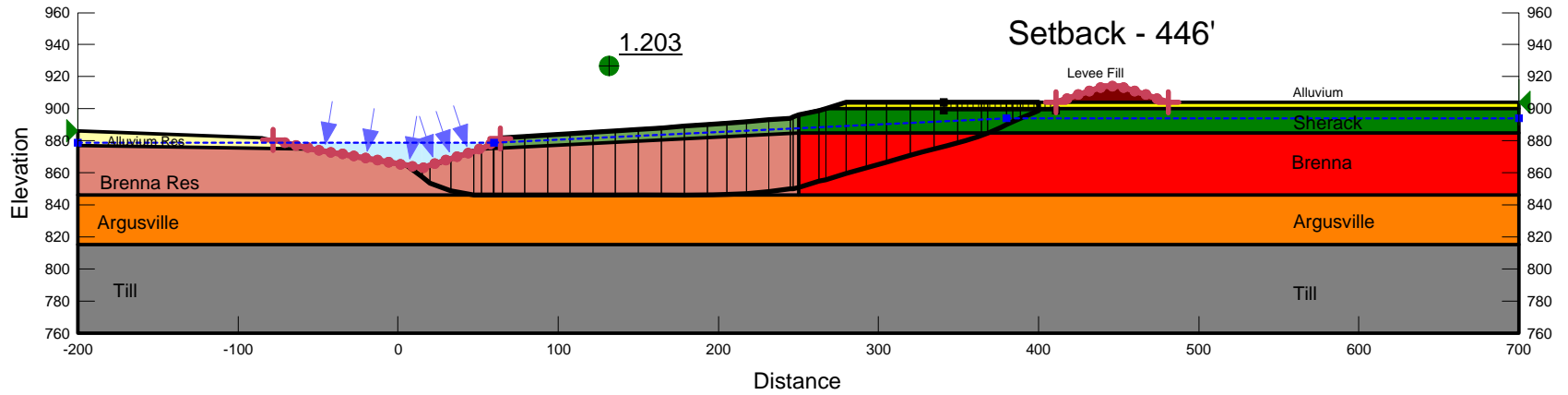


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Fargo-Moorhead Metro Feasibility Study Setback Distance for Levee (500 yr) Moorhead Section 19

Level of Protection: 914 ft

Soil Properties		
Alluvium Res	Alluvium	
119 pcf	119 pcf	
0 psf	0 psf	
20 °	31 °	
Sherack Res	Sherack	
118 pcf	118 pcf	
0 psf	0 psf	
13 °	28 °	
Brenna Res	Brenna	
103 pcf	103 pcf	
0 psf	0 psf	
9 °	13 °	
Levee Fill	Argusville	Till
118 pcf	106 pcf	122 pcf
250 psf	0 psf	0 psf
28 °	15 °	31 °



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Last Edited By: Foss, Jason MVP
Date: 12/16/2009