



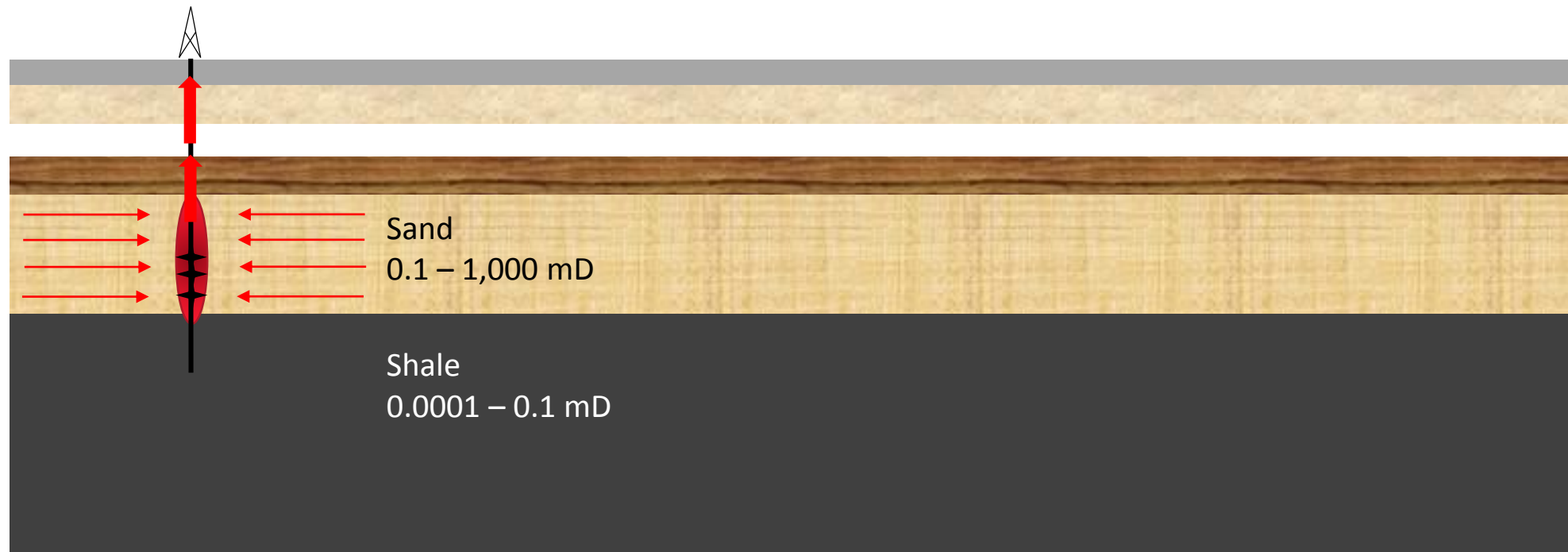
Shale Well Evolution – A Story in Five Easy Pieces

Liberty Educational Video



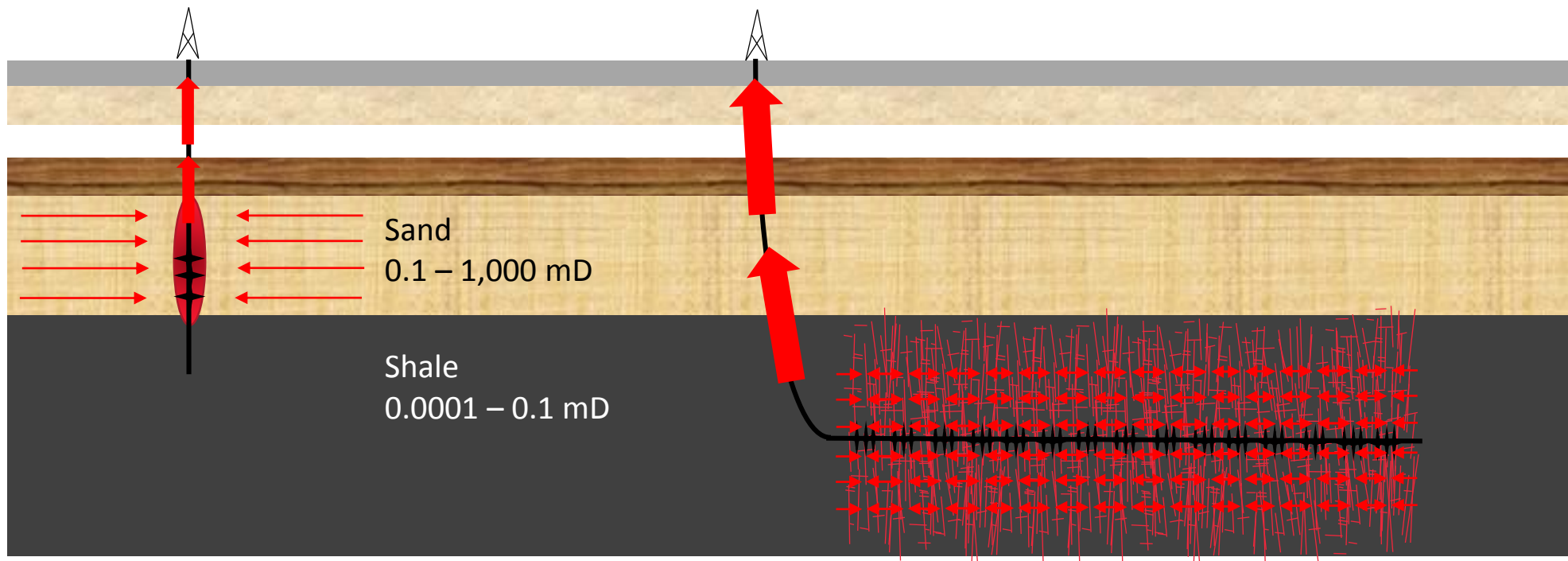
Conventional vs Shale Frac'ing

- 1947 – present
- Higher permeability sand – **Moving the hydrocarbon molecule to the frac**
- Vertical wells, mostly single stages
- Focus on conductivity



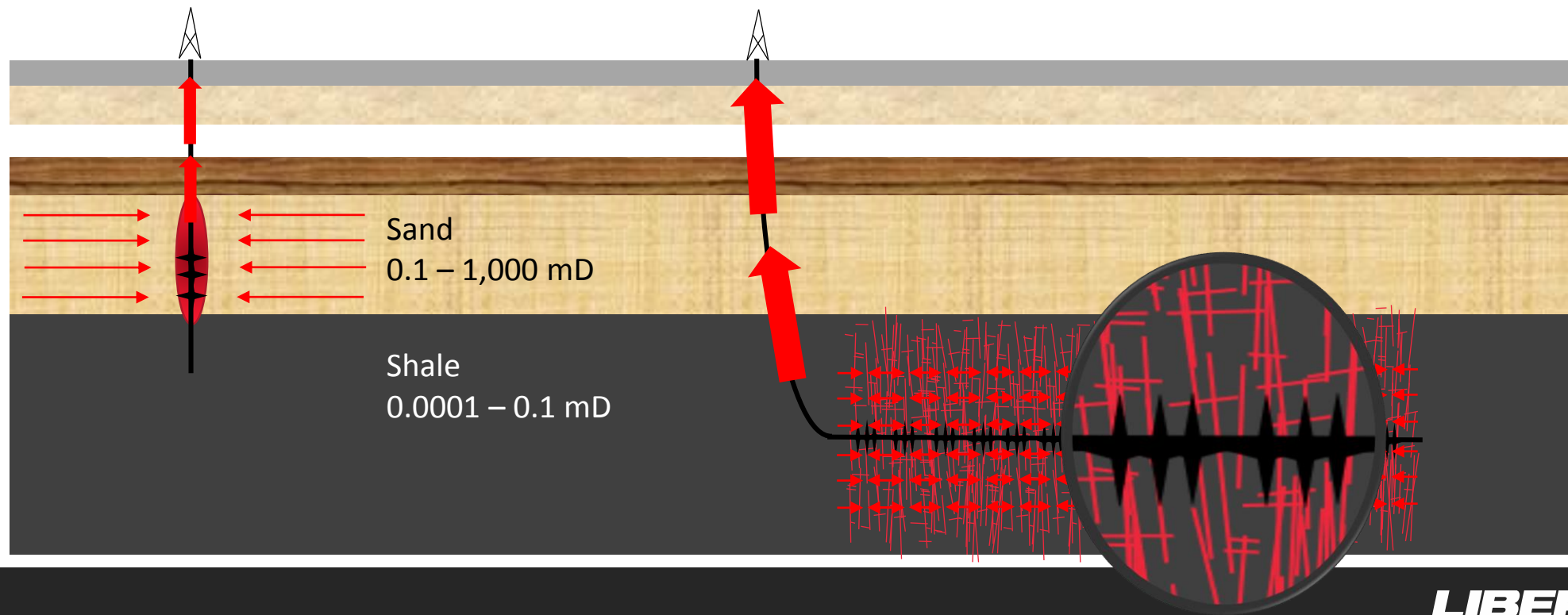
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- ~2000 – present
 - Low permeability shale – **Bringing the frac to the hydrocarbon molecule**
 - Multi-stage horizontal wells
 - Focus on complexity – “2 miles of plumbing”



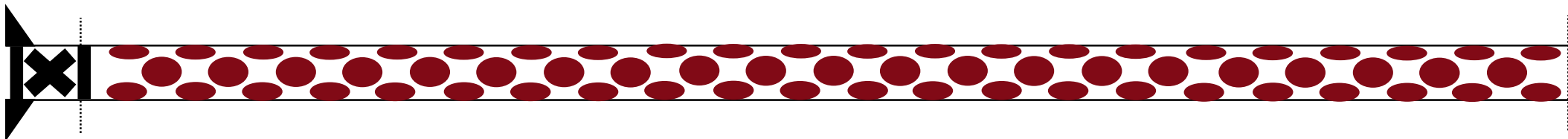
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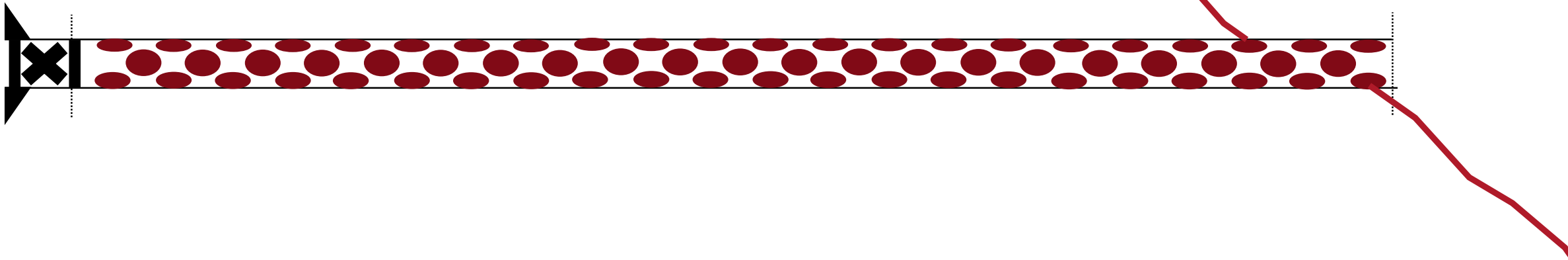


Five Pieces of Garden Hose – Hose #1

Name	Uncemented Slotted Liner
Vintage	2005
Lateral Length (ft)	4000
Stage Intensity (ft/stage)	4000
# Clusters / Stage	n/a
# Perforations / Stage	n/a
Rate (bpm)	40
Rate Intensity (bpm/ft)	0.01
Rate / Cluster (bpm/cluster)	n/a
Rate / Perf (bpm/perf)	0.0003
Perf Friction (psi)	0.000007
Rate (gpm)	1.0
Rate / Cluster (gpm/cluster)	n/a
Rate / Perf (gpm/perf)	0.000007
Perf Friction (psi)	0.00000005



Five Pieces of Garden Hose – Hose #1



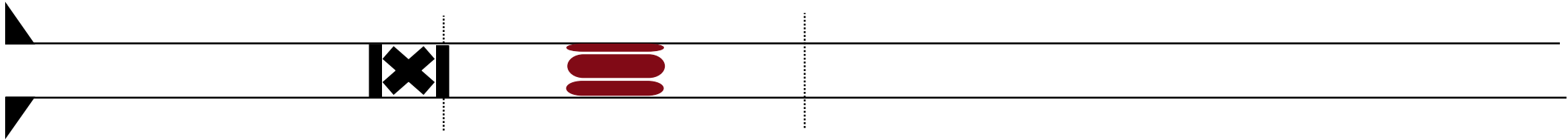
Poor coverage, no control, not a full effective horizontal, poor production, bad parent

Five Pieces of Garden Hose – Hose #2

Name	Uncemented Slotted Liner	Uncemented Sliding Sleeve
Vintage	2005	2010
Lateral Length (ft)	4000	5000
Stage Intensity (ft/stage)	4000	500
# Clusters / Stage	n/a	1
# Perforations / Stage	n/a	12
Rate (bpm)	40	40
Rate Intensity (bpm/ft)	0.01	0.08
Rate / Cluster (bpm/cluster)	n/a	40
Rate / Perf (bpm/perf)	0.0003	3.33
Perf Friction (psi)	0.000007	107
Rate (gpm)	1.0	1.0
Rate / Cluster (gpm/cluster)	n/a	1.0
Rate / Perf (gpm/perf)	0.000007	0.08
Perf Friction (psi)	0.00000005	0.7

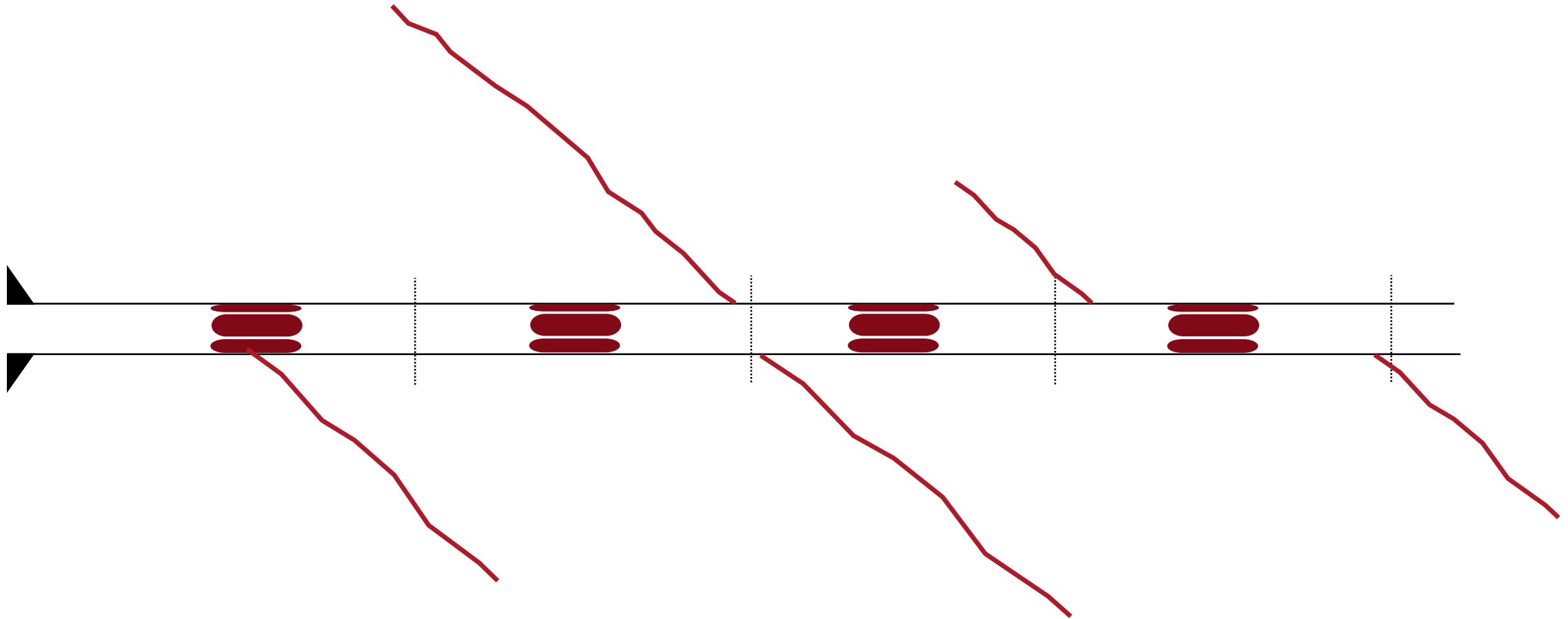


Five Pieces of Garden Hose – Hose #2



Improved coverage, little control, frags too far apart, low production

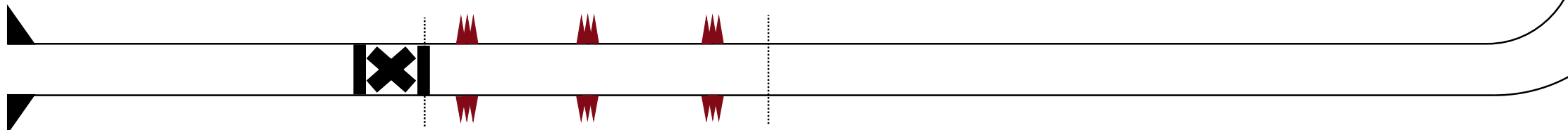
Five Pieces of Garden Hose – Hose #2



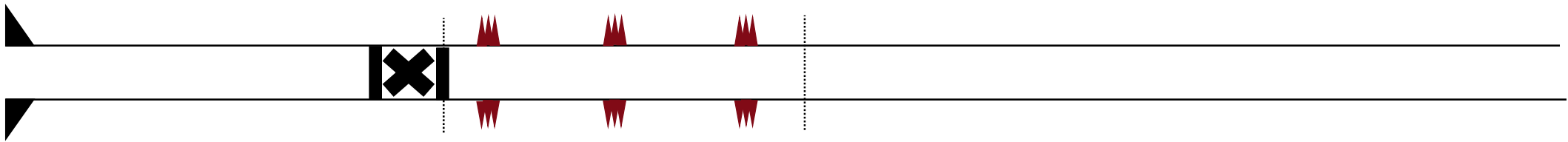
Improved coverage, little control, frags too far apart, low production

Five Pieces of Garden Hose – Hose #3

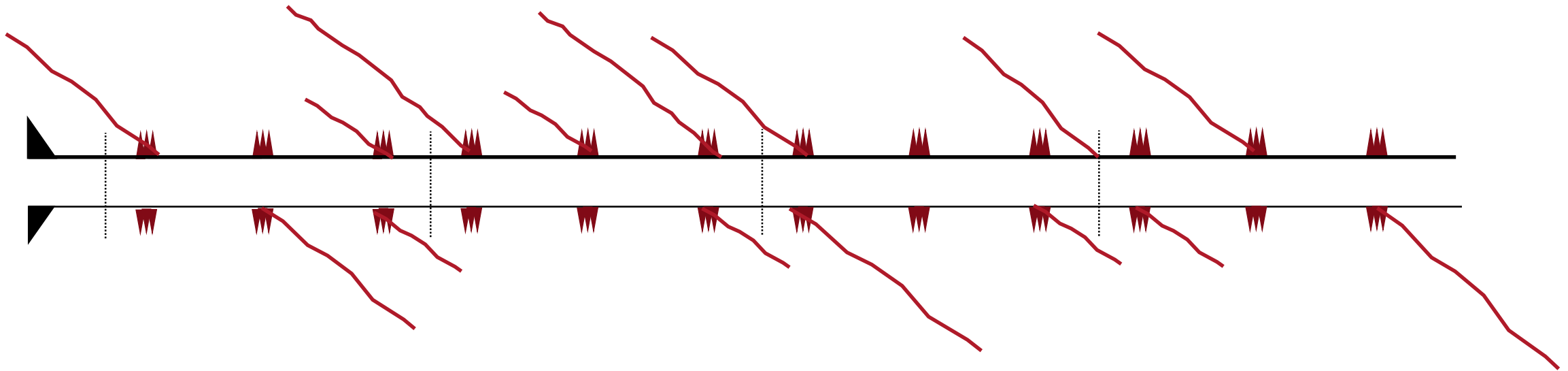
Name	Uncemented Slotted Liner	Uncemented Sliding Sleeve	Uncemented Plug&Perf
Vintage	2005	2010	2012
Lateral Length (ft)	4000	5000	6000
Stage Intensity (ft/stage)	4000	500	300
# Clusters / Stage	n/a	1	3
# Perforations / Stage	n/a	12	36
Rate (bpm)	40	40	60
Rate Intensity (bpm/ft)	0.01	0.08	0.20
Rate / Cluster (bpm/cluster)	n/a	40	20
Rate / Perf (bpm/perf)	0.0003	3.33	1.67
Perf Friction (psi)	0.000007	107	247
Rate (gpm)	1.0	1.0	1.5
Rate / Cluster (gpm/cluster)	n/a	1.0	0.5
Rate / Perf (gpm/perf)	0.000007	0.08	0.04
Perf Friction (psi)	0.00000005	0.7	1.7



Five Pieces of Garden Hose – Hose #3



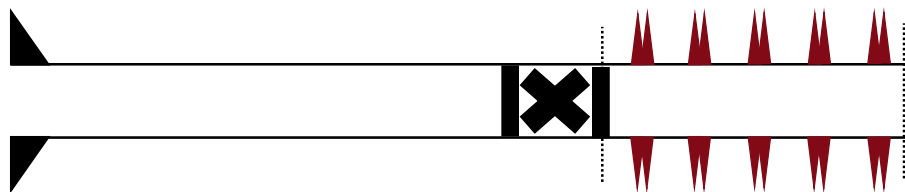
Five Pieces of Garden Hose – Hose #3



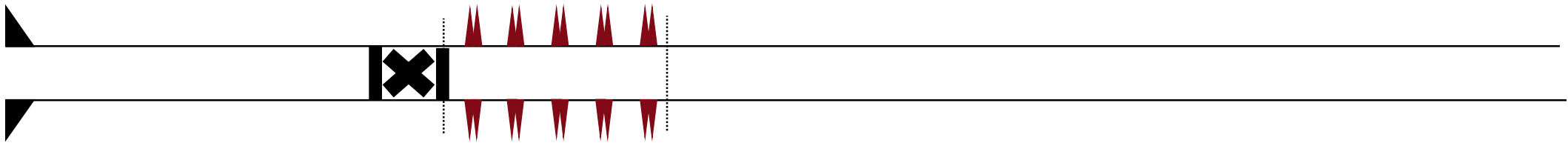
Better coverage, more control, significant length variation, moderate production

Five Pieces of Garden Hose – Hose #4

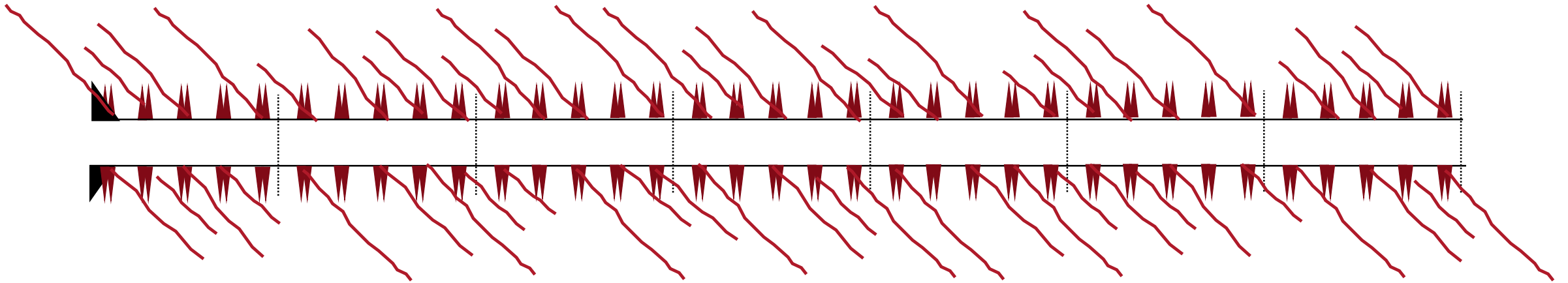
Name	Uncemented Slotted Liner	Uncemented Sliding Sleeve	Uncemented Plug&Perf	Cemented P&P LE
Vintage	2005	2010	2012	2017
Lateral Length (ft)	4000	5000	6000	7000
Stage Intensity (ft/stage)	4000	500	300	200
# Clusters / Stage	n/a	1	3	5
# Perforations / Stage	n/a	12	36	30
Rate (bpm)	40	40	60	75
Rate Intensity (bpm/ft)	0.01	0.08	0.20	0.38
Rate / Cluster (bpm/cluster)	n/a	40	20	15
Rate / Perf (bpm/perf)	0.0003	3.33	1.67	2.50
Perf Friction (psi)	0.000007	107	247	555
Rate (gpm)	1.0	1.0	1.5	1.8
Rate / Cluster (gpm/cluster)	n/a	1.0	0.5	0.4
Rate / Perf (gpm/perf)	0.000007	0.08	0.04	0.06
Perf Friction (psi)	0.00000005	0.7	1.7	3.9



Five Pieces of Garden Hose – Hose #4



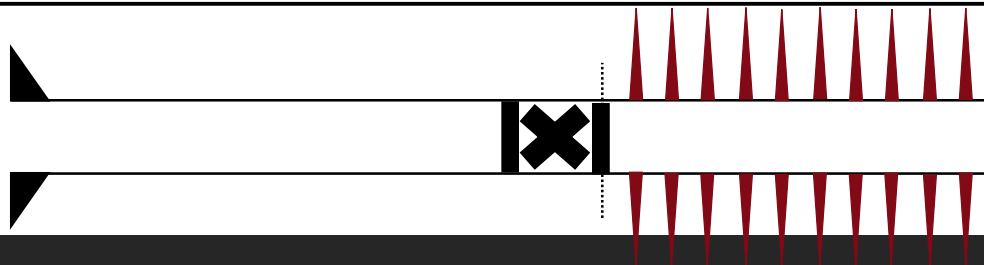
Five Pieces of Garden Hose – Hose #4



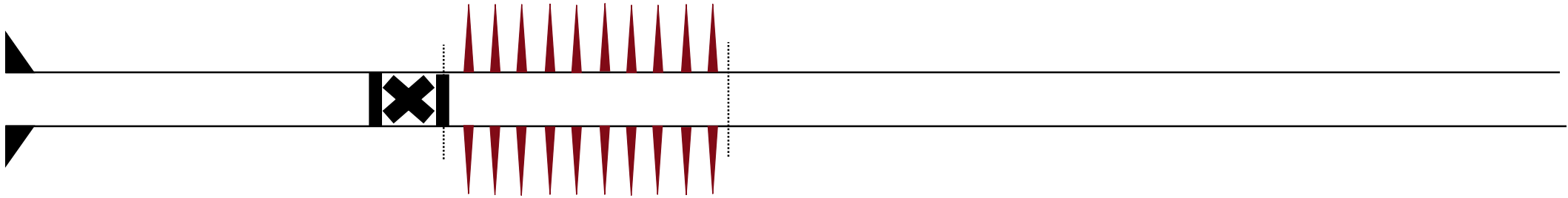
Higher cluster efficiency, some coverage variation, better production, higher cost

Five Pieces of Garden Hose – Hose \$5

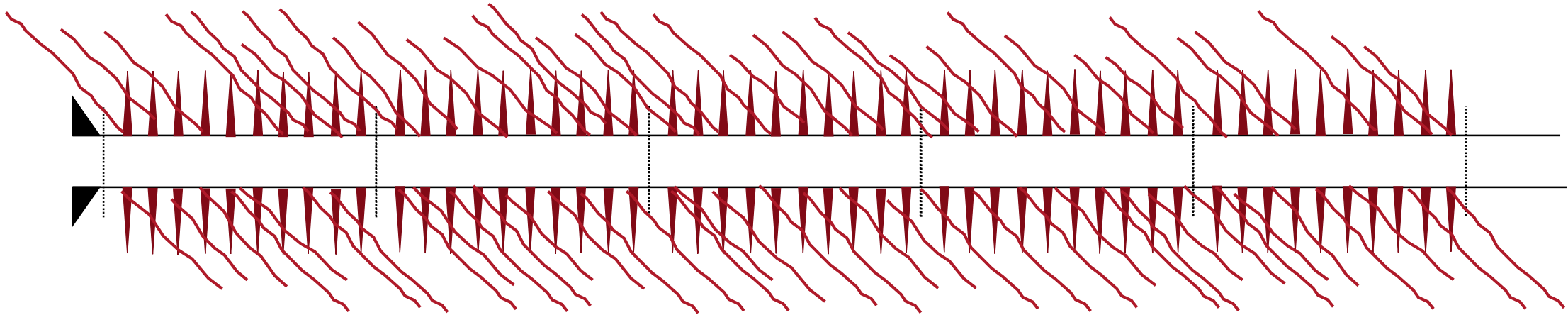
Name	Uncemented Slotted Liner	Uncemented Sliding Sleeve	Uncemented Plug&Perf	Cemented P&P LE	Cemented P&P XLE
Vintage	2005	2010	2012	2017	2020
Lateral Length (ft)	4000	5000	6000	7000	8000
Stage Intensity (ft/stage)	4000	500	300	200	250
# Clusters / Stage	n/a	1	3	5	12
# Perforations / Stage	n/a	12	36	30	24
Rate (bpm)	40	40	60	75	90
Rate Intensity (bpm/ft)	0.01	0.08	0.20	0.38	0.36
Rate / Cluster (bpm/cluster)	n/a	40	20	15	7.5
Rate / Perf (bpm/perf)	0.0003	3.33	1.67	2.50	3.75
Perf Friction (psi)	0.000007	107	247	555	1249
Rate (gpm)	1.0	1.0	1.5	1.8	2.2
Rate / Cluster (gpm/cluster)	n/a	1.0	0.5	0.4	0.2
Rate / Perf (gpm/perf)	0.000007	0.08	0.04	0.06	0.09
Perf Friction (psi)	0.00000005	0.7	1.7	3.9	8.7



Five Pieces of Garden Hose – Hose #5

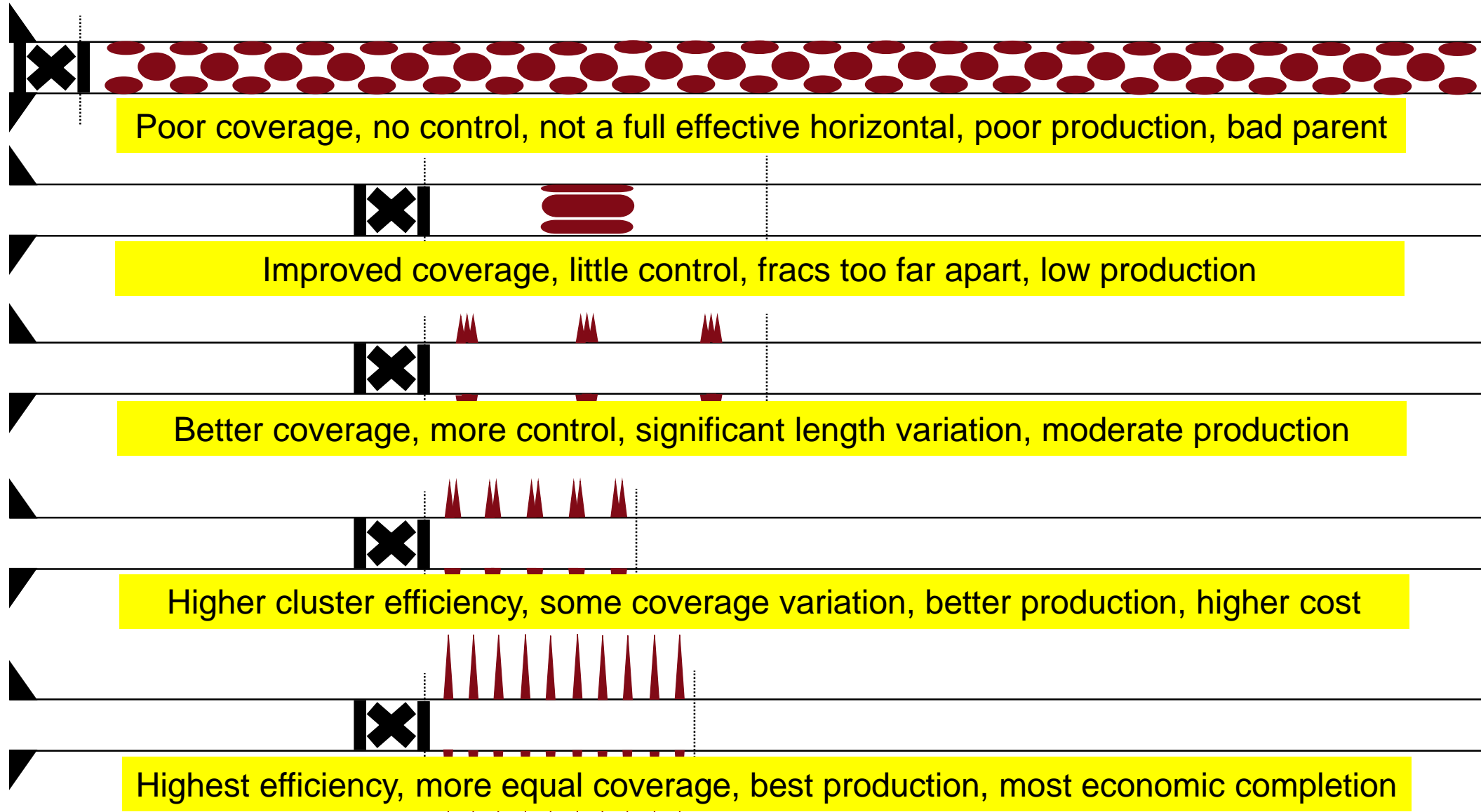


Five Pieces of Garden Hose – Hose #5



Highest efficiency, more equal coverage, best production, most economic completion

Five Pieces of Garden Hose – Summary





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