Appendix E-1 | E-1.1

Table 15 – Flood Management Evaluations Recommended by RFPG

FME ID	FME Name	Description	Associated Goals	Counties	HUC8s	HUC12s	Watershed Name	FME Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Study Cost ($)	RFPG Recommendation (Y/N)	Reason for Recommendation
011000001	Borger City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Hutchinson	11090106	110901060106, 110901060107, 110901060109, 110901060204	Middle Canadian-Spring	8.6	Riverine	Borger	Hutchinson, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Borger	No	$250,000	No	City is already developing a master plan
011000002	Clay County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Clay	11130102, 11130201, 11130206, 11130209	-	Blue-China, Farmers-Mud, Wichita, Wichita	985.0	Riverine	Clay	Montague, Clay, Wichita, Archer, Nortex Regional Planning Commission, Red River Authority of Texas, Wichita County Water Improvement District 2, Henrietta, Petrolia, Bellevue, Byers, Dean, Windthorst, Scotland, Jolly	No	$1,169,000	Yes	Action aligns with goals and meets TWDB guidance
011000003	Foard County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Foard	11130105, 11130204, 11130207	-	Pease, North Wichita, Southern Beaver	703.1	Riverine and Playa	Foard	Foard, Cottle, Wilbarger, Hardeman, Knox, King, Baylor, Nortex Regional Planning Commission, South Plains Association of Governments, West Central Texas Council of Governments, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Crowell	No	$749,000	Yes	Action aligns with goals and meets TWDB guidance
011000004	Cottle County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Cottle	11130101, 11130103, 11130104, 11130105, 11130204	-	Groesbeck-Sandy, North Pease, Middle Pease, Pease, North Wichita	899.7	Riverine and Playa	Cottle	Foard, Cottle, Motley, Hardeman, King, Dickens, Childress, Hall, Nortex Regional Planning Commission, Panhandle Regional Planning Commission, South Plains Association of Governments, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Paducah	No	$926,000	Yes	Action aligns with goals and meets TWDB guidance
011000005	Motley County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Motley	11130103, 11130104, 11130204	-	North Pease, Middle Pease, North Wichita	988.0	Riverine and Playa	Motley	Cottle, Motley, Floyd, King, Dickens, Crosby, Hall, Briscoe, Nortex Regional Planning Commission, Panhandle Regional Planning Commission, South Plains Association of Governments, Red River Authority of Texas, Matador Water District, Greenbelt Municipal & Industrial Water Authority, Matador, Roaring Springs	No	$974,000	Yes	Action aligns with goals and meets TWDB guidance
011000006	Floyd County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Floyd	11130103, 11130104	-	North Pease, Middle Pease	583.9	Riverine and Playa	Floyd	Motley, Floyd, Hale, Dickens, Crosby, Briscoe, Swisher, Panhandle Regional Planning Commission, South Plains Association of Governments, Red River Authority of Texas, Brazos River Authority, Lockney	No	$1,115,000	Yes	Action aligns with goals and meets TWDB guidance
011000007	Wilbarger County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Wilbarger	11130101, 11130102, 11130105, 11130206, 11130207	-	Groesbeck-Sandy, Blue-China, Pease, Wichita, Southern Beaver	975.5	Riverine	Wilbarger	Wichita, Foard, Wilbarger, Hardeman, Baylor, Archer, Nortex Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Electra, Vernon	No	$983,000	Yes	Action aligns with goals and meets TWDB guidance
011000008	Hardeman County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Hardeman	11120105, 11130101, 11130105	-	Lower Prairie Dog Town Fork Red, Groesbeck-Sandy, Pease	695.6	Riverine and Playa	Hardeman	Foard, Cottle, Wilbarger, Hardeman, Childress, Nortex Regional Planning Commission, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Chillicothe, Quanah	No	$678,000	Yes	Action aligns with goals and meets TWDB guidance
011000009	Knox County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Knox	11130204, 11130205, 11130206	111302040206, 111302040301, 111302040302, 111302040303, 111302040304, 111302040305, 111302040306, 111302050204, 111302050205, 111302050206, 111302050207, 111302050208, 111302060103	North Wichita, South Wichita, Wichita	421.0	Riverine and Playa	Knox	Foard, Knox, King, Baylor, Nortex Regional Planning Commission, South Plains Association of Governments, West Central Texas Council of Governments, Red River Authority of Texas, Brazos River Authority, Knox County WCID 1	No	$873,000	Yes	Action aligns with goals and meets TWDB guidance
011000010	King County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	King	11130204, 11130205	111302040102, 111302040103, 111302040104, 111302040108, 111302040204, 111302040205, 111302040206, 111302050102, 111302050103, 111302050104, 111302050105, 111302050106, 111302050107, 111302050201, 111302050202, 111302050203, 111302050204	North Wichita, South Wichita	575.6	Riverine and Playa	King	Foard, Cottle, Motley, Knox, King, Dickens, Nortex Regional Planning Commission, South Plains Association of Governments, West Central Texas Council of Governments, Red River Authority of Texas, Brazos River Authority, Greenbelt Municipal & Industrial Water Authority	No	$955,000	Yes	Action aligns with goals and meets TWDB guidance
011000011	Dickens County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Dickens	11130104, 11130204, 11130205	111301040202, 111301040203, 111301040206, 111301040207, 111301040208, 111301040209, 111301040210, 111301040301, 111301040303, 111302040101, 111302040102, 111302050101, 111302050102, 111302050103, 111302050105	Middle Pease, North Wichita, South Wichita	330.9	Riverine and Playa	Dickens	Cottle, Motley, Floyd, King, Dickens, Crosby, Nortex Regional Planning Commission, South Plains Association of Governments, Red River Authority of Texas, Brazos River Authority, Dickens County WCID 1	No	$920,000	Yes	Action aligns with goals and meets TWDB guidance
011000012	Baylor County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Baylor	11130204, 11130206, 11130207, 11130209	-	North Wichita, Wichita, Southern Beaver, Southern Beaver	506.1	Riverine and Playa	Baylor	Wichita, Foard, Wilbarger, Knox, Baylor, Archer, Nortex Regional Planning Commission, West Central Texas Council of Governments, Red River Authority of Texas, Brazos River Authority, Seymour	No	$912,000	Yes	Action aligns with goals and meets TWDB guidance
011000013	Carson County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Carson	11090105, 11090106, 11120103, 11120201, 11120301	-	Lake Meredith, Middle Canadian-Spring, Upper Prairie Dog Town Fork Red, Upper Salt Fork Red, Upper North Fork Red	925.2	Riverine and Playa	Carson	Carson, Potter, Roberts, Hutchinson, Moore, Donley, Armstrong, Randall, Gray, Panhandle Regional Planning Commission, Red River Authority of Texas, Palo Duro River Authority, White Deer, Skellytown, Panhandle, Groom	No	$826,000	Yes	Action aligns with goals and meets TWDB guidance
011000014	Oldham County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Oldham	11080006, 11090101, 11090102, 11090105, 11120102	-	Upper Canadian-Ute Reservoir, Middle Canadian-Trujillo, Punta de Agua, Lake Meredith, Palo Duro	1502.8	Riverine and Playa	Oldham	Potter, Oldham, Moore, Hartley, Randall, Deaf Smith, Panhandle Regional Planning Commission, Red River Authority of Texas, Llano Estacado Water District, Adrian, Vega	No	$1,447,000	Yes	Action aligns with goals and meets TWDB guidance
011000015	Hemphill County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Hemphill	11090106, 11090201, 11100203, 11120302, 11130301	-	Middle Canadian-Spring, Lower Canadian-Deer, Lower Wolf, Middle North Fork Red, Washita Headwaters	914.0	Riverine and Playa	Hemphill	Hemphill, Roberts, Wheeler, Gray, Lipscomb, Panhandle Regional Planning Commission, Red River Authority of Texas, Wheeler County Water Supply District, Canadian	No	$887,000	Yes	Action aligns with goals and meets TWDB guidance
011000016	Roberts County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Roberts	11090106, 11120302, 11130301	-	Middle Canadian-Spring, Middle North Fork Red, Washita Headwaters	925.4	Riverine and Playa	Roberts	Carson, Hemphill, Roberts, Hutchinson, Wheeler, Gray, Lipscomb, Ochiltree, Hansford, Panhandle Regional Planning Commission, Red River Authority of Texas, Roberts County FWSD 1, Miami	No	$870,000	Yes	Action aligns with goals and meets TWDB guidance
011000017	Hutchinson County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Hutchinson	11090105, 11090106, 11100104, 11100202	-	Lake Meredith, Middle Canadian-Spring, Palo Duro, Palo Duro	896.9	Riverine and Playa	Hutchinson	Carson, Roberts, Hutchinson, Moore, Sherman, Ochiltree, Hansford, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Palo Duro River Authority, Borger, Fritch, Sanford, Stinnett	No	$895,000	Yes	Action aligns with goals and meets TWDB guidance
011000018	Moore County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Moore	11090105, 11100104	-	Lake Meredith, Palo Duro	911.5	Riverine and Playa	Moore	Carson, Potter, Oldham, Hutchinson, Moore, Hartley, Sherman, Dallam, Hansford, Panhandle Regional Planning Commission, Red River Authority of Texas, Palo Duro River Authority, Cactus, Dumas, Sunray, Fritch	No	$835,000	Yes	Action aligns with goals and meets TWDB guidance

FME ID	FME Name	Description	Associated Goals	Counties	HUC8s	HUC12s	Watershed Name	FME Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Study Cost ($)	RFPG Recommendation (Y/N)	Reason for Recommendation
011000019	Hartley County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Hartley	11090101, 11090102, 11090103, 11090104, 11090105, 11100103, 11100104	-	Middle Canadian-Trujillo, Punta de Agua, Rita Blanca, Carrizo, Lake Meredith, Coldwater, Palo Duro	1466.1	Riverine and Playa	Hartley	Oldham, Moore, Hartley, Sherman, Dallam, Panhandle Regional Planning Commission, Red River Authority of Texas, Channing, Dalhart	No	$1,361,000	Yes	Action aligns with goals and meets TWDB guidance
011000020	Childress County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Childress	11120105, 11130101, 11130103, 11130105	-	Lower Prairie Dog Town Fork Red, Groesbeck-Sandy, North Pease, North Pease	713.1	Riverine and Playa	Childress	Cottle, Hardeman, Childress, Hall, Collingsworth, Nortex Regional Planning Commission, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Childress	No	$711,000	Yes	Action aligns with goals and meets TWDB guidance
011000021	Hall County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Hall	11120103, 11120105, 11130103	-	Upper Prairie Dog Town Fork Red, Lower Prairie Dog Town Fork Red, North Pease	903.4	Riverine and Playa	Hall	Cottle, Motley, Childress, Hall, Briscoe, Collingsworth, Donley, Nortex Regional Planning Commission, Panhandle Regional Planning Commission, South Plains Association of Governments, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Lakeview, Memphis, Estelline, Turkey	No	$892,000	Yes	Action aligns with goals and meets TWDB guidance
011000022	Briscoe County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Briscoe	11120103, 11120104, 11120105, 11130103	-	Upper Prairie Dog Town Fork Red, Tule, Lower Prairie Dog Town Fork Red, Lower Prairie Dog Town Fork Red	901.4	Riverine and Playa	Briscoe	Motley, Floyd, Hall, Briscoe, Swisher, Donley, Armstrong, Panhandle Regional Planning Commission, South Plains Association of Governments, Red River Authority of Texas, Mackenzie Municipal Water Authority, Greenbelt Municipal & Industrial Water Authority, Quitaque, Silverton	No	$902,000	Yes	Action aligns with goals and meets TWDB guidance
011000023	Swisher County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Swisher	11120103, 11120104, 11130103	-	Upper Prairie Dog Town Fork Red, Tule, North Pease	827.5	Riverine and Playa	Swisher	Floyd, Hale, Briscoe, Swisher, Castro, Armstrong, Randall, Panhandle Regional Planning Commission, South Plains Association of Governments, Red River Authority of Texas, Brazos River Authority, Mackenzie Municipal Water Authority, Tulia, Kress, Happy	No	$929,000	Yes	Action aligns with goals and meets TWDB guidance
011000024	Castro County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Castro	11120101, 11120104	111201010406, 111201010407, 111201010505, 111201040101, 111201040102, 111201040103, 111201040104, 111201040105, 111201040201, 111201040202, 111201040203, 111201040204, 111201040301, 111201040302, 111201040303, 111201040304, 111201040401, 111201040402	Tierra Blanca, Tule	447.3	Riverine and Playa	Castro	Swisher, Castro, Parmer, Randall, Deaf Smith, Panhandle Regional Planning Commission, Red River Authority of Texas, Brazos River Authority, Nazareth	No	$873,000	Yes	Action aligns with goals and meets TWDB guidance
011000025	Parmer County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Parmer	11120101, 11120104	111201010201, 111201010204, 111201010307, 111201010401, 111201010402, 111201010403, 111201010404, 111201010405, 111201010406, 111201010407, 111201010504, 111201010505, 111201040102	Tierra Blanca, Tule	331.4	Riverine and Playa	Parmer	Castro, Parmer, Deaf Smith, Panhandle Regional Planning Commission, Red River Authority of Texas, Brazos River Authority, Friona	No	$789,000	Yes	Action aligns with goals and meets TWDB guidance
011000026	Collingsworth County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Collingsworth	11120105, 11120202, 11120304, 11130101	-	Lower Prairie Dog Town Fork Red, Lower Salt Fork Red, Elm Fork Red, Elm Fork Red	919.2	Riverine	Collingsworth	Childress, Hall, Collingsworth, Donley, Wheeler, Gray, Panhandle Regional Planning Commission, Red River Authority of Texas, Wheeler County Water Supply District, Greenbelt Municipal & Industrial Water Authority, Dodson, Wellington	No	$909,000	Yes	Action aligns with goals and meets TWDB guidance
011000027	Donley County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Donley	11120103, 11120105, 11120201, 11120202, 11120301, 11120304	-	Upper Prairie Dog Town Fork Red, Lower Prairie Dog Town Fork Red, Upper Salt Fork Red, Lower Salt Fork Red, Upper North Fork Red, Elm Fork Red	933.0	Riverine and Playa	Donley	Carson, Hall, Briscoe, Collingsworth, Donley, Armstrong, Wheeler, Gray, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Hedley, Clarendon, Howardwick	No	$957,000	Yes	Action aligns with goals and meets TWDB guidance
011000028	Armstrong County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Armstrong	11120103, 11120201, 11120301	-	Upper Prairie Dog Town Fork Red, Upper Salt Fork Red, Upper North Fork Red	912.0	Riverine and Playa	Armstrong	Carson, Potter, Briscoe, Swisher, Donley, Armstrong, Randall, Gray, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Claude	No	$863,000	Yes	Action aligns with goals and meets TWDB guidance
011000029	Deaf Smith County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Deaf Smith	11090101, 11120101, 11120102, 11120104	-	Middle Canadian-Trujillo, Tierra Blanca, Palo Duro, Palo Duro	1497.9	Riverine and Playa	Deaf Smith	Potter, Oldham, Castro, Parmer, Randall, Deaf Smith, Panhandle Regional Planning Commission, Red River Authority of Texas, Llano Estacado Water District, Deaf Smith County FWSD 1, Hereford	No	$1,283,000	Yes	Action aligns with goals and meets TWDB guidance
011000030	Wheeler County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Wheeler	11120202, 11120301, 11120302, 11120304, 11130301	-	Lower Salt Fork Red, Upper North Fork Red, Middle North Fork Red, Elm Fork Red, Washita Headwaters	916.0	Riverine and Playa	Wheeler	Hemphill, Roberts, Collingsworth, Donley, Wheeler, Gray, Panhandle Regional Planning Commission, Red River Authority of Texas, Wheeler County Water Supply District, Greenbelt Municipal & Industrial Water Authority, Mobeetie, Shamrock, Wheeler	No	$892,000	Yes	Action aligns with goals and meets TWDB guidance
011000031	Sherman County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Sherman	11100101, 11100103, 11100104	-	Upper Beaver, Coldwater, Palo Duro	926.1	Riverine and Playa	Sherman	Hutchinson, Moore, Hartley, Sherman, Dallam, Hansford, Panhandle Regional Planning Commission, Red River Authority of Texas, Palo Duro River Authority, Cactus, Stratford, Texhoma	No	$838,000	Yes	Action aligns with goals and meets TWDB guidance
011000032	Dallam County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Dallam	11090102, 11090103, 11090104, 11100101, 11100103, 11100104	-	Punta de Agua, Rita Blanca, Carrizo, Upper Beaver, Coldwater, Palo Duro	1510.5	Riverine and Playa	Dallam	Moore, Hartley, Sherman, Dallam, Panhandle Regional Planning Commission, Red River Authority of Texas, Dalhart, Texline	No	$1,297,000	Yes	Action aligns with goals and meets TWDB guidance
011000033	Lipscomb County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Lipscomb	11090106, 11090201, 11100201, 11100202, 11100203	-	Middle Canadian-Spring, Lower Canadian-Deer, Lower Beaver, Upper Wolf, Lower Wolf	936.3	Riverine and Playa	Lipscomb	Hemphill, Roberts, Lipscomb, Ochiltree, Panhandle Regional Planning Commission, Red River Authority of Texas, Follett, Darrouzett, Higgins, Booker	No	$924,000	Yes	Action aligns with goals and meets TWDB guidance
011000034	Ochiltree County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Ochiltree	11090106, 11100102, 11100104, 11100201, 11100202	-	Middle Canadian-Spring, Middle Beaver, Palo Duro, Lower Beaver, Upper Wolf	922.5	Riverine and Playa	Ochiltree	Roberts, Hutchinson, Lipscomb, Ochiltree, Hansford, Panhandle Regional Planning Commission, Red River Authority of Texas, Palo Duro River Authority, Booker, Perryton	No	$859,000	Yes	Action aligns with goals and meets TWDB guidance

FME ID	FME Name	Description	Associated Goals	Counties	HUC8s	HUC12s	Watershed Name	FME Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Study Cost ($)	RFPG Recommendation (Y/N)	Reason for Recommendation
011000035	Hansford County FIS	Perform flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Hansford	11090106, 11100103, 11100104, 11100202	-	Middle Canadian-Spring, Coldwater, Palo Duro, Palo Duro	923.9	Riverine and Playa	Hansford	Roberts, Hutchinson, Moore, Sherman, Ochiltree, Hansford, Panhandle Regional Planning Commission, Red River Authority of Texas, Palo Duro River Authority, Spearman, Gruver	No	$841,000	Yes	Action aligns with goals and meets TWDB guidance
011000036	Cooke County FIS	Update flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Cooke	11130201	111302010508, 111302010701, 111302010702, 111302010703, 111302010704, 111302010705, 111302010707, 111302010708	Farmers-Mud	177.1	Riverine	Cooke	Cooke, Montague, Nortex Regional Planning Commission, Texoma Council of Governments, Red River Authority of Texas, Greater Texoma Utility Authortiy, Gainesville, Lindsay	No	$917,000	Yes	Action aligns with goals and meets TWDB guidance
011000037	Montague County FIS	Update flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Montague	11130201, 11130209, 12030103	-	Farmers-Mud, Little Wichita, Elm Fork Trinity	529.4	Riverine	Montague	Cooke, Montague, Clay, Nortex Regional Planning Commission, Texoma Council of Governments, Red River Authority of Texas, Clear Creek Watershed Authority, Farmers Creek Watershed Authority, Bowie Water Supply District, St. Jo, Bowie, Nocona	No	$981,000	Yes	Action aligns with goals and meets TWDB guidance
011000038	Wichita County FIS	Update flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Wichita	11130102, 11130206, 11130207, 11130209	-	Blue-China, Wichita, Southern Beaver, Southern Beaver	617.3	Riverine and Playa	Wichita	Clay, Wichita, Wilbarger, Baylor, Archer, Nortex Regional Planning Commission, Red River Authority of Texas, Archer County MUD 1, Wichita County Water Improvement District 2, Burkburnett, Electra, Pleasant Valley, Iowa Park, Wichita Falls, Cashion Community, Lakeside City	No	$643,000	Yes	Action aligns with goals and meets TWDB guidance
011000039	Hale County FIS	Update flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Hale	11120104, 11130103	111201040602, 111301030202	Tule, North Pease	7.0	Riverine and Playa	Hale	Floyd, Hale, Swisher, Panhandle Regional Planning Commission, South Plains Association of Governments, Red River Authority of Texas, Brazos River Authority	No	$1,076,000	Yes	Action aligns with goals and meets TWDB guidance
011000040	Potter County FIS	Update flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Potter	11090105, 11120102, 11120103, 11120301	-	Lake Meredith, Palo Duro, Upper Prairie Dog Town Fork Red, Upper Prairie Dog Town Fork Red	922.8	Riverine and Playa	Potter	Carson, Potter, Oldham, Moore, Armstrong, Randall, Deaf Smith, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Palo Duro River Authority, Llano Estacado Water District, Potter County FWSD 1, Amarillo, Bishop Hills	No	$929,000	Yes	Action aligns with goals and meets TWDB guidance
011000041	Randall County FIS	Update flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Randall	11090105, 11120101, 11120102, 11120103, 11120104, 11120301	-	Lake Meredith, Tierra Blanca, Palo Duro, Upper Prairie Dog Town Fork Red, Tule, Upper North Fork Red	922.3	Riverine and Playa	Randall	Carson, Potter, Oldham, Swisher, Castro, Armstrong, Randall, Deaf Smith, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Llano Estacado Water District, Randall County MUD 1, Amarillo, Happy, Palisades, Timbercreek Canyon, Canyon, Lake Tanglewood	No	$872,000	Yes	Action aligns with goals and meets TWDB guidance
011000042	Gray County FIS	Update flood insurance study for the county and develop regulatory mapping	01000001, 01000002	Gray	11090106, 11120201, 11120301, 11120302, 11120304, 11130301	-	Middle Canadian-Spring, Upper Salt Fork Red, Upper North Fork Red, Middle North Fork Red, Elm Fork Red, Washita Headwaters	930.6	Riverine and Playa	Gray	Carson, Hemphill, Roberts, Collingsworth, Donley, Armstrong, Wheeler, Gray, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Wheeler County Water Supply District, Gray County MUD 1, Greenbelt Municipal & Industrial Water Authority, Pampa, Lefors, McLean	No	$908,000	Yes	Action aligns with goals and meets TWDB guidance
011000043	Cooke County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Cooke	11130201	111302010508, 111302010701, 111302010702, 111302010703, 111302010704, 111302010705, 111302010707, 111302010708	Farmers-Mud	177.1	Riverine	Cooke	Cooke, Montague, Nortex Regional Planning Commission, Texoma Council of Governments, Red River Authority of Texas, Greater Texoma Utility Authortiy, Gainesville, Lindsay	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000044	Montague County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Montague	11130201, 11130209, 12030103	-	Farmers-Mud, Little Wichita, Elm Fork Trinity	529.4	Riverine	Montague	Cooke, Montague, Clay, Nortex Regional Planning Commission, Texoma Council of Governments, Red River Authority of Texas, Clear Creek Watershed Authority, Farmers Creek Watershed Authority, Bowie Water Supply District, St. Jo, Bowie, Nocona	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000045	Floyd County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; survey responses report issues with rivers, creeks, tributaries, and functioning floodplains	01000001, 01000002, 01000005, 01000006	Floyd	11130103, 11130104	-	North Pease, Middle Pease	583.9	Riverine and Playa	Floyd	Motley, Floyd, Hale, Dickens, Crosby, Briscoe, Swisher, Panhandle Regional Planning Commission, South Plains Association of Governments, Red River Authority of Texas, Brazos River Authority, Lockney	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000046	Wilbarger County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Wilbarger	11130101, 11130102, 11130105, 11130206, 11130207	-	Groesbeck-Sandy, Blue-China, Pease, Wichita, Southern Beaver	975.5	Riverine	Wilbarger	Wichita, Foard, Wilbarger, Hardeman, Baylor, Archer, Nortex Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Electra, Vernon	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000047	Dickens County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; survey responses report issues with rivers, creeks, tributaries, and functioning floodplains	01000001, 01000002, 01000005, 01000006	Dickens	11130104, 11130204, 11130205	111301040202, 111301040203, 111301040206, 111301040207, 111301040208, 111301040209, 111301040210, 111301040301, 111301040303, 111302040101, 111302040102, 111302050101, 111302050102, 111302050103, 111302050105	Middle Pease, North Wichita, South Wichita	330.9	Riverine and Playa	Dickens	Cottle, Motley, Floyd, King, Dickens, Crosby, Nortex Regional Planning Commission, South Plains Association of Governments, Red River Authority of Texas, Brazos River Authority, Dickens County WCID 1	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000048	Archer County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; survey responses report issues with rivers, creeks, tributaries, and functioning floodplains	01000001, 01000002, 01000005, 01000006	Archer	11130206, 11130209	-	Wichita, Little Wichita	787.8	Riverine and Playa	Archer	Young, Clay, Wichita, Wilbarger, Baylor, Archer, Nortex Regional Planning Commission, Red River Authority of Texas, Brazos River Authority, Archer County MUD 1, Wichita County Water Improvement District 2, Windthorst, Megargel, Scotland, Archer City, Holliday, Lakeside City	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000049	Carson County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Carson	11090105, 11090106, 11120103, 11120201, 11120301	-	Lake Meredith, Middle Canadian-Spring, Upper Prairie Dog Town Fork Red, Upper Salt Fork Red, Upper North Fork Red	925.2	Riverine and Playa	Carson	Carson, Potter, Roberts, Hutchinson, Moore, Donley, Armstrong, Randall, Gray, Panhandle Regional Planning Commission, Red River Authority of Texas, Palo Duro River Authority, White Deer, Skellytown, Panhandle, Groom	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000050	Potter County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Potter	11090105, 11120102, 11120103, 11120301	-	Lake Meredith, Palo Duro, Upper Prairie Dog Town Fork Red, Upper Prairie Dog Town Fork Red	922.8	Riverine and Playa	Potter	Carson, Potter, Oldham, Moore, Armstrong, Randall, Deaf Smith, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Palo Duro River Authority, Llano Estacado Water District, Potter County FWSD 1, Amarillo, Bishop Hills	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000051	Roberts County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Roberts	11090106, 11120302, 11130301	-	Middle Canadian-Spring, Middle North Fork Red, Washita Headwaters	925.4	Riverine and Playa	Roberts	Carson, Hemphill, Roberts, Hutchinson, Wheeler, Gray, Lipscomb, Ochiltree, Hansford, Panhandle Regional Planning Commission, Red River Authority of Texas, Roberts County FWSD 1, Miami	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000052	Hutchinson County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Hutchinson	11090105, 11090106, 11100104, 11100202	-	Lake Meredith, Middle Canadian-Spring, Palo Duro, Palo Duro	896.9	Riverine and Playa	Hutchinson	Carson, Roberts, Hutchinson, Moore, Sherman, Ochiltree, Hansford, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Palo Duro River Authority, Borger, Fritch, Sanford, Stinnett	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance

FME ID	FME Name	Description	Associated Goals	Counties	HUC8s	HUC12s	Watershed Name	FME Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Study Cost ($)	RFPG Recommendation (Y/N)	Reason for Recommendation
011000053	Hartley County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Hartley	11090101, 11090102, 11090103, 11090104, 11090105, 11100103, 11100104	-	Middle Canadian-Trujillo, Punta de Agua, Rita Blanca, Carrizo, Lake Meredith, Coldwater, Palo Duro	1466.1	Riverine and Playa	Hartley	Oldham, Moore, Hartley, Sherman, Dallam, Panhandle Regional Planning Commission, Red River Authority of Texas, Channing, Dalhart	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000054	Childress County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Childress	11120105, 11130101, 11130103, 11130105	-	Lower Prairie Dog Town Fork Red, Groesbeck-Sandy, North Pease, North Pease	713.1	Riverine and Playa	Childress	Cottle, Hardeman, Childress, Hall, Collingsworth, Nortex Regional Planning Commission, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Childress	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000055	Hall County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Hall	11120103, 11120105, 11130103	-	Upper Prairie Dog Town Fork Red, Lower Prairie Dog Town Fork Red, North Pease	903.4	Riverine and Playa	Hall	Cottle, Motley, Childress, Hall, Briscoe, Collingsworth, Donley, Nortex Regional Planning Commission, Panhandle Regional Planning Commission, South Plains Association of Governments, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Lakeview, Memphis, Estelline, Turkey	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000056	Swisher County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; survey responses report issues with rivers, creeks, tributaries, and functioning floodplains and playa lakes.	01000001, 01000002, 01000005, 01000006	Swisher	11120103, 11120104, 11130103	-	Upper Prairie Dog Town Fork Red, Tule, North Pease	827.5	Riverine and Playa	Swisher	Floyd, Hale, Briscoe, Swisher, Castro, Armstrong, Randall, Panhandle Regional Planning Commission, South Plains Association of Governments, Red River Authority of Texas, Brazos River Authority, Mackenzie Municipal Water Authority, Tulia, Kress, Happy	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000057	Randall County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Randall	11090105, 11120101, 11120102, 11120103, 11120104, 11120301	-	Lake Meredith, Tierra Blanca, Palo Duro, Upper Prairie Dog Town Fork Red, Tule, Upper North Fork Red	922.3	Riverine and Playa	Randall	Carson, Potter, Oldham, Swisher, Castro, Armstrong, Randall, Deaf Smith, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Llano Estacado Water District, Randall County MUD 1, Amarillo, Happy, Palisades, Timbercreek Canyon, Canyon, Lake Tanglewood	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000058	Wheeler County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Wheeler	11120202, 11120301, 11120302, 11120304, 11130301	-	Lower Salt Fork Red, Upper North Fork Red, Middle North Fork Red, Elm Fork Red, Washita Headwaters	916.0	Riverine and Playa	Wheeler	Hemphill, Roberts, Collingsworth, Donley, Wheeler, Gray, Panhandle Regional Planning Commission, Red River Authority of Texas, Wheeler County Water Supply District, Greenbelt Municipal & Industrial Water Authority, Mobeetie, Shamrock, Wheeler	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000059	Dallam County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Dallam	11090102, 11090103, 11090104, 11100101, 11100103, 11100104	-	Punta de Agua, Rita Blanca, Carrizo, Upper Beaver, Coldwater, Palo Duro	1510.5	Riverine and Playa	Dallam	Moore, Hartley, Sherman, Dallam, Panhandle Regional Planning Commission, Red River Authority of Texas, Dalhart, Texline	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000060	Lipscomb County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Lipscomb	11090106, 11090201, 11100201, 11100202, 11100203	-	Middle Canadian-Spring, Lower Canadian-Deer, Lower Beaver, Upper Wolf, Lower Wolf	936.3	Riverine and Playa	Lipscomb	Hemphill, Roberts, Lipscomb, Ochiltree, Panhandle Regional Planning Commission, Red River Authority of Texas, Follett, Darrouzett, Higgins, Booker	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000061	Ochiltree County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Ochiltree	11090106, 11100102, 11100104, 11100201, 11100202	-	Middle Canadian-Spring, Middle Beaver, Palo Duro, Lower Beaver, Upper Wolf	922.5	Riverine and Playa	Ochiltree	Roberts, Hutchinson, Lipscomb, Ochiltree, Hansford, Panhandle Regional Planning Commission, Red River Authority of Texas, Palo Duro River Authority, Booker, Perryton	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000062	Quitaque City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis	01000001, 01000002, 01000005, 01000006	Briscoe	11130103	111301030209, 111301030304	North Pease	0.7	Riverine and Playa	Quitaque	Briscoe, Panhandle Regional Planning Commission, Red River Authority of Texas, Quitaque	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000063	Jolly City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis	01000001, 01000002, 01000005, 01000006	Clay	11130209	111302090503, 111302090504, 111302090505	Little Wichita	1.4	Riverine	Jolly	Clay, Nortex Regional Planning Commission, Red River Authority of Texas, Dean, Jolly	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000064	Clarendon City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis and survey responses reporting issues with rivers, creeks, tributaries, and functioning floodplains and playa lakes.	01000001, 01000002, 01000005, 01000006	Donley	11120201	111202010203, 111202010204	Upper Salt Fork Red	3.0	Riverine and Playa	Clarendon	Donley, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Clarendon	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000065	Lake Tanglewood City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs and the needs analysis	01000001, 01000002, 01000005, 01000006	Randall	11120103	111201030103	Upper Prairie Dog Town Fork Red	1.8	Riverine and Playa	Randall, Lake Tanglewood	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Palisades, Lake Tanglewood	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000066	Palisades City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis and survey responses reporting issues with rivers, creeks, tributaries, and functioning floodplains	01000001, 01000002, 01000005, 01000006	Randall	11120103	111201030102, 111201030103	Upper Prairie Dog Town Fork Red	0.5	Riverine and Playa	Randall, Palisades	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Palisades, Timbercreek Canyon	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000067	Lakeview City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis	01000001, 01000002, 01000005, 01000006	Hall	11120105	111201050206	Lower Prairie Dog Town Fork Red	0.2	Riverine	Lakeview	Hall, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Lakeview	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000068	Windthorst City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Clay, Archer	11130209	111302090301, 111302090302	Little Wichita	2.3	Riverine	Windthorst	Clay, Archer, Nortex Regional Planning Commission, Red River Authority of Texas, Windthorst	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000069	Petrolia City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis	01000001, 01000002, 01000005, 01000006	Clay	11130206, 11130209	111302060502, 111302060503, 111302090508	Wichita, Little Wichita	0.8	Riverine	Petrolia	Clay, Nortex Regional Planning Commission, Red River Authority of Texas, Petrolia	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000070	Cashion City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis	01000001, 01000002, 01000005, 01000006	Wichita	11130102, 11130206	111301020304, 111302060501	Blue-China, Wichita	1.8	Riverine	Cashion Community	Wichita, Nortex Regional Planning Commission, Red River Authority of Texas, Burkburnett, Cashion Community	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance

FME ID	FME Name	Description	Associated Goals	Counties	HUC8s	HUC12s	Watershed Name	FME Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Study Cost ($)	RFPG Recommendation (Y/N)	Reason for Recommendation
011000071	Canadian City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Hemphill	11090106	110901060801	Middle Canadian-Spring	1.4	Riverine	Canadian	Hemphill, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000072	Pampa City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis	01000001, 01000002, 01000005, 01000006	Gray	11090106, 11120301	110901060601, 110901060602, 111203010303	Middle Canadian-Spring, Upper North Fork Red	8.9	Riverine and Playa	Pampa	Gray, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Gray County MUD 1, Pampa	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000073	Pleasant Valley City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis and survey responses reporting issues with rivers, creeks, tributaries, and functioning floodplains	01000001, 01000002, 01000005, 01000006	Wichita	11130206	111302060406, 111302060407	Wichita	2.6	Riverine	Pleasant Valley	Wichita, Nortex Regional Planning Commission, Red River Authority of Texas, Wichita County Water Improvement District 2, Pleasant Valley, Wichita Falls	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000074	Tulia City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on survey responses	01000001, 01000002, 01000005, 01000006	Swisher	11120104	111201040204, 111201040205, 111201040206, 111201040304	Tule	3.6	Riverine and Playa	Tulia	Swisher, Panhandle Regional Planning Commission, Red River Authority of Texas, Tulia	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000075	Shamrock City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis and survey responses reporting issues with rivers, creeks, tributaries, and functioning floodplains, wetlands, and playa lakes.	01000001, 01000002, 01000005, 01000006	Wheeler	11120302, 11120304	111203020104, 111203040105	Middle North Fork Red, Elm Fork Red	1.9	Riverine	Shamrock	Wheeler, Panhandle Regional Planning Commission, Red River Authority of Texas, Wheeler County Water Supply District, Shamrock	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000076	Holliday City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs and the needs analysis	01000001, 01000002, 01000005, 01000006	Archer	11130206	111302060302, 111302060303, 111302060405	Wichita	2.5	Riverine	Holliday	Archer, Nortex Regional Planning Commission, Red River Authority of Texas, Holliday	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000077	Silverton City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on survey responses reporting issues with many natural features	01000001, 01000002, 01000005, 01000006	Briscoe	11130103	111301030101	North Pease	1.0	Playa	Silverton	Briscoe, Panhandle Regional Planning Commission, Red River Authority of Texas, Silverton	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000078	Hereford City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on survey responses	01000001, 01000002, 01000005, 01000006	Deaf Smith	11120101	111201010505, 111201010507	Tierra Blanca	5.7	Riverine and Playa	Hereford	Deaf Smith, Panhandle Regional Planning Commission, Red River Authority of Texas, Hereford	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000079	Scotland City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Clay, Archer	11130209	111302090207, 111302090208, 111302090301, 111302090302, 111302090304	Little Wichita	10.0	Riverine	Scotland	Clay, Archer, Nortex Regional Planning Commission, Red River Authority of Texas, Scotland	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000080	Lefors City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on survey responses reporting issues with rivers, creeks, tributaries, and functioning floodplains	01000001, 01000002, 01000005, 01000006	Gray	11120301	111203010305	Upper North Fork Red	0.3	Riverine	Lefors	Gray, Panhandle Regional Planning Commission, Red River Authority of Texas, Lefors	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000081	Burkburnett City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis	01000001, 01000002, 01000005, 01000006	Wichita	11130102	111301020302, 111301020304, 111301020305	Blue-China	11.1	Riverine	Burkburnett	Wichita, Nortex Regional Planning Commission, Red River Authority of Texas, Burkburnett	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000082	Amarillo City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Update existing drainage mater plan.	01000001, 01000002, 01000005, 01000006	Potter, Randall	11090105, 11120103, 11120301	110901050308, 110901050309, 110901050402, 111201030101, 111201030102, 111201030106, 111201030107, 111203010101, 111203010102	Lake Meredith, Upper Prairie Dog Town Fork Red, Upper North Fork Red	101.6	Riverine and Playa	Randall, Amarillo	Potter, Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$1,000,000	Yes	Action aligns with goals and meets TWDB guidance
011000083	Nocona City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on survey responses	01000001, 01000002, 01000005, 01000006	Montague	11130201	111302010209, 111302010502	Farmers-Mud	2.7	Riverine	Nocona	Montague, Nortex Regional Planning Commission, Red River Authority of Texas, Nocona	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000084	Vega City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on survey responses	01000001, 01000002, 01000005, 01000006	Oldham	11090105, 11120102	110901050101, 111201020205, 111201020206	Lake Meredith, Palo Duro	1.1	Riverine	Vega	Oldham, Panhandle Regional Planning Commission, Red River Authority of Texas, Llano Estacado Water District, Vega	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000085	Seymour City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on survey responses reporting issues with rivers, creeks, tributaries, and functioning floodplains. Only a small portion of the city is within the region.	01000001, 01000002, 01000005, 01000006	Baylor	11130206	111302060104, 111302060106	Wichita	0.1	None	Seymour	Baylor, Nortex Regional Planning Commission, Red River Authority of Texas, Seymour	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000086	Darrouzett City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on survey responses reporting issues with rivers, creeks, tributaries, and functioning floodplains	01000001, 01000002, 01000005, 01000006	Lipscomb	11100201	111002010306	Lower Beaver	0.4	Riverine	Darrouzett	Lipscomb, Panhandle Regional Planning Commission, Red River Authority of Texas, Darrouzett	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000087	Spearman City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis and survey responses reporting issues with rivers, creeks, tributaries, and functioning floodplains	01000001, 01000002, 01000005, 01000006	Hansford	11100104	111001040311, 111001040312	Palo Duro	1.8	Riverine and Playa	Spearman	Hansford, Panhandle Regional Planning Commission, Palo Duro River Authority, Spearman	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000088	Vernon City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis	01000001, 01000002, 01000005, 01000006	Wilbarger	11130105	111301050204, 111301050206	Pease	8.1	Riverine	Vernon	Wilbarger, Nortex Regional Planning Commission, Red River Authority of Texas, Vernon	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000089	Iowa Park City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on survey responses and the needs analysis	01000001, 01000002, 01000005, 01000006	Wichita	11130206	111302060404, 111302060406	Wichita	4.5	Riverine	Iowa Park	Wichita, Nortex Regional Planning Commission, Red River Authority of Texas, Wichita County Water Improvement District 2, Iowa Park	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000090	Childress City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Childress	11120105, 11130101, 11130103	111201050302, 111201050308, 111201050501, 111301010101, 111301030504	Lower Prairie Dog Town Fork Red, Groesbeck-Sandy, North Pease	7.7	Riverine	Childress	Childress, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Childress	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000091	Perryton City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs and survey responses	01000001, 01000002, 01000005, 01000006	Ochiltree	11100201	111002010201, 111002010301, 111002010302	Lower Beaver	4.4	Riverine and Playa	Perryton	Ochiltree, Panhandle Regional Planning Commission, Perryton	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000092	Megargel City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Archer	11130209	111302090105	Little Wichita	0.4	None	Megargel	Archer, Nortex Regional Planning Commission, Red River Authority of Texas, Megargel	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance

FME ID	FME Name	Description	Associated Goals	Counties	HUC8s	HUC12s	Watershed Name	FME Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Study Cost ($)	RFPG Recommendation (Y/N)	Reason for Recommendation
011000093	Groom City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Carson	11120201, 11120301	111202010104, 111203010201	Upper Salt Fork Red, Upper North Fork Red	0.7	Riverine and Playa	Groom	Carson, Panhandle Regional Planning Commission, Red River Authority of Texas, Groom	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000094	White Deer City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Carson	11120301	111203010301	Upper North Fork Red	1.7	Riverine and Playa	White Deer	Carson, Panhandle Regional Planning Commission, Red River Authority of Texas, White Deer	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000095	Timbercreek Canyon City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis	01000001, 01000002, 01000005, 01000006	Randall	11120103	111201030102, 111201030103	Upper Prairie Dog Town Fork Red	1.4	Riverine and Playa	Randall, Timbercreek Canyon	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Palisades, Timbercreek Canyon	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000096	Electra City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis	01000001, 01000002, 01000005, 01000006	Wichita	11130102, 11130206, 11130207	111301020203, 111302060403, 111302070402	Blue-China, Wichita, Southern Beaver	2.9	Riverine	Electra	Wichita, Nortex Regional Planning Commission, Red River Authority of Texas, Electra	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000097	Lakeside City City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs and the needs analysis	01000001, 01000002, 01000005, 01000006	Wichita, Archer	11130206	111302060303	Wichita	0.6	Riverine and Playa	Lakeside City	Wichita, Archer, Nortex Regional Planning Commission, Red River Authority of Texas, Lakeside City	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000098	Wichita Falls City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Update existing drainage mater plan. Selected based on survey responses and needs analysis.	01000001, 01000002, 01000005, 01000006	Wichita	11130206, 11130209	111302060303, 111302060304, 111302060406, 111302060407, 111302060501, 111302090502, 111302090503	Wichita, Little Wichita	71.6	Riverine and Playa	Wichita Falls	Wichita, Nortex Regional Planning Commission, Red River Authority of Texas, Wichita County Water Improvement District 2, Pleasant Valley, Wichita Falls	No	$1,000,000	Yes	Action aligns with goals and meets TWDB guidance
011000099	Dalhart City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on the needs analysis	01000001, 01000002, 01000005, 01000006	Hartley, Dallam	11090103	110901030405, 110901030406, 110901030408	Rita Blanca	4.7	Riverine and Playa	Dalhart	Hartley, Dallam, Panhandle Regional Planning Commission, Red River Authority of Texas, Dalhart	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000100	Skelleytown City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Carson	11090106	110901060302, 110901060307	Middle Canadian-Spring	0.5	None	Skellytown	Carson, Panhandle Regional Planning Commission, Red River Authority of Texas, Skellytown	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000101	Panhandle City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Carson	11120301	111203010105, 111203010107	Upper North Fork Red	2.2	Riverine and Playa	Panhandle	Carson, Panhandle Regional Planning Commission, Red River Authority of Texas, Panhandle	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000102	City of Clarendon GIS Development	Develop GIS inventory and condition assessment for flood infrastructure; selected based on survey response	01000001, 01000002	Donley	11120201	111202010203, 111202010204	Upper Salt Fork Red	3.0	Riverine and Playa	Clarendon	Donley, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Clarendon	No	$50,000	Yes	Action aligns with goals and meets TWDB guidance
011000103	City of Palisades GIS Development	Develop GIS inventory and condition assessment for flood infrastructure; selected based on survey response	01000001, 01000002	Randall	11120103	111201030102, 111201030103	Upper Prairie Dog Town Fork Red	0.5	Riverine and Playa	Randall, Palisades	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Palisades, Timbercreek Canyon	No	$50,000	Yes	Action aligns with goals and meets TWDB guidance
011000104	City of Shamrock GIS Development	Develop GIS inventory and condition assessment for flood infrastructure; selected based on survey response	01000001, 01000002	Wheeler	11120302, 11120304	111203020104, 111203040105	Middle North Fork Red, Elm Fork Red	1.9	Riverine	Shamrock	Wheeler, Panhandle Regional Planning Commission, Red River Authority of Texas, Wheeler County Water Supply District, Shamrock	No	$50,000	Yes	Action aligns with goals and meets TWDB guidance
011000105	City of Silverton GIS Development	Develop GIS inventory and condition assessment for flood infrastructure; selected based on survey response	01000001, 01000002	Briscoe	11130103	111301030101	North Pease	1.0	Playa	Silverton	Briscoe, Panhandle Regional Planning Commission, Red River Authority of Texas, Silverton	No	$50,000	Yes	Action aligns with goals and meets TWDB guidance
011000106	City of Lefors GIS Development	Develop GIS inventory and condition assessment for flood infrastructure; selected based on survey response	01000001, 01000002	Gray	11120301	111203010305	Upper North Fork Red	0.3	Riverine	Lefors	Gray, Panhandle Regional Planning Commission, Red River Authority of Texas, Lefors	No	$50,000	Yes	Action aligns with goals and meets TWDB guidance
011000107	City of Fritch GIS Development	Develop GIS inventory and condition assessment for flood infrastructure; selected based on survey response	01000001, 01000002	Hutchinson, Moore	11090105, 11090106	110901050707, 110901050708, 110901060105	Lake Meredith, Middle Canadian-Spring	1.6	Riverine and Playa	Fritch	Hutchinson, Moore, Panhandle Regional Planning Commission, Red River Authority of Texas, Palo Duro River Authority, Fritch	No	$50,000	Yes	Action aligns with goals and meets TWDB guidance
011000108	City of Seymour GIS Development	Develop GIS inventory and condition assessment for flood infrastructure; selected based on survey response. Only a small portion of the city is within the region.	01000001, 01000002	Baylor	11130206	111302060104, 111302060106	Wichita	0.1	None	Seymour	Baylor, Nortex Regional Planning Commission, Red River Authority of Texas, Seymour	No	$50,000	Yes	Action aligns with goals and meets TWDB guidance
011000109	City of Spearman GIS Development	Develop GIS inventory and condition assessment for flood infrastructure; selected based on survey response	01000001, 01000002	Hansford	11100104	111001040311, 111001040312	Palo Duro	1.8	Riverine and Playa	Spearman	Hansford, Panhandle Regional Planning Commission, Palo Duro River Authority, Spearman	No	$50,000	Yes	Action aligns with goals and meets TWDB guidance
011000110	City of Perryton GIS Development	Develop GIS inventory and condition assessment for flood infrastructure; selected based on survey response	01000001, 01000002	Ochiltree	11100201	111002010201, 111002010301, 111002010302	Lower Beaver	4.4	Riverine and Playa	Perryton	Ochiltree, Panhandle Regional Planning Commission, Perryton	No	$50,000	Yes	Action aligns with goals and meets TWDB guidance
011000111	City of Dalhart GIS Development	Develop GIS inventory and condition assessment for flood infrastructure; selected based on survey response	01000001, 01000002	Hartley, Dallam	11090103	110901030405, 110901030406, 110901030408	Rita Blanca	4.7	Riverine and Playa	Dalhart	Hartley, Dallam, Panhandle Regional Planning Commission, Red River Authority of Texas, Dalhart	No	$50,000	Yes	Action aligns with goals and meets TWDB guidance
011000112	City of Panhandle GIS Development	Develop GIS inventory and condition assessment for flood infrastructure; selected based on survey response	01000001, 01000002	Carson	11120301	111203010105, 111203010107	Upper North Fork Red	2.2	Riverine and Playa	Panhandle	Carson, Panhandle Regional Planning Commission, Red River Authority of Texas, Panhandle	No	$50,000	Yes	Action aligns with goals and meets TWDB guidance
011000113	Potter County GIS Development	Develop GIS inventory and condition assessment for flood infrastructure; selected based on survey response	01000001, 01000002	Potter	11090105, 11120102, 11120103, 11120301	-	Lake Meredith, Palo Duro, Upper Prairie Dog Town Fork Red, Upper Prairie Dog Town Fork Red	922.8	Riverine and Playa	Potter	Carson, Potter, Oldham, Moore, Armstrong, Randall, Deaf Smith, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Palo Duro River Authority, Llano Estacado Water District, Potter County FWSD 1, Amarillo, Bishop Hills	No	$50,000	Yes	Action aligns with goals and meets TWDB guidance
011000114	Region-Wide Dam Safety	Coordinate region-wide investigation into current dam safety status; selected based on stakeholder feedback	01000007, 01000008	-	-	-	-	34626.1	Riverine and Playa	Panhandle Regional Planning Commission	-	No	$1,718,000	Yes	Action aligns with goals and meets TWDB guidance
011000115	Farmers Creek Watershed Authority Dam Evaluation	Investigate survey responses of deficient or non-functioning flood protection dams	01000007, 01000008	Montague	11130201	111302010209, 111302010502, 111302010504, 111302010505, 111302010506, 111302010507, 111302010508, 111302010701	Farmers-Mud	121.0	Riverine	Farmers Creek Watershed Authority	Montague, Nortex Regional Planning Commission, Red River Authority of Texas, Clear Creek Watershed Authority, Farmers Creek Watershed Authority	No	$517,000	Yes	Action aligns with goals and meets TWDB guidance
011000116	East Amarillo Creek Project Planning - St. Francis Ave. Tributary Channel Reach (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements include installing 5-barrel, 5'x3' concrete boxes, and improving the channel. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050402	Lake Meredith	19.0	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000117	East Amarillo Creek Project Planning - Echo Street Tributary Channel Reach (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements include replacing it with a concrete box, installing additional concrete boxes, raising the road, and improving the channel. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050402	Lake Meredith	19.0	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000118	Comanche Drainage Channel (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements to Comanche Drainage Channel. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030106	Upper Prairie Dog Town Fork Red	10.8	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000119	Culverts: Various Locations (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements to culverts. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050402	Lake Meredith	19.0	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance

FME ID	FME Name	Description	Associated Goals	Counties	HUC8s	HUC12s	Watershed Name	FME Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Study Cost ($)	RFPG Recommendation (Y/N)	Reason for Recommendation
011000120	West Amarillo Creek Project Planning - Amarillo Country Club Channel Reach (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvement includes installing and replacing concrete boxes, improving the channel, and replacing 2 driveway structures. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050308	Lake Meredith	10.2	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000121	West Amarillo Creek Project Planning - Partridge/Cloud Crest Channel Reach (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements to West Amarillo Creek Study Area - Partridge/Cloud Crest Channel Reach. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050308	Lake Meredith	11.1	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000122	Quail Creek Channel from Plum Creek Storm Channel Reach (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements to Quail Creek Channel from Plum Creek Storm Channel Reach. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050308	Lake Meredith	11.1	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000123	East Amarillo Creek Project Planning - Lower East Amarillo Creek Channel Reach (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Replace four arch CMP and improve channels. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050402	Lake Meredith	19.0	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000124	East Amarillo Creek Project Planning - Hastings Ave. to River Road Channel Reach (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements include installing additional concrete boxes, a reinforced concrete bridge, and improving the channel. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050402	Lake Meredith	19.0	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000125	East Amarillo Creek Project Planning - Valley Park Tributary Channel Reach (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements include modifying and installing concrete boxes, raising roads, and improving channels. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050402	Lake Meredith	19.0	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000126	SE 34th/ Grand at Comanche Golf Course Channel (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements to SE 34th/ Grand at Comanche Golf Course Channel. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030106	Upper Prairie Dog Town Fork Red	10.8	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000127	West Amarillo Creek Project Planning - Westcliff Channel Reach (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements include 2 additional 36" RCP at Kouba Drive and improving channel from W. 9th Ave to Kouba Dr. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050308	Lake Meredith	10.2	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000128	West Amarillo Creek Project Planning - Wolfin Avenue Channel Reach (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements include additional RCPs, installing concrete boxes, improving channel, and installing RCP with inlet and outlet structure. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050308	Lake Meredith	11.1	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000129	West Amarillo Creek Project Planning - Tascosa/Westwood Channel Reach (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements to West Amarillo Creek Study Area - Tascosa/Westwood Channel Reach. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050308	Lake Meredith	10.2	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000130	East Amarillo Creek Project Planning - Ross Rogers Tributary Channel Reach (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements include replacing arch CMP with concrete boxes, raising roads, and installing an additional concrete box. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050402	Lake Meredith	19.0	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000131	Playa No. 14 Project Planning - Diamond Horseshoe Lake (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Proposed improvement include new 750 GMP pumping station with 8" suction line, and new 8" force main. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	1.7	Riverine	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000132	Playa No. 7 Project Planning (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Proposed improvements include excavating 100,000 CY, add new 3,000 GPM pumping station withsuction line, and add new force main. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	2.9	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000133	McCarty Lake Project Planning (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Excavate 900,000 CY. Raise street and install equalization culverts. Add new pumping station with suction line, and add new force main. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	6.3	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$382,000	Yes	Action aligns with goals and meets TWDB guidance
011000134	Willow Grove Project Planning (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Excavate ~5,000 CY to El. 3564.0 to connect two playa chambers. Add new 500 GPM pumping station with 8" suction line and 6" force main. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030102	Upper Prairie Dog Town Fork Red	1.7	Riverine	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000135	Bennett Lake Project Planning (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Excavate 140,000 CY, add new 5,000 GPM pumping station with suction line, add several force mains at various sizes. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	1.3	Riverine	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$556,000	Yes	Action aligns with goals and meets TWDB guidance
011000136	Lawrence Lake Project Planning (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Add new 3,000 GMP pumps at both pumps, replace 15" PV with 20", and replace 16" STL with 24". Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11120103	111201030101	Upper Prairie Dog Town Fork Red	9.1	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000137	Playa No. 34 Project Planning (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements include adding an outfall channel. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter, Randall	11120103	111201030107	Upper Prairie Dog Town Fork Red	4.1	Riverine and Playa	Randall, Amarillo	Potter, Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000138	Wild Horse Lake Project Planning (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements include adding a 30" relief culvert and a new junction box w/ flap gate. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050402	Lake Meredith	3.7	Riverine and Playa	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000139	West Amarillo Creek Project Planning - AISD/B I-40/MediPark (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements to West Amarillo Creek Study Area - AISD/B I-40/MediPark. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050308	Lake Meredith	11.1	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000140	East Amarillo Creek Project Planning - North Bolton St. Storm Sewer (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements include adding 1 new 42" RCP and 2 new 48" RCP. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050402	Lake Meredith	19.0	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000141	McCarty Lake Project Planning - Fulton/ Hampton Storm Sewer (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements to McCarty Lake Study Area - Fulton/ Hampton Storm Sewer. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	6.3	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance

FME ID	FME Name	Description	Associated Goals	Counties	HUC8s	HUC12s	Watershed Name	FME Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Study Cost ($)	RFPG Recommendation (Y/N)	Reason for Recommendation
011000142	Playa No. 4 Outfall (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements to Playa No. 4 Outfall. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120102, 11120103	111201020303, 111201030101	Palo Duro, Upper Prairie Dog Town Fork Red	2.9	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000143	McDonald Lake Project Planning - Wesley, Tripp/Van Winkle Storm Sewer (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements to McDonald Lake Study Area - Wesley, Tripp/Van Winkle Storm Sewer. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	1.9	Riverine	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000144	McDonald Lake Project Planning - Walmart/ Lowes Storm Sewer (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements to McDonald Lake Study Area - Walmart/ Lowes Storm Sewer. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	1.9	Riverine	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000145	Lawrence Lake Outfall (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Project improvements include 2 inlet boxes and parallel relief line that will outfall at the current cascaded outfall. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter, Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	9.1	Riverine	Randall, Amarillo	Potter, Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000146	Playa No. 7 Coulter/Loop 335 Storm Sewer (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements to Playa No. 7 Coulter/Loop 335 Storm Sewer. System takes flow from Playa watersheds 11 and 14 and outflows to Playa 7. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	4.6	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000147	McCarty Lake Project Planning - Downstream I-27 (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Proposed improvements consist of constructing a relief interceptor sized to take storm flows to McCarty Lake. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	6.3	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$383,000	Yes	Action aligns with goals and meets TWDB guidance
011000148	McCarty Lake Project Planning - Hillside/Hampton Storm Sewer (1B) (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Proposed improvements include adding storm drain, adding parallel system, and then connecting to the existing crossing. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11090105, 11120103	110901050308, 111201030101	Lake Meredith, Upper Prairie Dog Town Fork Red	6.3	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000149	Willow Grove Project Planning - Rushmore/Hayden Storm Sewer (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Replace four pipes with 60" or 66" pipes. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030102	Upper Prairie Dog Town Fork Red	1.7	Riverine	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000150	Gooch Lake Project Planning - 27th Ave/RR Storm Sewer (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements include adding inlets, a 24" RCP lateral, and a manhole. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11120103	111201030106	Upper Prairie Dog Town Fork Red	10.8	Riverine and Playa	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000151	Wild Horse Lake Project Planning - ONG/Lipscomb Storm Sewer (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements include replacing 5 pipes with larger diameters, adding two RCP, and adding a new diversion structure. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105, 11120103	110901050402, 111201030101	Lake Meredith, Upper Prairie Dog Town Fork Red	3.7	Riverine and Playa	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000152	McDonald Lake Project Planning - Coulter Street Storm Sewer (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements include adding 36" RCP parallel to several pipes, adding 6 new RCP, and replacing the 72" RCP with a 84" RCP. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	1.9	Riverine	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000153	Lawrence Lake Project Planning - Dilday Draw Storm Sewer (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements include channel improvement on several RCP, replacing a 54" and 48" RCP with 60" RCP and adding 30" PCP parallel to 72" RCP. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11120103	111201030101	Upper Prairie Dog Town Fork Red	9.1	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000154	Lawrence Lake Project Planning - Fleetwood Drive Storm Sewer (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Replace pipes with ones with larger diameters, add three new pipes, and connect two pipes in three locations. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	9.1	Riverine	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000155	Lawrence Lake Project Planning - Julian Blvd. Storm Sewer (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Proposed improvements consist of adding a major trunkline, and a lateral and inlets. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11120103	111201030101	Upper Prairie Dog Town Fork Red	9.1	Riverine	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000156	Lawrence Lake Project Planning - Olsen/Emil Storm Sewer (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Proposed improvements include new inlets and laterals, and upsizing existing laterals and trunk line through the outfall. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter, Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	9.1	Riverine	Randall, Amarillo	Potter, Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000157	Lawrence Lake Project Planning - SW 26th Avenue Storm Sewer (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Proposed improvements include adding multiple inlets and laterals and connecting them into an existing parallel line. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter, Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	9.1	Riverine	Randall, Amarillo	Potter, Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000158	Wild Horse Lake Improvement (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements to Wild Horse Lake. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050402	Lake Meredith	3.7	Riverine and Playa	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000159	McCarty Lake Project Planning - Hillside/Hampton Storm Sewer (2A) (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Proposed improvements include the interceptor and inlets and parallel storm drain to direct flow into the existing storm drain system. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11090105, 11120103	110901050308, 111201030101	Lake Meredith, Upper Prairie Dog Town Fork Red	6.3	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000160	McCarty Lake Project Planning - Hillside/Hampton Storm Sewer (2B) (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Proposed improvements include inlets and capacity, including extending the storm drain to tie into the Catalpa storm drain and outfall. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Randall	11090105, 11120103	110901050308, 111201030101	Lake Meredith, Upper Prairie Dog Town Fork Red	6.3	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000161	Playa 4 Watershed Study (City of Amarillo)	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Marked as high priority in 2019 Amarillo DMP	01000001, 01000002	Randall	11120102, 11120103	111201020303, 111201030101	Palo Duro, Upper Prairie Dog Town Fork Red	2.9	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$431,000	Yes	Action aligns with goals and meets TWDB guidance
011000162	McDonald Lake Watershed Study (City of Amarillo)	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Marked as high priority in 2019 Amarillo DMP	01000001, 01000002	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	1.9	Riverine	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$282,000	Yes	Action aligns with goals and meets TWDB guidance
011000163	Playa 8 Watershed Study (City of Amarillo)	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Marked as high priority in 2019 Amarillo DMP	01000001, 01000002	Randall	11120102, 11120103	111201020303, 111201030101	Palo Duro, Upper Prairie Dog Town Fork Red	1.9	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$284,000	Yes	Action aligns with goals and meets TWDB guidance
011000164	Lawrence Lake Watershed Study (City of Amarillo)	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Marked as very high priority in 2019 Amarillo DMP	01000001, 01000002	Potter, Randall	11090105, 11120103	110901050308, 110901050402, 111201030101, 111201030106	Lake Meredith, Upper Prairie Dog Town Fork Red	9.1	Riverine	Randall, Amarillo	Potter, Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$1,000,000	Yes	Action aligns with goals and meets TWDB guidance
011000165	Bennett Lake Watershed Study (City of Amarillo)	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Marked as very high priority in 2019 Amarillo DMP	01000001, 01000002	Randall	11120103	111201030101, 111201030102	Upper Prairie Dog Town Fork Red	1.3	Riverine	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$195,000	Yes	Action aligns with goals and meets TWDB guidance

FME ID	FME Name	Description	Associated Goals	Counties	HUC8s	HUC12s	Watershed Name	FME Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Study Cost ($)	RFPG Recommendation (Y/N)	Reason for Recommendation
011000166	Playa 11 Watershed Study (City of Amarillo)	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Marked as high priority in 2019 Amarillo DMP	01000001, 01000002	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	2.9	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$424,000	Yes	Action aligns with goals and meets TWDB guidance
011000167	Diamond Horseshoe Lake Watershed Study (City of Amarillo)	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Marked as high priority in 2019 Amarillo DMP	01000001, 01000002	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	1.7	Riverine	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$247,000	Yes	Action aligns with goals and meets TWDB guidance
011000168	McCarty Lake Watershed Study (City of Amarillo)	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Marked as high priority in 2019 Amarillo DMP	01000001, 01000002	Randall	11120103	111201030101, 111201030102	Upper Prairie Dog Town Fork Red	6.3	Riverine and Playa	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$923,000	Yes	Action aligns with goals and meets TWDB guidance
011000169	Willow Grove Lake Watershed Study (City of Amarillo)	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Marked as very high priority in 2019 Amarillo DMP	01000001, 01000002	Randall	11120103	111201030101, 111201030102	Upper Prairie Dog Town Fork Red	1.7	Riverine	Randall, Amarillo	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$246,000	Yes	Action aligns with goals and meets TWDB guidance
011000170	Playa 35 Watershed Study (City of Amarillo)	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Marked as high priority in 2019 Amarillo DMP	01000001, 01000002	Potter	11120103	111201030107, 111201030501	Upper Prairie Dog Town Fork Red	2.9	Riverine and Playa	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$420,000	Yes	Action aligns with goals and meets TWDB guidance
011000171	Wild Horse Lake Watershed Study (City of Amarillo)	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Marked as very high priority in 2019 Amarillo DMP	01000001, 01000002	Potter	11090105, 11120103	110901050308, 110901050309, 110901050402, 111201030101, 111201030106	Lake Meredith, Upper Prairie Dog Town Fork Red	3.7	Riverine and Playa	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$548,000	Yes	Action aligns with goals and meets TWDB guidance
011000172	Pump Station Rehab (City of Amarillo)	Evaluate six current pump stations to identify improvements; selected based on stakeholder feedback	01000003, 01000004	Potter, Randall	11090105, 11120103, 11120301	110901050308, 110901050309, 110901050402, 111201030101, 111201030102, 111201030106, 111201030107, 111203010101, 111203010102	Lake Meredith, Upper Prairie Dog Town Fork Red, Upper North Fork Red	101.6	Riverine and Playa	Randall, Canyon	Potter, Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$125,000	Yes	Action aligns with goals and meets TWDB guidance
011000173	Convert Playa ASAPP Models into ICPR (City of Amarillo)	Create Streamline Technologies ICPR Version 4 model of Amarillo Playas in order to more easily update and use models	01000001, 01000002	Potter, Randall	11090105, 11120103, 11120301	110901050308, 110901050309, 110901050402, 111201030101, 111201030102, 111201030106, 111201030107, 111203010101, 111203010102	Lake Meredith, Upper Prairie Dog Town Fork Red, Upper North Fork Red	101.6	Riverine and Playa	Randall, Amarillo	Potter, Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000174	Bivins Lake Dam Evaluation (City of Amarillo)	Evaluate Bivins Lake and dam to determine potential modifications to enhance flood control function; selected based on USACE report and stakeholder feedback	01000001, 01000002	Randall, Deaf Smith	11120102	111201020302	Palo Duro	32.8	Riverine and Playa	Randall, Amarillo	Randall, Deaf Smith, Panhandle Regional Planning Commission, Red River Authority of Texas	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000175	Spring Draw Watershed Study	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Marked as high priority in 2019 Amarillo DMP. Joint effort between Amarillo, Canyon, and Randall County	01000001, 01000002	Potter, Randall	11120102	111201020303	Palo Duro	43.9	Riverine and Playa	Potter, Randall, Canyon	Potter, Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Amarillo, Canyon	No	$499,000	Yes	Action aligns with goals and meets TWDB guidance
011000176	Tributary to West Amarillo Creek Watershed Study (City of Amarillo)	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects. Marked as high priority in 2019 Amarillo DMP	01000001, 01000002	Potter, Randall	11090105, 11120103	110901050308, 111201030101	Lake Meredith, Upper Prairie Dog Town Fork Red	11.1	Riverine	Randall, Amarillo	Potter, Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$1,000,000	Yes	Action aligns with goals and meets TWDB guidance
011000177	Canyon Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects, with a focus on downtown Canyon. Project identified from HMAP	01000001, 01000002, 01000005, 01000006	Randall	11120101, 11120102, 11120103	111201010609, 111201020303, 111201020304, 111201030101	Tierra Blanca, Palo Duro, Upper Prairie Dog Town Fork Red	7.1	Riverine and Playa	Randall, Canyon	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canyon	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000178	Improve Storm Water Drainage and Control Systems (City of Canyon)	Initiate a centralized data collection program to identify recurring flooding locations based on citizen complaints and road maintenance logs; selected based on stakeholder feedback	01000001, 01000002, 01000005, 01000006	Randall	11120101, 11120102, 11120103	111201010609, 111201020303, 111201020304, 111201030101	Tierra Blanca, Palo Duro, Upper Prairie Dog Town Fork Red	7.1	Riverine and Playa	Randall, Canyon	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canyon	No	$50,000	Yes	Action aligns with goals and meets TWDB guidance
011000179	Detailed Hydrologic and Hydraulic Study of the Wichita River	Perform a detailed H&H study of the Wichita River watershed with a focus on the area in and around Wichita Falls; selected based on stakeholder feedback	01000001, 01000002	Wichita, Foard, Cottle, Motley, Wilbarger, Knox, King, Dickens, Baylor, Archer	11130204, 11130205, 11130206, 11130207	-	North Wichita, South Wichita, Wichita, Wichita	3174.1	Riverine and Playa	Wichita Falls	-	No	$528,000	Yes	Action aligns with goals and meets TWDB guidance
011000180	Improve Creek Crossing (City of Palisades)	Evaluate proposed improvements (upgrade bridge and increase channel flow) to current crossing to develop a cost, quantify benefits, evaluate impacts, and begin design. Project identified from survey response.	01000005, 01000006	Randall	11120103	111201030102, 111201030103	Upper Prairie Dog Town Fork Red	0.5	Riverine and Playa	Randall, Canyon	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Palisades, Timbercreek Canyon	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000181	Clay County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Clay	11130102, 11130201, 11130206, 11130209	-	Blue-China, Farmers-Mud, Wichita, Wichita	985.0	Riverine	Clay	Montague, Clay, Wichita, Archer, Nortex Regional Planning Commission, Red River Authority of Texas, Wichita County Water Improvement District 2, Henrietta, Petrolia, Bellevue, Byers, Dean, Windthorst, Scotland, Jolly	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000182	Baylor County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on HMAPs	01000001, 01000002, 01000005, 01000006	Baylor	11130204, 11130206, 11130207, 11130209	-	North Wichita, Wichita, Southern Beaver, Southern Beaver	506.1	Riverine and Playa	Baylor	Wichita, Foard, Wilbarger, Knox, Baylor, Archer, Nortex Regional Planning Commission, West Central Texas Council of Governments, Red River Authority of Texas, Brazos River Authority, Seymour	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000183	Culverts: Various Locations (City of Amarillo)	Evaluate project to quantify benefits, evaluate impacts and begin design. Improvements to culverts. Project identified from 2019 Amarillo DMP.	01000003, 01000004	Potter	11090105	110901050402	Lake Meredith	3.7	Riverine and Playa	Amarillo	Potter, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000189	Wichita County Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on stakeholder feedback.	01000001, 01000002, 01000005, 01000006	Wichita	11130102, 11130206, 11130207, 11130209	-	Blue-China, Wichita, Southern Beaver, Southern Beaver	617.3	Riverine and Playa	Wichita	Clay, Wichita, Wilbarger, Baylor, Archer, Nortex Regional Planning Commission, Red River Authority of Texas, Archer County MUD 1, Wichita County Water Improvement District 2, Burkburnett, Electra, Pleasant Valley, Iowa Park, Wichita Falls, Cashion Community, Lakeside City	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance
011000191	Chillicothe City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on additional outreach	01000001, 01000002, 01000005, 01000006	Hardeman	11130101	111301010404	Groesbeck-Sandy	1.0	Riverine	Chillicothe	Chillicothe	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000192	Henrietta City Drainage Master Plan	Perform H&H modeling, develop conceptual alternatives and OPCC, and rank projects; selected based on additional outreach	01000001, 01000002, 01000005, 01000006	Clay	11130209	111302090507, 111302090509, 111302090506	Little Wichita	4.6	Riverine	Henrietta	Henrietta	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000193	Hazelwood SD/Stephens SD/Sterling St Culvert	Perform post-project modeling to determine if project meets no negative impact requirements and complete up to 30% design	01000001, 01000002	Hutchinson	11090106	110901060107, 110901060204	Middle Canadian-Spring	0.3	Riverine and Urban/Local	Borger	Borger	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000194	Haggard SD/Finger SD/11th St Culvert	Perform post-project modeling to determine if project meets no negative impact requirements and complete up to 30% design	01000001, 01000002	Hutchinson	11090106	110901060109, 110901060107, 110901060204	Middle Canadian-Spring	0.2	Riverine and Urban/Local	Borger	Borger	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000195	Turner SD	Perform post-project modeling to determine if project meets no negative impact requirements and complete up to 30% design	01000001, 01000002	Hutchinson	11090106	110901060109	Middle Canadian-Spring	0.1	Riverine and Urban/Local	Borger	Borger	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000196	Garrett SD/Peiffer SD/Teague SD	Perform post-project modeling to determine if project meets no negative impact requirements and complete up to 30% design	01000001, 01000002	Hutchinson	11090106	110901060204	Middle Canadian-Spring	0.1	Riverine and Urban/Local	Borger	Borger	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000197	Monroe Basin	Perform post-project modeling to determine if project meets no negative impact requirements and complete up to 30% design	01000001, 01000002	Hutchinson	11090106	110901060107, 110901060204	Middle Canadian-Spring	0.3	Riverine and Urban/Local	Borger	Borger	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000198	1st St - Main to Hedgecoke	Perform post-project modeling to determine if project meets no negative impact requirements and complete up to 30% design	01000001, 01000002	Hutchinson	11090106	110901060107, 110901060204	Middle Canadian-Spring	0.1	Riverine and Urban/Local	Borger	Borger	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance
011000199	2nd St - Hedgecoke to Bryan	Perform post-project modeling to determine if project meets no negative impact requirements and complete up to 30% design	01000001, 01000002	Hutchinson	11090106	110901060107, 110901060204	Middle Canadian-Spring	0.2	Riverine and Urban/Local	Borger	Borger	No	$250,000	Yes	Action aligns with goals and meets TWDB guidance

FME ID	FME Name	Description	Associated Goals	Counties	HUC8s	HUC12s	Watershed Name	FME Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Study Cost ($)	RFPG Recommendation (Y/N)	Reason for Recommendation
011000200	Tule Dams	Perform a watershed-wide evaluation of 1 dam to assess flood protection performance for the 100-year and 500-year events, develop breach analyses mapping and assess hazard classification, develop risk indices, and evaluate dam safety performance.	01000007	Hale, Briscoe, Swisher, Castro, Parmer, Randall, Deaf Smith	11130103, 12050005, 11120101, 11120104, 11120103	-	Tule	1274.6	Riverine and Playa	Tulia	Tulia	No	$58,000	Yes	Action aligns with goals and meets TWDB guidance
011000201	Palo Duro Dams (South)	Perform a watershed-wide evaluation of 1 dam to assess flood protection performance for the 100-year and 500-year events, develop breach analyses mapping and assess hazard classification, develop risk indices, and evaluate dam safety performance.	01000007	Potter, Oldham, Randall, Deaf Smith	11090105, 11090101, 11120102, 11120101, 11120103	-	Palo Duro	958.9	Riverine and Playa	Amarillo	Amarillo	No	$58,000	Yes	Action aligns with goals and meets TWDB guidance
011000203	Lower Prairie Dog Town Fork Red Dams	Perform a watershed-wide evaluation of 6 dams to assess flood protection performance for the 100-year and 500-year events, develop breach analyses mapping and assess hazard classification, develop risk indices, and evaluate dam safety performance.	01000007	Hardeman, Childress, Hall, Briscoe, Collingsworth, Donley	11130103, 11120201, 11120105, 11120202, 11120103, 11130101	-	Lower Prairie Dog Town Fork Red	1426.6	Riverine and Playa	Childress, Darrouzet	Childress, Darrouzet	No	$277,000	Yes	Action aligns with goals and meets TWDB guidance
011000204	Upper Wolf Dams	Perform a watershed-wide evaluation of 1 dam to assess flood protection performance for the 100-year and 500-year events, develop breach analyses mapping and assess hazard classification, develop risk indices, and evaluate dam safety performance.	01000007	Hutchinson, Lipscomb, Ochiltree, Hansford	11100104, 11100202, 11100203, 11100201, 11090106	-	Upper Wolf	835.3	Riverine and Playa	Ochiltree	Ochiltree	No	$58,000	Yes	Action aligns with goals and meets TWDB guidance
011000205	Southern Beaver Dams	Perform a watershed-wide evaluation of 1 dam to assess flood protection performance for the 100-year and 500-year events, develop breach analyses mapping and assess hazard classification, develop risk indices, and evaluate dam safety performance.	01000007	Wichita, Foard, Wilbarger, Baylor	11130105, 11130207, 11130102, 11130204, 11130206	-	Southern Beaver	678.4	Riverine and Playa	Electra	Electra	No	$58,000	Yes	Action aligns with goals and meets TWDB guidance
011000206	Upper Prairie Dog Town Fork Red Dams	Perform a watershed-wide evaluation of 4 dams to assess flood protection performance for the 100-year and 500-year events, develop breach analyses mapping and assess hazard classification, develop risk indices, and evaluate dam safety performance.	01000007	Carson, Potter, Hall, Briscoe, Swisher, Donley, Armstrong, Randall	11090105, 11120301, 11130103, 11120201, 11120105, 11120102, 11120101, 11120104, 11120103	-	Upper Prairie Dog Town Fork Red	2152.5	Riverine and Playa	Donley County SWCD, Hall Childress SWCD	Donley County SWCD, Hall Childress SWCD	No	$189,000	Yes	Action aligns with goals and meets TWDB guidance
011000207	Wichita Dams	Perform a watershed-wide evaluation of 4 dams to assess flood protection performance for the 100-year and 500-year events, develop breach analyses mapping and assess hazard classification, develop risk indices, and evaluate dam safety performance.	01000007	Clay, Wichita, Wilbarger, Knox, Baylor, Archer	12060101, 11130209, 11130201, 11130205, 11130207, 11130102, 11130204, 11130206	-	Wichita	1019.6	Riverine and Playa	Petrolia, Iowa Park, Byers	Petrolia, Iowa Park, Byers	No	$189,000	Yes	Action aligns with goals and meets TWDB guidance
011000208	Middle Canadian-Spring Dams	Perform a watershed-wide evaluation of 2 dams to assess flood protection performance for the 100-year and 500-year events, develop breach analyses mapping and assess hazard classification, develop risk indices, and evaluate dam safety performance.	01000007	Carson, Hemphill, Roberts, Hutchinson, Gray, Lipscomb, Ochiltree, Hansford	11130301, 11090105, 11120301, 11100104, 11120302, 11100202, 11100203, 11090106, 11090201	-	Middle Canadian-Spring	2759.4	Riverine and Playa	Donley County SWCD	Donley County SWCD	No	$102,000	Yes	Action aligns with goals and meets TWDB guidance
011000209	Upper North Fork Red Dams	Perform a watershed-wide evaluation of 6 dams to assess flood protection performance for the 100-year and 500-year events, develop breach analyses mapping and assess hazard classification, develop risk indices, and evaluate dam safety performance.	01000007	Carson, Potter, Donley, Armstrong, Randall, Wheeler, Gray	11090105, 11120301, 11120201, 11120302, 11120304, 11120103, 11090106	-	Upper North Fork Red	1179.5	Riverine and Playa	Gray County SWCD	Gray County SWCD	No	$277,000	Yes	Action aligns with goals and meets TWDB guidance
011000210	Rita Blanca Dams	Perform a watershed-wide evaluation of 1 dam to assess flood protection performance for the 100-year and 500-year events, develop breach analyses mapping and assess hazard classification, develop risk indices, and evaluate dam safety performance.	01000007	Hartley, Dallam	11090103, 11100104, 11090104, 11090102, 11100103	-	Rita Blanca	664.9	Riverine and Playa	Dalhart	Dalhart	No	$58,000	Yes	Action aligns with goals and meets TWDB guidance
011000211	Little Wichita Dams	Perform a watershed-wide evaluation of 3 dams to assess flood protection performance for the 100-year and 500-year events, develop breach analyses mapping and assess hazard classification, develop risk indices, and evaluate dam safety performance.	01000007	Young, Montague, Clay, Wichita, Baylor, Archer	12060101, 11130209, 11130201, 12030101, 12060201, 11130206	-	Little Wichita	1479.4	Riverine	Archer City, Windthorst WSC	Archer City, Windthorst WSC	No	$145,000	Yes	Action aligns with goals and meets TWDB guidance
011000212	Upper Salt Fork Red Dams	Perform a watershed-wide evaluation of 1 dam to assess flood protection performance for the 100-year and 500-year events, develop breach analyses mapping and assess hazard classification, develop risk indices, and evaluate dam safety performance.	01000007	Carson, Donley, Armstrong, Gray	11120301, 11120201, 11120105, 11120202, 11120304, 11120103	-	Upper Salt Fork Red	740.6	Riverine and Playa	Greenbelt Municipal & Industrial Water Authority	Greenbelt Municipal & Industrial Water Authority	No	$58,000	Yes	Action aligns with goals and meets TWDB guidance
011000213	Palo Duro Dams (North)	Perform a watershed-wide evaluation of 1 dam to assess flood protection performance for the 100-year and 500-year events, develop breach analyses mapping and assess hazard classification, develop risk indices, and evaluate dam safety performance.	01000007	Hutchinson, Moore, Hartley, Sherman, Dallam, Ochiltree, Hansford	11090105, 11090103, 11100102, 11100104, 11100202, 11090102, 11100103, 11100201, 11090106	-	Palo Duro	1797.7	Riverine and Playa	Palo Duro River Authority	Palo Duro River Authority	No	$58,000	Yes	Action aligns with goals and meets TWDB guidance
011000214	Farmers-Mud Dams	Perform a watershed-wide evaluation of 7 dams to assess flood protection performance for the 100-year and 500-year events, develop breach analyses mapping and assess hazard classification, develop risk indices, and evaluate dam safety performance.	01000007	Cooke, Montague, Clay	11130209, 11130201, 12030101, 11130102, 12030104, 11130210, 11130206, 12030103	-	Farmers-Mud	833.4	Riverine	Gainesville, Nocona, Denison, Upper Elm-Red SWCD	Gainesville, Nocona, Denison, Upper Elm-Red SWCD	No	$321,000	Yes	Action aligns with goals and meets TWDB guidance
011000215	Wichita County Streams Evaluation	Perform hydrologic, hydraulic, and geomorphic assessments of County- and drainage district-maintained channels to identify long-term, reach-level solutions for drainage capacity and channel stability issues	01000001, 01000002	Wichita	11130209, 11130207, 11130102, 11130206	-	Blue-China, Southern Beaver, Wichita, Little Wichita	617.3	Riverine and Playa	Wichita	Wichita	No	$500,000	Yes	Action aligns with goals and meets TWDB guidance

Appendix E-1 | E-1.2

Table 16 – Potentially Feasible Flood Mitigation Projects Recommended by RFPG

FMP ID	FMP Name	Description	Associated Goals (ID)	Counties	HUC8s	HUC12s	Watershed Name	Project Type	Project Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa, Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Project Cost ($)	Potential Funding Sources and Amount	Cost/ Structure removed	Percent Nature-based Solution (by cost)	Negative Impact (Y/N)	Negative Impact Mitigation (Y/N)	Water Supply Benefit (Y/N)	Benefit-Cost Ratio	Social Vulnerability Index (SVI)	RFPG Recommendation (Y/N)	Reason for Recommendation
013000001	T-Anchor Lake Watershed Drainage Improvements	Four phase playa excavation project, pump station relocation and construction of storm sewer improvements along Ross-Osage Street and Southeast 10th Street to provide 100-year flood protection	01000003, 01000004	Potter	11120103	111201030106	Upper Prairie Dog Town Fork Red	Infrastructure	4.15	Localized and Playa	Amarillo	Potter	No	$31,300,000	Amarillo Drainage Utility Fee, $9,390,000	$78,816	0	No	No	No	1.7	0.90	Yes	Alignment with RFPG goals and TWDB guidance
013000002	Rhea Road Drainage Project	The proposed improvements include the installation of a storm drain system along north on Rhea Road that would eliminate structure flooding in the 100-year storm event.	01000003, 01000004	Wichita	11130206	111302060304	Wichita	Storm Drain	0.33	Localized	Wichita Falls	Wichita	No	$2,995,000	Wichita Falls Stormwater Utility Fees, $2,995,000	$110,929	0	No	No	No	1.1	0.60	Yes	Alignment with RFPG goals and TWDB guidance
013000003	Brenda Hursh Enhancement Project (City of Wichita Falls)	Install a bypass system that will intercept flow from Brenda Hursh Creek and Brenda Hursh Channel at their respective Weeks Street Road crossings and convey the runoff to the west through a proposed pipe system	01000003, 01000004, 01000013	Wichita	11130206	111302060304	Wichita	Infrastructure	1.68	Riverine	Wichita Falls	Wichita, Nortex Regional Planning Commission, Red River Authority of Texas, Wichita Falls	No	$4,151,000	Wichita Falls Stormwater Utility Fee, $4,151,000	$64,865	8.5	No	Yes	No	1.1	0.17	Yes	Action aligns with goals and meets TWDB guidance
013000004	Diversion Channel through Golf Course	Construct a vegetated diversion channel with a narrow meandering pilot channel in the bottom in the area of the existing channel.	01000003, 01000004	Randall	11120102	111201020304	Palo Duro	Infrastructure	1.20	Riverine and Playa	Canyon	Randall	No	-	-, -	-	-	-	No	No	-	0.29	No	Sponsor prefers other alternatives
013000005	Flood Walls Through the Golf Course Area for Isolated Groups of Structures	These were determined to be one of the more viable flood risk reduction measures for houses around the golf course. Locations have been proposed around the golf course based on 100- and 500- year storms.	01000003, 01000004	Randall	11120102	111201020304	Palo Duro	Infrastructure	0.92	Riverine and Playa	Canyon	Randall	No	-	-, -	-	-	-	No	No	-	0.29	No	Sponsor prefers other alternatives
013000006	Dredging of Palo Duro Creek and Tierra Blanca Creek	Remove sediment deposits left behind form previous flooding events to increase channel capacity.	01000003, 01000004	Randall	11120101, 11120102, 11120103	111201010608, 111201010609, 111201020303, 111201020304, 111201030101, 111201030102	Tierra Blanca, Palo Duro, Upper Prairie Dog Town Fork Red	Infrastructure	8.39	Riverine and Playa	Canyon	Randall	No	-	-, -	-	-	-	No	No	-	0.26	No	Sponsor prefers other alternatives
013000007	Modify Golf Course Pond Dam, Spillway, and Channel	Remove obstruction and replace with a bridge, and add a concrete spillway in the pond dam on the northeast corner of the golf course	01000003, 01000004	Randall	11120101, 11120102	111201010609, 111201020304	Tierra Blanca, Palo Duro	Infrastructure	0.83	Riverine and Playa	Canyon	Randall	No	-	-, -	-	-	-	No	No	-	0.29	No	Sponsor prefers other alternatives
013000008	Upstream Detention Pond	Two potential detention facilities were identified upstream of the Canyon City Golf course. One is immediately upstream of FM 2590 and the other is upstream of the Canyon City Country Club where a tributary to Palo Duro Creek comes in from the north.	01000003, 01000004	Randall	11120102	111201020304	Palo Duro	Infrastructure	4.84	Riverine and Playa	Canyon	Randall	No	-	-, -	-	-	-	No	No	-	0.24	No	Sponsor prefers other alternatives
013000009	Bivins Lake Modifications for Flood Control	Modify Bivins Lake to provide flood storage above the City of Canyon and operate essentially as a dry structure.	01000003, 01000004	Randall	11120102	111201020302	Palo Duro	Infrastructure	0.97	Riverine and Playa	Canyon	Randall	No	-	-, -	-	-	-	No	No	-	0.24	No	FME recommended for further study
013000010	Bivins Dam Rehabilitation with Diversion Channel	Combine strategies to modify Bivins Lake and construct the enlarged channel through the Canyon City Golf Course area	01000003, 01000004	Randall	11120101, 11120102	111201010609, 111201020301, 111201020302, 111201020304	Tierra Blanca, Palo Duro	Infrastructure	5.79	Riverine and Playa	Canyon	Randall	No	-	-, -	-	-	-	No	No	-	0.24	No	FME recommended for further study
013000011	Adrian Avenue Drainage Project (City of Wichita Falls)	The proposed project would be to build an additional concrete flume north of 1802 Adrian Drive into Seabury Lake	01000003, 01000004	Wichita	11130206	111302060407	Wichita	Infrastructure	0.01	Riverine	Wichita Falls	Wichita	No	-	-, -	-	-	-	No	No	-	0.58	No	Sponsor request
013000012	City of Canyon Flood Mitigation Project	The proposed improvements include upstream and midstream detention ponds, channel enlargements and low water crossings improvements to reduce flooding in the residential area near Palo Duro Creek Golf Course.	01000003, 01000004	Randall	11120102	111201020304	Palo Duro	Other	0.61	Riverine	Canyon	Canyon	No	$37,238,000	-, -	$1,379,176	0	No	No	No	0.50999999	0.53	Yes	Alignment with RFPG goals and TWDB guidance
013000013	Wichita Gardens Drainage Improvements	The proposed improvements include for the installation of concrete curb and gutter throughout entire development in order to install a storm drain system with curb inlets and a trunk line that runs to an outfall at the Wichita River.	01000003, 01000004	Wichita	11130206	111302060407	Wichita	Storm Drain	0.22	Localized	Wichita Falls	Wichita Falls	No	$10,008,000	Wichita Falls Stormwater Utility Fees, $10,008,000	$100,082	0	No	No	No	3.0999999	0.63	Yes	Alignment with RFPG goals and TWDB guidance
013000014	Briargate Drainage Reconstruction Project (City of Wichita Falls)	Evaluate project to quantify benefits, evaluate impacts and begin design. The proposed project would construct a five-acre detention pond. Project identified from 2011 Wichita Falls DMP.	01000003, 01000004	Wichita	11130206	111302060303	Wichita	Infrastructure	0.63	Riverine	Wichita Falls	Wichita	No	$1,595,000	-, -	-	-	-	No	No	-	0.36	No	Sponsor request
013000015	Echo/Neta Lane Drainage Project	Install a storm drain system with curb and gutter along Jacksboro Highway beginning south of Echo Lane and reaching north to Norman Street.	01000003, 01000004	Wichita	11130206	111302060304	Wichita	Storm Drain	0.27	Localized	Wichita Falls	Wichita	No	$2,853,000	Wichita Falls Stormwater Utility Fees, $2,853,000	$203,779	0	No	No	No	3.7	0.24	Yes	Alignment with RFPG goals and TWDB guidance
013000016	Hirschi - Huskie Drainage Project (City of Wichita Falls)	Extend the existing storm drain system on Huskie Drive to reach to the north and south on Hirschi Lane. Additionally, acquire properties along the north side of Iowa Park Road between Hirschi Lane and Ridgeway Drive.	01000003, 01000004	Wichita	11130206	111302060407	Wichita	Storm Drain	0.04	Localized	Wichita Falls	Wichita	No	$632,000	Wichita Falls Stormwater Utility Fees, $632,000	$18,071	0	No	No	No	0.8	0.76	Yes	Alignment with RFPG goals and TWDB guidance
013000017	Landon, Duty and Sunset St Drainage Project	The proposed solution is be a combination of curb and gutter street improvements for Duty Lane, Landon Road, and Sunset Lane south of Duty Lane.	01000003, 01000004	Wichita	11130206	111302060407	Wichita	Storm Drain	0.05	Localized	Wichita Falls	Wichita	No	$2,120,000	Wichita Falls Stormwater Utility Fees, $2,120,000	$51,707	0	No	No	No	10.6000004	0.76	Yes	Alignment with RFPG goals and TWDB guidance
013000018	Spanish Trace Drainage Project	The proposed improvements include re-grading of an abandoned irrigation canal to convey flow north towards Johnson Road, connecting to the existing torm sewer system.	01000003, 01000004	Wichita	11130206	111302060303	Wichita	Storm Drain	0.05	Localized	Wichita Falls	Wichita	No	$1,043,000	Wichita Falls Stormwater Utility Fees, $1,043,000	$130,322	0	No	No	No	1.20000005	0.51	Yes	Alignment with RFPG goals and TWDB guidance
013000019	China Creek	Installing staff gauges, flashers, and flood hazard signs to warn drivers of flooding, as well as guardrails and roadway lighting for drivers to be able to see better.	01000005, 01000006	Wichita	11130102, 11130207	111302070304, 111302070307, 111302070402, 111301020203, 111301020202	Blue-China	Preparedness	26.72	Riverine	Wichita	Wichita	No	$455,000	-, -	-	0	No	No	No	0	0.21	Yes	Alignment with RFPG goals and TWDB guidance
013000020	Wild Horse Creek	Replaces existing culvert with a bridge and grading to increase road level of service.	01000003, 01000004, 01000005, 01000006	Wichita	11130102	111301020304, 111301020302	Blue-China	Infrastructure	1.25	Riverine	Burkburnett	Burkburnett	No	$3,411,000	-, -	$1,705,452	0	No	No	No	2.9	0.50	Yes	Alignment with RFPG goals and TWDB guidance
013000021	Buffalo Creek	Minor channel grading to reduce structure flooding in neighborhood.	01000003, 01000004	Wichita	11130206	111302060406, 111302060404	Wichita	Infrastructure	1.42	Riverine	Iowa Park	Iowa Park	No	$686,000	-, -	$228,819	0	No	No	No	0.3	0.33	Yes	Alignment with RFPG goals and TWDB guidance
013000022	Gilbert Creek	Raises road and replaces existing culverts with larger culverts and a bridge with grading to increase road level of service.	01000005, 01000006	Wichita	11130102, 11130206	111301020305, 111302060501, 111302060402, 111302060407	Blue-China	Infrastructure	41.91	Riverine	Burkburnett, Wichita	Burkburnett, Wichita	No	$11,783,000	-, -	-	0	No	No	No	2.3	0.48	Yes	Alignment with RFPG goals and TWDB guidance

FMP ID	FMP Name	Description	Associated Goals (ID)	Counties	HUC8s	HUC12s	Watershed Name	Project Type	Project Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa, Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Estimated Project Cost ($)	Potential Funding Sources and Amount	Cost/ Structure removed	Percent Nature-based Solution (by cost)	Negative Impact (Y/N)	Negative Impact Mitigation (Y/N)	Water Supply Benefit (Y/N)	Benefit-Cost Ratio	Social Vulnerability Index (SVI)	RFPG Recommendation (Y/N)	Reason for Recommendation
013000023	Site 01-Rockwell & Soncy	Upsize the culvert crossing, raise the road, modify channel	01000005, 01000006	Randall	11120102	111201020303	Palo Duro	LWC upgrade	40.22	Riverine	Randall	Randall	No	$713,000	Randall County General Funds, $71,300	-	0	No	No	No	0.1	0.07	Yes	Alignment with RFPG goals and TWDB guidance
013000024	Site 02-Happy West & Bell	Upsize the culvert crossing, raise the road, modify channel	01000005, 01000006	Randall	11120103	111201030201	Upper Prairie Dog Town Fork Red	LWC Upgrade	25.27	Riverine	Randall	Randall	No	$1,225,000	Randall County General Funds, $122,500	-	0	No	No	No	0	0.07	Yes	Alignment with RFPG goals and TWDB guidance
013000025	Site 03-Hix & FM 217	Upsize the culvert crossing, raise the road, modify channel	01000005, 01000006	Randall	11120101	111201010609	Tierra Blanca	LWC Upgrade	3.42	Riverine	Randall	Randall	No	$1,216,000	Randall County General Funds, $121,600	-	0	No	No	No	0	0.07	Yes	Alignment with RFPG goals and TWDB guidance
013000026	Site 04-Country Club	Upsize the culvert crossing, raise the road, modify channel	01000005, 01000006	Randall	11120103	111201030101	Upper Prairie Dog Town Fork Red	LWC Upgrade	53.17	Riverine	Randall	Randall	No	$1,243,000	Randall County General Funds, $124,300	-	0	No	No	No	0	0.55	Yes	Alignment with RFPG goals and TWDB guidance
013000027	Site 08-Running Water & FM 1714	Replace the bridge crossing with culverts, raise the road	01000005, 01000006	Randall	11120101	111201010609	Tierra Blanca	LWC Upgrade	3.61	Riverine	Randall	Randall	No	$471,000	Randall County General Funds, $47,100	-	0	No	No	No	0.5	0.07	Yes	Alignment with RFPG goals and TWDB guidance
013000028	Site 09-Hill & 46th	Raise the road	01000005, 01000006	Randall	11120102	111201020303	Palo Duro	LWC Upgrade	8.60	Playa	Randall	Randall	No	$2,373,000	Randall County General Funds, $237,300	-	0	No	No	No	0	0.07	Yes	Alignment with RFPG goals and TWDB guidance
013000029	Site 11-Gordon-Cummings	Increase the bridge opening & raising the low chord, raise the road	01000005, 01000006	Randall	11120101	111201010608	Tierra Blanca	LWC Upgrade	740.80	Riverine	Randall	Randall	No	$1,181,000	Randall County General Funds, $118,100	-	0	No	No	No	1.3	0.07	Yes	Alignment with RFPG goals and TWDB guidance
013000030	Site 12-Tradewinds & Farmers	Raise the road	01000005, 01000006	Randall	11120103	111201030102	Upper Prairie Dog Town Fork Red	LWC Upgrade	8.20	Playa	Randall	Randall	No	$3,885,000	Randall County General Funds, $388,500	-	0	No	No	No	1.3	0.41	Yes	Alignment with RFPG goals and TWDB guidance

Appendix E-1 | E-1.3

Table 17 – Potentially Feasible Flood Management Strategies Recommended by RFPG

FMS ID	FMS Name	Description	Associated Goals (ID)	Counties	HUC8s	HUC12s	Watershed Name	Project Type	Strategy Project Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Nonrecurring, Noncapital Cost ($)	Estimated Total Strategy Cost ($)	Potential Funding Sources and Amount	Cost/ Structure Removed	Consideration of Nature-based Solution (Y/N)	Negative Impact (Y/N)	Negative Impact Mitigation (Y/N)	Water Supply Benefit (Y/N)	RFPG Recommendation (Y/N)	Reason for Recommendation
012000001	City of Canyon Create Floodplain Ordinances	Establish drainage criteria	01000003, 01000004	Randall	11120101, 11120102, 11120103	111201010609, 111201020303, 111201020304, 111201030101	Tierra Blanca, & Palo Duro, Upper Prairie Dog Town Fork Red	Regulatory and Guidance	7.1	Riverine and Playa	Randall, Canyon	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canyon	No	0	$100,000	None	Not Applicable	No	No	No	No	No	Already have ordinance, CRS FMS makes project redudant as well
012000002	Quitaque NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Briscoe	11130103	111301030209, 111301030304	North Pease	Regulatory and Guidance	0.7	Riverine and Playa	Quitaque	Briscoe, Panhandle Regional Planning Commission, Red River Authority of Texas, Quitaque	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000003	Dean NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Clay	11130206, 11130209	111302060501, 111302090503, 111302090505	Wichita, Little Wichita	Regulatory and Guidance	1.5	Riverine	Dean	Clay, Nortex Regional Planning Commission, Red River Authority of Texas, Dean	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000004	Jolly NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Clay	11130209	111302090503, 111302090504, 111302090505	Little Wichita	Regulatory and Guidance	1.4	Riverine	Jolly	Clay, Nortex Regional Planning Commission, Red River Authority of Texas, Dean, Jolly	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000005	Mobeetie NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Wheeler	11120302	111203020203, 111203020204	Middle North Fork Red	Regulatory and Guidance	0.9	Riverine	Mobeetie	Wheeler, Panhandle Regional Planning Commission, Red River Authority of Texas, Wheeler County Water Supply District, Mobeetie	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000006	Hedley NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Donley	11120105, 11120202	111201050401, 111202020101	Lower Prairie Dog Town Fork Red, Lower Salt Fork Red	Regulatory and Guidance	0.7	Riverine	Hedley	Donley, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Hedley	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000007	Nazareth NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Castro	11120104	111201040202	Tule	Regulatory and Guidance	0.3	Playa	Nazareth	Castro, Panhandle Regional Planning Commission, Red River Authority of Texas, Nazareth	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000008	Texhoma NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Sherman	11100101, 11100103	111001010804, 111001030407, 111001030408	Upper Beaver, Coldwater	Regulatory and Guidance	1.9	Riverine	Texhoma	Sherman, Panhandle Regional Planning Commission, Texhoma	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000009	Lakeview NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Hall	11120105	111201050206	Lower Prairie Dog Town Fork Red	Regulatory and Guidance	0.2	Riverine	Lakeview	Hall, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Lakeview	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000010	Estelline NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Hall	11120105	111201050301	Lower Prairie Dog Town Fork Red	Regulatory and Guidance	0.8	Riverine	Estelline	Hall, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Estelline	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000011	Stratford NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Sherman	11100103	111001030209, 111001030403, 111001030404	Coldwater	Regulatory and Guidance	1.8	Riverine	Stratford	Sherman, Panhandle Regional Planning Commission, Stratford	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000012	Windthorst NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Clay, Archer	11130209	111302090301, 111302090302	Little Wichita	Regulatory and Guidance	2.3	Riverine	Windthorst	Clay, Archer, Nortex Regional Planning Commission, Red River Authority of Texas, Windthorst	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000013	Bellevue NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Clay	11130201, 11130209	111302010203, 111302090403	Farmers-Mud, Little Wichita	Regulatory and Guidance	0.9	Riverine	Bellevue	Clay, Nortex Regional Planning Commission, Red River Authority of Texas, Bellevue	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000014	Adrian NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Oldham	11090101	110901010703	Middle Canadian-Trujillo	Regulatory and Guidance	0.8	Riverine and Playa	Adrian	Oldham, Panhandle Regional Planning Commission, Red River Authority of Texas, Llano Estacado Water District, Adrian	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000015	Cashion NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Wichita	11130102, 11130206	111301020304, 111302060501	Blue-China, Wichita	Regulatory and Guidance	1.8	Riverine	Cashion Community	Wichita, Nortex Regional Planning Commission, Red River Authority of Texas, Burkburnett, Cashion Community	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000016	Dodson NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Collingsworth	11130101	111301010301, 111301010303	Groesbeck-Sandy	Regulatory and Guidance	0.6	Riverine	Dodson	Collingsworth, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Dodson	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000017	Silverton NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Briscoe	11130103	111301030101	North Pease	Regulatory and Guidance	1.0	Playa	Silverton	Briscoe, Panhandle Regional Planning Commission, Red River Authority of Texas, Silverton	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000018	Lockney NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Floyd	11130103	111301030203	North Pease	Regulatory and Guidance	0.2	Playa	Lockney	Floyd, South Plains Association of Governments, Red River Authority of Texas, Brazos River Authority, Lockney	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000019	Chillicothe NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Hardeman	11130101	111301010404	Groesbeck-Sandy	Regulatory and Guidance	1.0	Riverine	Chillicothe	Hardeman, Nortex Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Chillicothe	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000020	Vega NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Oldham	11090105, 11120102	110901050101, 111201020205, 111201020206	Lake Meredith, Palo Duro	Regulatory and Guidance	1.1	Riverine	Vega	Oldham, Panhandle Regional Planning Commission, Red River Authority of Texas, Llano Estacado Water District, Vega	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000021	McLean NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Gray	11120301, 11120304	111203010208, 111203040102	Upper North Fork Red, Elm Fork Red	Regulatory and Guidance	1.2	Riverine	McLean	Gray, Panhandle Regional Planning Commission, Red River Authority of Texas, McLean	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000022	Stinnett NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Hutchinson	11090106	110901060106, 110901060108	Middle Canadian-Spring	Regulatory and Guidance	2.0	Riverine	Stinnett	Hutchinson, Panhandle Regional Planning Commission, Red River Authority of Texas, Stinnett	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000023	Sanford NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Hutchinson	11090106	110901060105	Middle Canadian-Spring	Regulatory and Guidance	0.2	Riverine	Sanford	Hutchinson, Panhandle Regional Planning Commission, Red River Authority of Texas, Sanford	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000024	Follett NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Lipscomb	11100203	111002030201, 111002030401	Lower Wolf	Regulatory and Guidance	1.0	Riverine	Follett	Lipscomb, Panhandle Regional Planning Commission, Red River Authority of Texas, Follett	No	0	$100,000	None	Not Applicable	No	No	No	No	No	Community not interested in participation
012000025	Perryton NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Ochiltree	11100201	111002010201, 111002010301, 111002010302	Lower Beaver	Regulatory and Guidance	4.4	Riverine and Playa	Perryton	Ochiltree, Panhandle Regional Planning Commission, Perryton	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000026	Miami NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Roberts	11090106	110901060604, 110901060605, 110901060606	Middle Canadian-Spring	Regulatory and Guidance	1.8	Riverine	Miami	Roberts, Panhandle Regional Planning Commission, Red River Authority of Texas, Miami	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000027	Skellytown NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Carson	11090106	110901060302, 110901060307	Middle Canadian-Spring	Regulatory and Guidance	0.5	None	Skellytown	Carson, Panhandle Regional Planning Commission, Red River Authority of Texas, Skellytown	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000028	Claude NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Armstrong	11120103	111201030504, 111201030505	Upper Prairie Dog Town Fork Red	Regulatory and Guidance	1.7	Riverine and Playa	Claude	Armstrong, Panhandle Regional Planning Commission, Red River Authority of Texas, Claude	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000029	Matador NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Motley	11130104	111301040402	Middle Pease	Regulatory and Guidance	1.4	Riverine	Matador	Motley, South Plains Association of Governments, Red River Authority of Texas, Matador Water District, Matador	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000030	Cottle County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Cottle	11130101, 11130103, 11130104, 11130105, 11130204	-	Groesbeck-Sandy, North Pease, Middle Pease, Pease, North Wichita	Regulatory and Guidance	899.7	Riverine and Playa	Cottle	Cottle, Nortex Regional Planning Commission, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Paducah	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000031	Hardeman County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Hardeman	11120105, 11130101, 11130105	-	Lower Prairie Dog Town Fork Red, Groesbeck-Sandy, Pease	Regulatory and Guidance	695.6	Riverine and Playa	Hardeman	Hardeman, Nortex Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Chillicothe, Quanah	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance

FMS ID	FMS Name	Description	Associated Goals (ID)	Counties	HUC8s	HUC12s	Watershed Name	Project Type	Strategy Project Area (sqmi)	Flood Risk Type (Riverine, Coastal, Urban, Playa Other)	Sponsor	Entities with Oversight	Emergency Need (Y/N)	Nonrecurring, Noncapital Cost ($)	Estimated Total Strategy Cost ($)	Potential Funding Sources and Amount	Cost/ Structure Removed	Consideration of Nature-based Solution (Y/N)	Negative Impact (Y/N)	Negative Impact Mitigation (Y/N)	Water Supply Benefit (Y/N)	RFPG Recommendation (Y/N)	Reason for Recommendation
012000032	Knox County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Knox	11130204, 11130205, 11130206	111302040206, 111302040301, 111302040302, 111302040303, 111302040304, 111302040305, 111302040306, 111302050204, 111302050205, 111302050206, 111302050207, 111302050208, 111302060103	North Wichita, South Wichita, & Wichita	Regulatory and Guidance	421.0	Riverine and Playa	Knox	Knox, Nortex Regional Planning Commission, South Plains Association of Governments, West Central Texas Council of Governments, Red River Authority of Texas, Brazos River Authority, Knox County WCID 1	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000033	Carson County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Carson	11090105, 11090106, 11120103, 11120201, 11120301	-	Lake Meredith, Middle Canadian-Spring, Upper Prairie Dog Town Fork Red, Upper Salt Fork Red, Upper North Fork Red	Regulatory and Guidance	925.2	Riverine and Playa	Carson	Carson, Panhandle Regional Planning Commission, Red River Authority of Texas, Palo Duro River Authority, White Deer, Skellytown, Panhandle, Groom	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000034	Hemphill County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Hemphill	11090106, 11090201, 11100203, 11120302, 11130301	-	Middle Canadian-Spring, Lower Canadian-Deer, Lower Wolf, Middle North Fork Red, Washita Headwaters	Regulatory and Guidance	914.0	Riverine and Playa	Hemphill	Hemphill, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000035	Roberts County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Roberts	11090106, 11120302, 11130301	-	Middle Canadian-Spring, Middle North Fork Red, Washita Headwaters	Regulatory and Guidance	925.4	Riverine and Playa	Roberts	Roberts, Panhandle Regional Planning Commission, Red River Authority of Texas, Roberts County FWSD 1, Miami	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000036	Hutchinson County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Hutchinson	11090105, 11090106, 11100104, 11100202	-	Lake Meredith, Middle Canadian-Spring, Palo Duro, Upper Wolf	Regulatory and Guidance	896.9	Riverine and Playa	Hutchinson	Hutchinson, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Palo Duro River Authority, Borger, Fritch, Sanford, Stinnett	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000037	Moore County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Moore	11090105, 11100104	-	Lake Meredith, Palo Duro	Regulatory and Guidance	911.5	Riverine and Playa	Moore	Moore, Panhandle Regional Planning Commission, Red River Authority of Texas, Palo Duro River Authority, Cactus, Dumas, Sunray, Fritch	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000038	Hartley County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Hartley	11090101, 11090102, 11090103, 11090104, 11090105, 11100103, 11100104	-	Middle Canadian-Trujillo, Punta de Agua, Rita Blanca, Carrizo, Lake Meredith, Coldwater & Palo Duro	Regulatory and Guidance	1,466.1	Riverine and Playa	Hartley	Hartley, Panhandle Regional Planning Commission, Red River Authority of Texas, Channing, Dalhart	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000039	Briscoe County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Briscoe	11120103, 11120104, 11120105, 11130103	-	Upper Prairie Dog Town Fork Red, Tule, Lower Prairie Dog Town Fork Red, North Pease	Regulatory and Guidance	901.4	Riverine and Playa	Briscoe	Briscoe, Panhandle Regional Planning Commission, Red River Authority of Texas, Mackenzie Municipal Water Authority, Greenbelt Municipal & Industrial Water Authority, Quitaque, Silverton	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000040	Donley County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Donley	11120103, 11120105, 11120201, 11120202, 11120301, 11120304	-	Upper Prairie Dog Town Fork Red, Lower Prairie Dog Town Fork Red, Upper Salt Fork Red, Lower Salt Fork Red, Upper North Fork Red, Elm Fork Red	Regulatory and Guidance	933.0	Riverine and Playa	Donley	Donley, Panhandle Regional Planning Commission, Red River Authority of Texas, Greenbelt Municipal & Industrial Water Authority, Hedley, Clarendon, Howardwick	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000041	Armstrong County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Armstrong	11120103, 11120201, 11120301	-	Upper Prairie Dog Town Fork Red, Upper Salt Fork Red, Upper North Fork Red	Regulatory and Guidance	912.0	Riverine and Playa	Armstrong	Armstrong, Panhandle Regional Planning Commission, Red River Authority of Texas, Claude	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000042	Deaf Smith County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Deaf Smith	11090101, 11120101, 11120102, 11120104	-	Middle Canadian-Trujillo, Tierra Blanca, Palo Duro, Tule	Regulatory and Guidance	1,497.9	Riverine and Playa	Deaf Smith	Deaf Smith, Panhandle Regional Planning Commission, Red River Authority of Texas, Llano Estacado Water District, Deaf Smith County FWSD 1, Hereford	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000043	Wheeler County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Wheeler	11120202, 11120301, 11120302, 11120304, 11130301	-	Lower Salt Fork Red, Upper North Fork Red, Middle North Fork Red, Elm Fork Red, Washita Headwaters	Regulatory and Guidance	916.0	Riverine and Playa	Wheeler	Wheeler, Panhandle Regional Planning Commission, Red River Authority of Texas, Wheeler County Water Supply District, Greenbelt Municipal & Industrial Water Authority, Mobeetie, Shamrock, Wheeler	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000044	Sherman County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Sherman	11100101, 11100103, 11100104	-	Upper Beaver, Coldwater, Palo Duro	Regulatory and Guidance	926.1	Riverine and Playa	Sherman	Sherman, Panhandle Regional Planning Commission, Red River Authority of Texas, Palo Duro River Authority, Cactus, Stratford, Texhoma	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000045	Dallam County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Dallam	11090102, 11090103, 11090104, 11100101, 11100103, 11100104	-	Punta de Agua, Rita Blanca, Carrizo, Upper Beaver, Coldwater, Palo Duro	Regulatory and Guidance	1,510.5	Riverine and Playa	Dallam	Dallam, Panhandle Regional Planning Commission, Red River Authority of Texas, Dalhart, Texline	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000046	Lipscomb County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Lipscomb	11090106, 11090201, 11100201, 11100202, 11100203	-	Middle Canadian-Spring, Lower Canadian-Deer, Lower Beaver, Upper Wolf, Lower Wolf	Regulatory and Guidance	936.3	Riverine and Playa	Lipscomb	Lipscomb, Panhandle Regional Planning Commission, Red River Authority of Texas, Follett, Darrouzett, Higgins, Booker	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000047	Ochiltree County NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Ochiltree	11090106, 11100102, 11100104, 11100201, 11100202	-	Middle Canadian-Spring, Middle Beaver, Palo Duro, Lower Beaver, Upper Wolf	Regulatory and Guidance	922.5	Riverine and Playa	Ochiltree	Ochiltree, Panhandle Regional Planning Commission, Red River Authority of Texas, Palo Duro River Authority, Booker, Perryton	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance

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012000048	Region-Wide Turn Around/Don't Drown	Educate public on Turn Around/Don't Drown program	01000005, 01000006	-	-	-	-	Education and Outreach	34,626.1	Riverine and Playa	Panhandle Regional Planning Commission	Panhandle Regional Planning Commission	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000049	Region-Wide Public Awareness	Educate public on flood safety	01000005, 01000006	-	-	-	-	Education and Outreach	34,626.1	Riverine and Playa	Panhandle Regional Planning Commission	Panhandle Regional Planning Commission	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000050	City of Amarillo Update Stormwater Criteria	Update stormwater criteria based on recommendations identified in the 2019 Drainage Master Plan	01000003, 01000004	Potter, Randall	11090105, 11120103, 11120301	110901050308, 110901050309, 110901050402, 111201030101, 111201030102, 111201030106, 111201030107, 111203010101, 111203010102	Lake Meredith, Upper Prairie Dog Town Fork Red, Upper North Fork Red	Regulatory and Guidance	101.6	Riverine and Playa	Randall, Amarillo	Potter, Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000051	City of Amarillo Develop Criteria for Playa Development	Address sustainable playa development; establish modelling standard	01000003, 01000004	Potter, Randall	11090105, 11120103, 11120301	110901050308, 110901050309, 110901050402, 111201030101, 111201030102, 111201030106, 111201030107, 111203010101, 111203010102	Lake Meredith, Upper Prairie Dog Town Fork Red, Upper North Fork Red	Regulatory and Guidance	101.6	Riverine and Playa	Randall, Amarillo	Potter, Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000052	City of Amarillo Gages for Playas	Install gages on playa lakes	01000001, 01000002	Potter, Randall	11090105, 11120103, 11120301	110901050308, 110901050309, 110901050402, 111201030101, 111201030102, 111201030106, 111201030107, 111203010101, 111203010102	Lake Meredith, Upper Prairie Dog Town Fork Red, Upper North Fork Red	Flood Measurement and Warning	101.6	Riverine and Playa	Randall, Amarillo	Potter, Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	0	$250,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000053	City of Amarillo Flood Warning System	Implement flood warning system in the north side of town	01000005, 01000006	Potter, Randall	11090105, 11120103, 11120301	110901050308, 110901050309, 110901050402, 111201030101, 111201030102, 111201030106, 111201030107, 111203010101, 111203010102	Lake Meredith, Upper Prairie Dog Town Fork Red, Upper North Fork Red	Flood Measurement and Warning	101.6	Riverine and Playa	Randall, Amarillo	Potter, Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canadian River Municipal Water Authority, Amarillo	No	0	$250,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000054	City of Canyon Establish Stormwater Utility Fee	Perform stormwater utility rate evaluation and implement a stormwater utility fee to create a dedicated funding source for stormwater projects and storm sewer maintenance	01000011, 01000012	Randall	11120101, 11120102, 11120103	111201010609, 111201020303, 111201020304, 111201030101	Tierra Blanca, Palo Duro, Upper Prairie Dog Town Fork Red	Regulatory and Guidance	7.1	Riverine and Playa	Randall, Canyon	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canyon	No	0	$200,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000055	City of Canyon Acquire, Buyout, and Flood-Proofing Program	Develop a program to identify and either acquire (buy out/relocate) or elevate structures in the floodplain	01000003, 01000004	Randall	11120101, 11120102, 11120103	111201010609, 111201020303, 111201020304, 111201030101	Tierra Blanca, Palo Duro, Upper Prairie Dog Town Fork Red	Property Acquisition and Structural Elevation	7.1	Riverine and Playa	Randall, Canyon	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canyon	No	0	$6,000,000	None	$250,000	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000056	City of Canyon Flood Warning Gages	Install flood warning gages to protect Canyon citizens and downstream communities	01000005, 01000006	Randall	11120101, 11120102, 11120103	111201010609, 111201020303, 111201020304, 111201030101	Tierra Blanca, Palo Duro, Upper Prairie Dog Town Fork Red	Flood Measurement and Warning	7.1	Riverine and Playa	Randall, Canyon	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canyon	No	0	$250,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000057	City of Canyon Stream and Culvert Maintenance	Perform stream and culvert maintenance	01000005, 01000006	Randall	11120101, 11120102, 11120103	111201010609, 111201020303, 111201020304, 111201030101	Tierra Blanca, Palo Duro, Upper Prairie Dog Town Fork Red	Other	7.1	Riverine and Playa	Randall, Canyon	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canyon	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000058	City of Canyon Floodplain Regulation and Higher Standards (CRS)	Evaluate existing ordinances and development criteria and update as necessary to implement protective floodplain management standards and consider CRS participation	01000009, 01000010	Randall	11120101, 11120102, 11120103	111201010609, 111201020303, 111201020304, 111201030101	Tierra Blanca, Palo Duro, Upper Prairie Dog Town Fork Red	Regulatory and Guidance	7.1	Riverine and Playa	Randall, Canyon	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canyon	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000059	City of Canyon Installation of LWC Gates on Flood-Prone Roadways	Barrier installation keeps the public from entering high-water areas during flooding events.	01000005, 01000006	Randall	11120101, 11120102, 11120103	111201010609, 111201020303, 111201020304, 111201030101	Tierra Blanca, Palo Duro, Upper Prairie Dog Town Fork Red	Infrastructure Projects	7.1	Riverine and Playa	Randall, Canyon	Randall, Panhandle Regional Planning Commission, Red River Authority of Texas, Canyon	No	0	$1,000,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000060	Wichita County Ordinance Development	Update subdivision ordiance for enhanced consideration for floodplain management	01000001, 01000002	Wichita	11130102, 11130206, 11130207, 11130209	-	Blue-China, Wichita, Southern Beaver & Little Wichita	Regulatory and Guidance	617.3	Riverine and Playa	Wichita	Clay, Wichita, Wilbarger, Baylor, Archer, Nortex Regional Planning Commission, Red River Authority of Texas, Archer County MUD 1, Wichita County Water Improvement District 2, Burkburnett, Electra, Pleasant Valley, Iowa Park, Wichita Falls, Cashion Community, Lakeside City	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000062	Channing NFIP Involvement	Application to join NFIP or adopt equivalent standards	01000009, 01000010	Hartley	11090105, 11090102	110901050104, 110901020702	Lake Meredith, Punta de Agua	Regulatory and Guidance	1.0	Riverine	Channing	Channing, Hartley, Panhandle Regional Planning Commission, Red River Authority of Texas	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance
012000063	Region-Wide Initiative to Increase Communities with Dedicated Funding Sources for Operations & Maintenance of Storm Drainage System	Provide resources and assistance for communities looking to developing funding sources for drainage	01000011, 01000012	-	-	-	-	Regulatory and Guidance	34,626.1	Riverine and Playa	Panhandle Regional Planning Commission	Panhandle Regional Planning Commission	No	0	$100,000	None	Not Applicable	No	No	No	No	Yes	Action aligns with goals and meets TWDB guidance

Appendix E-1 | E-1.4

No Negative Impacts Table

Region Number	FMP ID	FMP Name	FMP Meets ALL No Negative Impacts Requirements from Exhibit C Section 3.6.A (Yes/ No)	Negative Impact Description	Planning level Mitigation Plan (Yes/ No)	Mitigation Plan Description	No Negative Impact Determination (Yes/No)	Basis of No Negative Impact Determination (Model, Study, Engineering Judgement)	Model ID	Model Name	Model Submitted	Study Name and Location	Engineer of Record (Optional)	Engineering Judgement Description
01	013000001	T-Anchor Lake Watershed Drainage Improvements	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000003, 010000000004	Amarillo T-Anchor Lake Study	Yes	City of Amarillo	Freese and Nichols	Not Applicable
01	013000002	Rhea Road Drainage Project	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000005	Rhea Road Hydraulic Model	Yes	City of Wichita Falls	HDR	Not Applicable
01	013000003	Brenda Hursh Enhancement Project (City of Wichita Falls)	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000006, 010000000012	Brenda Hursh Hydraulic Model, Brenda Hursh Hydrologic Model	Yes	City of Wichita Falls	Freese and Nichols	Not Applicable
01	013000012	City of Canyon Flood Mitigation Project	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000001, 010000000002	USACE City of Canyon Flood Study	Yes	City of Canyon	HDR	Not Applicable
01	013000013	Wichita Gardens Drainage Improvements	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000007	Wichita Gardens Hydraulic Model	Yes	City of Wichita Falls	HDR	Not Applicable
01	013000015	Echo/Neta Lane Drainage Project	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000008	Echo Neta Hydraulic Model	Yes	City of Wichita Falls	HDR	Not Applicable
01	013000016	Hirschi - Huskie Drainage Project (City of Wichita Falls)	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000009	Hirschi - Huskie Hydraulic Model	Yes	City of Wichita Falls	HDR	Not Applicable
01	013000017	Landon, Duty and Sunset St Drainage Project	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000010	Landon, Duty and Sunset Hydraulic Model	Yes	City of Wichita Falls	HDR	Not Applicable
01	013000018	Spanish Trace Drainage Project	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000011	Spanish Trace Drainage Project	Yes	City of Wichita Falls	HDR	Not Applicable
01	013000019	China Creek	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000013, 010000000019	China Creek Hydrologic Model, China Creek Hydraulic Model	Yes	Wichita County	Freese and Nichols	Not Applicable
01	013000020	Wild Horse Creek	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000014, 010000000018	Wild Horse Creek Hydrologic Model, Wild Horse Creek Hydraulic Model	Yes	City of Burkburnett	Freese and Nichols	Not Applicable
01	013000021	Buffalo Creek	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000013, 010000000020	Buffalo Creek Hydrologic Model, Buffalo Creek Hydraulic Model	Yes	City of Iowa Park	Freese and Nichols	Not Applicable
01	013000022	Gilbert Creek	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000017	Gilbert Creek Hydraulic Model	Yes	City of Burkburnett	Freese and Nichols	Not Applicable
01	013000023	Site 01-Rockwell & Soncy	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000021, 010000000028	Randall Country Hydrologic Model, W Rockwell Road Hydraulic Model	Yes	Randall County	HDR	Not Applicable
01	013000024	Site 02-Happy West & Bell	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000021, 010000000025	Randall Country Hydrologic Model, Happy West Road Hydraulic Model	Yes	Randall County	HDR	Not Applicable
01	013000025	Site 03-Hix & FM 217	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000021, 010000000024	Randall Country Hydrologic Model, Hix Drive and FM 217 Hydraulic Model	Yes	Randall County	HDR	Not Applicable
01	013000026	Site 04-Country Club	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000021, 010000000027	Randall Country Hydrologic Model, Country Club Road Hydraulic Model	Yes	Randall County	HDR	Not Applicable
01	013000027	Site 08-Running Water & FM 1714	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000021, 010000000023	Randall Country Hydrologic Model, Running Water Road Hydraulic Model	Yes	Randall County	HDR	Not Applicable
01	013000028	Site 09-Hill & 46th	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000021	Randall Country Hydrologic Model	Yes	Randall County	HDR	Not Applicable
01	013000029	Site 11-Gordon-Cummings	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000021, 010000000026	Randall Country Hydrologic Model, Gordon Cummings Road Hydraulic Model	Yes	Randall County	HDR	Not Applicable
01	013000030	Site 12-Tradewinds & Farmers	Yes	Not Applicable	Not Applicable	Not Applicable	Yes	Model	010000000021	Randall Country Hydrologic Model	Yes	Randall County	HDR	Not Applicable

Appendix E-2 | E-2.1

Map 19 – Recommended Flood Management Evaluations

FME Type	Count	Total Recommended Evaluation Area (Sq. Mi.)
Preparedness	1	102
Project Planning	55	437
Watershed Planning	136	74,194
Other	15	35,698
TOTAL	207	110,431

Region 1 - Canadian - Upper Red

Recommended Flood Management Evaluations

Map 19

Appendix E-2 | E-2.2

Map 20 – Recommended Flood Mitigation Projects

FMP Area	Identified	Count	Total Recommended Project Area (Sq. Mi.)
Amarillo	5	5	114
Canyon	10	3	8
Wichita County	13	11	74
Hereford	2	2	766
TOTAL	30	21	962

Region 1 - Canadian - Upper Red

Recommended Flood Mitigation Projects

Map

20

1 of 3

FMP Area	Identified	Count	Total Recommended Project Area (Sq. Mi.)
Amarillo	5	5	114
Canyon	10	3	8
Wichita County	13	11	74
Hereford	2	2	766
TOTAL	30	21	962

REGION 1 CANADIAN UPPER RED REGIONAL FLOOD PLANNING GROUP

FREESE NICHOLS

Map 20

2 of 3

DATE 6/19/2023

SCALE 1:200,000

FMP Area	Identified	Count	Total Recommended Project Area (Sq. Mi.)
Amarillo	5	5	114
Canyon	10	3	8
Wichita County	13	11	74
Hereford	2	2	766
TOTAL	30	21	962

Region 1 - Canadian - Upper Red

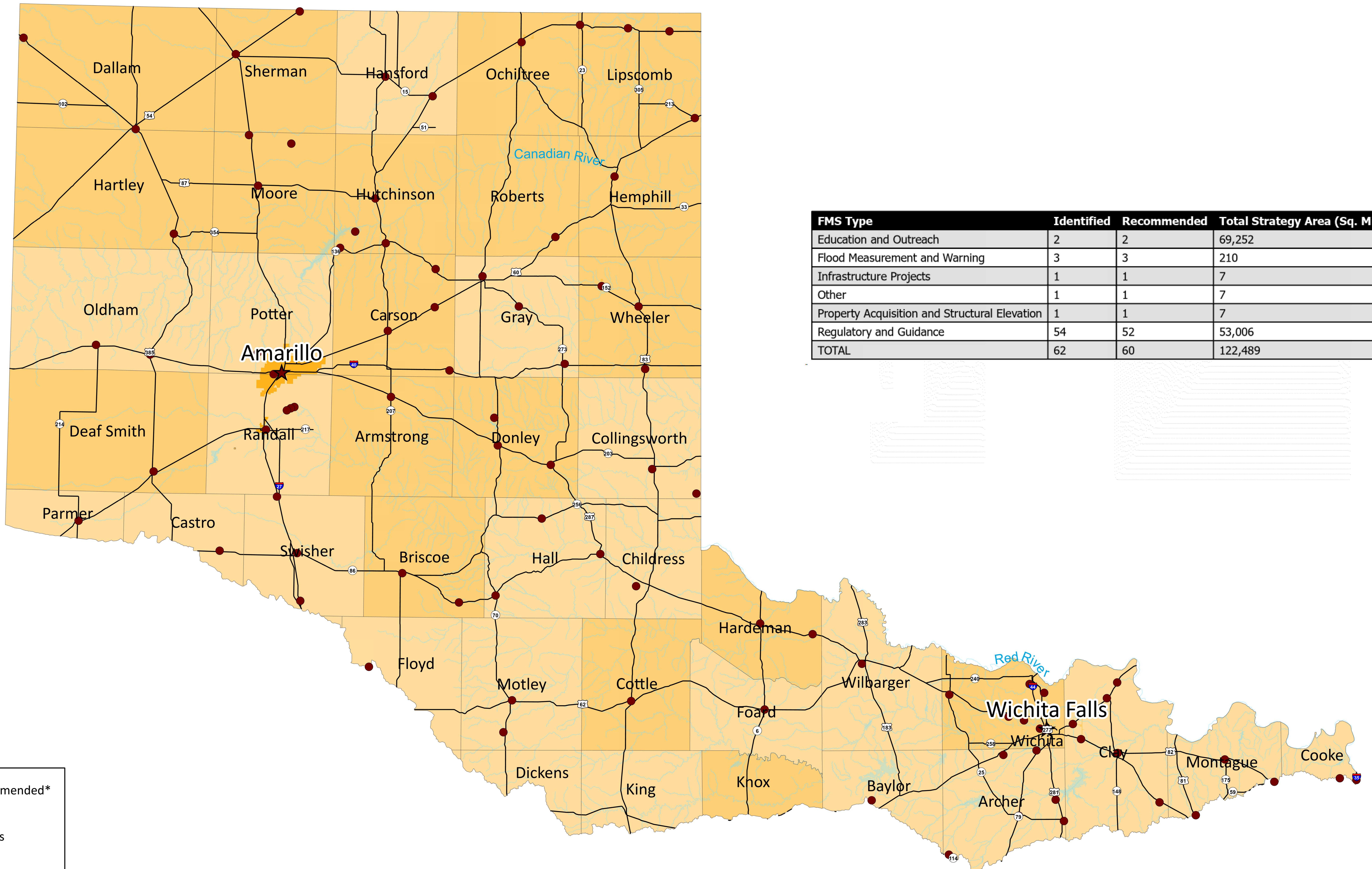
Recommended Flood Mitigation Projects

Map 20

3 of 3

Appendix E-2 | E-2.3

Map 21 – Recommended Flood Management Strategies



FMS Type	Identified	Recommended	Total Strategy Area (Sq. Mi.)
Education and Outreach	2	2	69,252
Flood Measurement and Warning	3	3	210
Infrastructure Projects	1	1	7
Other	1	1	7
Property Acquisition and Structural Elevation	1	1	7
Regulatory and Guidance	54	52	53,006
TOTAL	62	60	122,489

Legend
- FMS Recommended*
- Major City
- City
- Major Roads
- Rivers

*A darker shade represents overlapping FMS boundaries

Region 1 - Canadian - Upper Red

Recommended Flood Management Strategies

Map 21

Appendix E-3 | E-3.1

FMP Technical Memoranda

801 Cherry Street, Suite 2800 + Fort Worth, Texas 76102 + 817-735-7300 + FAX 817-735-7491

www.freese.com

TO: Region 1 Canadian-Upper Red Regional Flood Planning Group

FROM: Scott Hubley, PE, CFM

SUBJECT: T Anchor Playa Excavation and Storm Drain Improvements – FMP Evaluation

PROJECT: Canadian-Upper Red Regional Flood Plan (FNI Proj. No. PPC21323)

DATE: April 8, 2022

CC: David Dunn – HDR Engineering, Inc., Kyle Schniederjan – City of Amarillo

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PROJECT OVERVIEW

Halff Associates prepared the *Tee Anchor Lake Drainage Master Plan* for the City of Amarillo in August 2014. Tee Anchor (also, and from here forth, "T Anchor") Lake is a series of five interconnected playas located in central Amarillo. The lake is bordered to the south by Interstate Highway 40, to the west by Ross Street, and to the north and east by Southeast 10th Avenue/T Anchor Boulevard. A location map is included as **Figure 1**.

The master plan evaluated the T Anchor Lake watershed and recommended Capital Improvement Project (CIP) alternatives to alleviate flood hazards. The recommended improvements for this watershed included a four-phase series of playa excavation projects entailing 1.6 million cubic yards of excavation and the relocation of one pump station to provide 100-year flood protection to surrounding homes and businesses. The master plan also recommended improvements to two closed storm systems along Ross-Osage St and the SE 10th Ave corridor that outfall into the lake to improve drainage in these two areas, which experience repeated and severe flooding.

In April 2019, the City of Amarillo commissioned a City-wide *Drainage Utility Master Plan*, also executed by Halff Associates. The master plan included a 5-year CIP plan comprised of the City's top 9 highest ranking projects. The Tee Anchor improvements were included on this prioritized list, as presented in **Table 1**.

Table 1: Tee Anchor CIP Project Ranking

Project Name	Project Type	CIP Rank
T Anchor – Ross-Osage Street	Storm Sewer Lines	7
T Anchor – SE 10th Avenue	Storm Sewer Lines	8
T Anchor – Playa Excavation (Phases 1-IV)	Playa Lake	9

Figure 1: T Anchor Lake Vicinity Map

The T Anchor projects have been rolled into one Flood Mitigation Project (FMP) for the purpose of inclusion in the 2023 Regional Flood Plan (RFP) for the Canadian-Upper Red Flood Planning Region (Region 1). For consideration as an FMP, a project must be defined in a sufficient level of detail to meet the technical requirements of the flood planning project *Scope of Work* and the associated *Technical Guidelines* developed by the Texas Water Development Board (TWDB).

As the technical consultant for Region 1, Freese and Nichols (FNI) used the information developed during the previous evaluations of this watershed as a basis for developing the supporting technical details for inclusion in the RFP. This included:

1. Developing flood risk indicator information for the area and evaluating impacts to the flood hazard area boundary due to project implementation.
2. Updating construction cost estimates and estimates of project benefits to perform a benefit-cost analysis (BCA).
3. Evaluating a series of hydrologic and hydraulic criteria in order to certify that the project causes no adverse impacts on adjacent or downstream properties.

The following sections outline the methodology and results of the technical analysis.

FLOOD RISK INDICATORS

The flood planning process looks at several flood risk indicators to evaluate the flood risk reduction benefit of an FMP. This is largely a GIS-based exercise that documents anticipated benefits by calculating:

- Reduction in habitable, equivalent living units flood risk
- Reduction in residential population flood risk
- Reduction in critical facilities flood risk
- Reduction in road closure occurrences
- Reduction in acres of active farmland and ranchland flood risk
- Estimated reduction in fatalities, when available
- Estimated reduction in injuries, when available
- Reduction in expected annual damages from residential, commercial, and public property
- Other benefits as deemed relevant by the RFPG including environmental benefits and other public benefits

These estimated benefits were determined from geospatial data by defining a project service area (FMP feature class) and developing a proposed, post-project flood hazard area (FMP_HazPost). Once these features were defined, the existing and proposed flood exposure for the project service area was quantified by intersecting the flood hazard area boundaries with various sets of features, such as buildings and roads. Existing and proposed conditions were then compared to calculate the reduction of flood risk achieved by implementation of the FMP. Existing information from the master plan report was used where possible to populate analogous fields.

A summary of this information will be presented in the RFP as *Table 13: Potentially feasible flood mitigation projects identified by RFPG*. An excerpt of this table for the T Anchor FMP is provided as **Appendix A**.

BENEFIT-COST ANALYSIS (BCA)

The 2014 master plan included planning level cost estimates for the project. These costs were presented in 2014 USD ($). FNI used the Consumer Cost Index (CCI) values to escalate the total cost of the project to September 2020 $, as required by the *Technical Guidelines*. FNI also confirmed that the cost estimates included all the required line items and cost considerations for FMPs outlined in *Table 22* of the *Technical Guidelines*. The original costs associated with the project and the revised costs used in the BCA are presented in **Table 2**. Individual opinions of probable construction cost (OPCC) are included as **Appendix B**.

Table 2: Summary of Project Costs

Project Name	Cost (2014 $)	Cost (2020 $)
Playa Excavation – Phase I	$6.8 M	$7.9 M
Playa Excavation – Phase II	$3.9 M	$4.6 M
Playa Excavation – Phase III	$6.4 M	$7.5 M
Playa Excavation – Phase IV	$3.1 M	$3.7 M
Storm Drain Improvements – SE 10th Ave	$4.1 M	$4.8 M
Storm Drain Improvements – Ross-Osage St	$2.4 M	$2.8 M
Total	**$26.7 M**	**$31.3 M**

The 2014 master plan also included a determination of damages associated with the 100-year (1% annual chance) flood inundation depths at the surrounding structures. This analysis used standard FEMA flood damage curves and the calculated depth of flooding at each structure to estimate the damages. A detailed description of this evaluation is included in Section 5.3 of the report.

The existing conditions analysis performed in 2014 identified 407 structures in the floodplain. Using 2013 Potter-Randall County Appraisal District (PRAD) appraisal values for each structure, the estimated damages associated with the level of inundation for the 100-year event equated to $46.4 million. FNI used House Price Index data for Amarillo published by the Federal Housing Finance Agency (FHFA) to escalate these damage estimates to a 2020 value of $57.2 million. After implementation of the playa excavation components, only 10 structures remained in the 100-year floodplain, and estimated damages are reduced by 94%, providing a benefit of $53.6 million.

Damages due to flooded roadways are not classified with a structural damage value in the report. The system was modeled as a 1D closed pipe system, so inundation depth rasters are not available to make a system-wide determination. However, a summary of ponding depths at critical locations was included, and an excerpt is provided as **Table 3**.

Table 3: Storm Drain Project Benefits

System	Existing Inundation	Inundation with Proposed Project	Change
SE 10th Ave	2-yr: 4.1 ft of ponding at the underpass. 100-yr: 12.8 ft of ponding at the underpass. Street flooding on 10th Ave east of Ross St.	2-yr: No ponding at the underpass. 100-yr: 5.6 ft of ponding at the underpass. 2-yr flows on 10th Ave contained east of Ross St.	2-yr: -4.1 ft 100-yr: -7.2 ft
Ross-Osage St	2-yr: 1.0 ft of ponding at Ross St north of SE 22nd Ave. 100-yr: 1.4 ft of ponding at Ross St north of SE 22nd Ave.	2-yr: No ponding at Ross St north of SE 22nd Ave. 100-yr: 1.3 ft of ponding at Ross St north of SE 22nd Ave.	2-yr: -1.0 ft 100-yr: -0.1 ft

Qualitatively, both storm drain projects address areas of flooding that have historically been locations of high-water rescues and at least one instance of loss of life. The report also recommended that:

> *"a higher priority be placed on upgrading the storm sewer system as this will provide an immediate improvement in the level of service of the City's streets during a rainfall event. Increased capacity in the storm sewer system will be immediately recognized by the public as they will be able to travel along routes that were previously impassable during most rainfall events."*

Even without quantifying the benefit for the storm drain improvements, the T Anchor FMP demonstrates a favorable benefit-cost ratio. The summary of the benefit-cost analysis is presented in Table 4. The final BCA was calculated to be 1.7, and it is certain that this number would be even higher if the benefits due to the reduced road flooding were discretely evaluated.

Table 4: Benefit Cost Ratio of Project Components

Project Name	Cost (2020 $)	Benefit (2020 $)	BCR
Playa Excavation – all phases	$23.7M	$53.6 M	2.3
Storm Drain Improvements – SE 10th Ave*	$4.8 M	$ -- M	---
Storm Drain Improvements – Ross-Osage St*	$2.8 M	$ -- M	---
Total	**$31.3 M**	**$53.6 M**	**1.7**

**Project benefits have not been quantified in a dollar amount.*

NO NEGATIVE IMPACT ANALYSIS

Each identified FMS and FMP must demonstrate that there would be no negative impacts on a neighboring area due to its implementation. No negative impact means that a project will not increase flood risk of surrounding properties. Using best available data, the increase in flood risk must be measured by the 100-year

(1 percent annual chance event) water surface elevation and peak discharge. It is recommended that no rise in water surface elevation or discharge should be permissible, and that the analysis extent must be vast enough to prove proposed project conditions are equal to or less than the existing conditions.

For the purposes of this flood planning effort, a determination of no negative impact can be established if stormwater does not increase inundation of infrastructure such as residential and commercial buildings and structures. Additionally, all of the following requirements, per TWDB *Technical Guidelines*, should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement
2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity
3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section
4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 ft) measured at each computation cell
5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis

The 2014 master plan report should be referred to for a detailed description of the engineering analysis performed to develop these project alternatives and an evaluation of the proposed impacts. However, while the report presents a series of conceptual alternatives, no official certification of no negative impact is provided. FNI has evaluated the recommended projects in consideration of the requirements outlined in the *Technical Guidelines* and presents the following conclusions:

1. **Inundation and water surface evaluation** - The 100-year playa level is reduced from 3617.3 feet (NAVD88) under existing conditions to 3614 feet after completion of the playa excavation project. A total of 397 properties are removed from the floodplain. Acquisition of additional right-of-way is proposed as part of Phase III and IV to expand the footprint of the lake and add storage volume. Increases in depth are contained within the proposed limits of excavation.

   With respect to the storm drain improvements, ponding depths in the street are reduced throughout the system. A summary of ponding at key locations is summarized in the Benefit-Cost Analysis. Therefore, FNI concludes that the project concept demonstrates an overall decrease in water surface elevations and inundation throughout the system and adherence to the intent of the technical criteria listed in points 1, 2, 3, and 4.

2. **Peak discharge evaluation –** The lake serves as the ultimate outfall for the Ross-Osage St and SE 10th Ave systems. While peak discharges from the storm drain systems increase due to the substantial increase in conveyance, the playa is a storage-based system, meaning that the water surface elevation is based on the total volume of water entering the system, rather than timing. As a result, the increase

in peaks is not expected to cause an adverse flood impact on surrounding properties since the lake is designed with sufficient storage volume.

The playa is drained by a pump station that ultimately discharges into an existing gravity storm sewer system. However, the pump station does not operate during a storm event, and as a result, no downstream impacts from changes to the playa stage-storage relationship or relocation of the pump station are anticipated. Consequently, FNI concludes that the project concept adheres to the intent of the technical criteria listed in point 5.

Models that are used to evaluate hydrologic and hydraulic impacts at the planning level undergo multiple revisions as projects proceed through design and construction. At this stage, FNI concludes that the T Anchor project meets all requirements to demonstrate no adverse impacts. FNI has assessed the reasonableness of the proposed project and does not anticipate potential future issues related to flood impacts. Nevertheless, it is anticipated that impacts will be periodically evaluated, and any negative impacts will be addressed, as part of the design process.

While this preliminary determination of no adverse impacts is suitable to recommended inclusion of the T Anchor project in the RFP, FNI makes no guarantee of project performance, and it is the responsibility of the design engineer to ensure that no adverse impacts criteria are met. As an additional consideration, the City's *Flood Damage Prevention Ordinance* will apply, which prohibits increased flooding on insurable structures. The project area is part of the regulatory floodplain Zone AE and therefore will require coordination with FEMA.

REGION 1: CANADIAN - UPPER RED REGIONAL FLOOD PLANNING GROUP

OPINION OF PROBABLE CONSTRUCTION COST

FMP ID	01000001	SPONSOR ID	010000001
FMP NAME	TEE ANCHOR EXCAVATION - PHASE I	SPONSOR NAME	CITY OF AMARILLO
REPORT NAME	TEE ANCHOR LAKE DRAINAGE MASTER PLAN	INITIAL ESTIMATE YEAR	2014

INITIAL ESTIMATE CREATED BY:	REVISED ESTIMATE CREATED BY:	REVISED ESTIMATE CHECKED BY:
HALFF ASSOCIATES	FREESE & NICHOLS, INC.	HDR ENGINEERING, INC.

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION LINE ITEMS					
1	CONSTRUCTION STAKING	1	LS	$ 5,000	$ 5,000
2	CARE OF WATER	1	LS	$ 10,000	$ 10,000
3	SWPPP IMPLEMENTATION AND EROSION CONTROL	1	LS	$ 15,000	$ 15,000
4	SITE PREPARATION AND MOBILIZATION	1	LS	$ 25,000	$ 25,000
5	TEMPORARY CONSTRUCTION ENTRANCE	1	EA	$ 3,600	$ 3,600
6	UNCLASSIFIED EXCAVATION	572400	CY	$ 9	$ 5,151,600
7	BROADCAST SEED - NATIVE MIX MULCH	18	AC	$ 1,500	$ 27,000
8	COMPOST TOPSOIL (4")	9841	CY	$ 40	$ 393,640

SUBTOTAL	(2014 COSTS)	$ 5,630,840
CONTINGENCY	15%	$ 844,630
SUBTOTAL	(2014 COSTS)	$ 6,475,470
LAND ACQUISITION	LS	$
ENGINEERING, DESIGN, PERMITTING, FEMA SUBMITTALS	LS	$ 300,000
SUBTOTAL		$ 6,775,470
COST ESCALATION FACTOR	17%	$ 1,151,830

PROJECT TOTAL (2020 COSTS)	**$ 7,927,300**
RECURRING COSTS	
Debt Service Total (*add interest rate % and term years*)	$ -
Operations & Maintenance Total (*30-year project life*)	$ -
ANNUAL RECURRING TOTAL (2020 COSTS)	**$**
TOTAL (2020 COSTS)	**$ 7,927,300**

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NOTES:

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OPINION OF PROBABLE CONSTRUCTION COST

FMP ID	01000002	SPONSOR ID	010000001
FMP NAME	TEE ANCHOR EXCAVATION - PHASE II	SPONSOR NAME	CITY OF AMARILLO
REPORT NAME	TEE ANCHOR LAKE DRAINAGE MASTER PLAN	INITIAL ESTIMATE YEAR	2014

INITIAL ESTIMATE CREATED BY:	REVISED ESTIMATE CREATED BY:	REVISED ESTIMATE CHECKED BY:
HALFF ASSOCIATES	FREESE & NICHOLS, INC.	HDR ENGINEERING, INC.

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION LINE ITEMS					
1	CONSTRUCTION STAKING	1	LS	$ 5,000	$ 5,000
2	CARE OF WATER	1	LS	$ 10,000	$ 10,000
3	SWPPP IMPLEMENTATION AND EROSION CONTROL	1	LS	$ 15,000	$ 15,000
4	SITE PREPARATION AND MOBILIZATION	1	LS	$ 25,000	$ 25,000
5	TEMPORARY CONSTRUCTION ENTRANCE	1	EA	$ 3,600	$ 3,600
6	UNCLASSIFIED EXCAVATION	314900	CY	$ 9	$ 2,834,100
7	BROADCAST SEED - NATIVE MIX MULCH	12	AC	$ 1,500	$ 18,000
8	COMPOST TOPSOIL (4")	6351	CY	$ 40	$ 254,040
		SUBTOTAL		(2014 COSTS)	$ 3,164,740
		CONTINGENCY		15%	$ 474,720
		SUBTOTAL		(2014 COSTS)	$ 3,639,460
		LAND ACQUISITION		LS	$
		ENGINEERING, DESIGN, PERMITTING, FEMA SUBMITTALS		LS	$ 300,000
		SUBTOTAL			$ 3,939,460
		COST ESCALATION FACTOR		17%	$ 669,708

PROJECT TOTAL (2020 COSTS)	**$ 4,609,168**
RECURRING COSTS	
Debt Service Total (*add interest rate % and term years*)	$ -
Operations & Maintenance Total (*30-year project life*)	$ -
ANNUAL RECURRING TOTAL (2020 COSTS)	**$**
TOTAL (2020 COSTS)	**$ 4,609,168**

Opinions of probable costs have been developed in accordance with the Rules and Technical Guidelines governing Flood Planning provided by the TWDB. The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs.

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OPINION OF PROBABLE CONSTRUCTION COST

FMP ID	01000003	SPONSOR ID	010000001
FMP NAME	TEE ANCHOR EXCAVATION - PHASE III	SPONSOR NAME	CITY OF AMARILLO
REPORT NAME	TEE ANCHOR LAKE DRAINAGE MASTER PLAN	INITIAL ESTIMATE YEAR	2014

INITIAL ESTIMATE CREATED BY:	REVISED ESTIMATE CREATED BY:	REVISED ESTIMATE CHECKED BY:
HALFF ASSOCIATES	FREESE & NICHOLS, INC.	HDR ENGINEERING, INC.

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION LINE ITEMS					
1	CONSTRUCTION STAKING	1	LS	$ 5,000	$ 5,000
2	CARE OF WATER	1	LS	$ 10,000	$ 10,000
3	SWPPP IMPLEMENTATION AND EROSION CONTROL	1	LS	$ 15,000	$ 15,000
4	SITE PREPARATION AND MOBILIZATION	1	LS	$ 25,000	$ 25,000
5	TEMPORARY CONSTRUCTION ENTRANCE	1	EA	$ 3,600	$ 3,600
6	UNCLASSIFIED EXCAVATION	498500	CY	$ 9	$ 4,486,500
7	BROADCAST SEED - NATIVE MIX MULCH	19	AC	$ 1,500	$ 28,500
8	COMPOST TOPSOIL (4")	10481	CY	$ 40	$ 419,240
9	RIPRAP PROTECTION	1245	CY	$ 125	$ 155,625

SUBTOTAL	(2014 COSTS)	$ 5,148,470
CONTINGENCY	15%	$ 772,280
SUBTOTAL	(2014 COSTS)	$ 5,920,750
LAND ACQUISITION	LS	$ 102,700
ENGINEERING, DESIGN, PERMITTING, FEMA SUBMITTALS	LS	$ 380,000
SUBTOTAL		$ 6,403,450
COST ESCALATION FACTOR	17%	$ 1,088,587

PROJECT TOTAL (2020 COSTS)	**$ 7,492,037**
RECURRING COSTS	
Debt Service Total (*add interest rate % and term years*)	$ -
Operations & Maintenance Total (*30-year project life*)	$ -
ANNUAL RECURRING TOTAL (2020 COSTS)	**$**
TOTAL (2020 COSTS)	**$ 7,492,037**

Opinions of probable costs have been developed in accordance with the Rules and Technical Guidelines governing Flood Planning provided by the TWDB. The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs.

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2. Project does not have any costs associated with mitigation, utility relocation, buyouts or property elevations.

OPINION OF PROBABLE CONSTRUCTION COST

FMP ID	01000004	SPONSOR ID	010000001
FMP NAME	TEE ANCHOR EXCAVATION - PHASE IV	SPONSOR NAME	CITY OF AMARILLO
REPORT NAME	TEE ANCHOR LAKE DRAINAGE MASTER PLAN	INITIAL ESTIMATE YEAR	2014

INITIAL ESTIMATE CREATED BY:	REVISED ESTIMATE CREATED BY:	REVISED ESTIMATE CHECKED BY:
HALFF ASSOCIATES	FREESE & NICHOLS, INC.	HDR ENGINEERING, INC.

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION LINE ITEMS					
1	CONSTRUCTION STAKING	1	LS	$ 5,000	$ 5,000
2	CARE OF WATER	1	LS	$ 10,000	$ 10,000
3	SWPPP IMPLEMENTATION AND EROSION CONTROL	1	LS	$ 15,000	$ 15,000
4	SITE PREPARATION AND MOBILIZATION	1	LS	$ 25,000	$ 25,000
5	TEMPORARY CONSTRUCTION ENTRANCE	3	EA	$ 3,600	$ 10,800
6	UNCLASSIFIED EXCAVATION	202100	CY	$ 9	$ 1,818,900
7	BROADCAST SEED - NATIVE MIX MULCH	3	AC	$ 1,500	$ 4,500
8	COMPOST TOPSOIL (4")	1450	CY	$ 40	$ 58,000
9	RIPRAP PROTECTION	160	CY	$ 125	$ 20,000
10	CONCRETE WET WELL (INCL. EXCAVATION AND BACKFILL)	1	LS	$ 70,000	$ 70,000
11	NEW PUMP, VALVES, PIPE, POWER & CONTROLS	1	LS	$ 180,000	$ 180,000

SUBTOTAL	(2014 COSTS)	$ 2,217,200
CONTINGENCY	15%	$ 332,580
SUBTOTAL	(2014 COSTS)	$ 2,549,780
LAND ACQUISITION	LS	$ 102,700
ENGINEERING, DESIGN, PERMITTING, FEMA SUBMITTALS	LS	$ 480,000
SUBTOTAL		$ 3,132,480
COST ESCALATION FACTOR	17%	$ 532,522

PROJECT TOTAL (2020 COSTS)	**$ 3,665,002**
RECURRING COSTS	
Debt Service Total (*add interest rate % and term years*)	$ -
Operations & Maintenance Total (*30-year project life*)	$ -
ANNUAL RECURRING TOTAL (2020 COSTS)	**$**
TOTAL (2020 COSTS)	**$ 3,665,002**

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NOTES:

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2. Project does not have any costs associated with mitigation, utility relocation, buyouts or property elevations.

REGION 1: CANADIAN - UPPER RED REGIONAL FLOOD PLANNING GROUP

OPINION OF PROBABLE CONSTRUCTION COST

FMP ID	01000005	SPONSOR ID	010000001
FMP NAME	TEE ANCHOR STORM DRAIN - SE 10TH ST	SPONSOR NAME	CITY OF AMARILLO
REPORT NAME	TEE ANCHOR LAKE DRAINAGE MASTER PLAN	INITIAL ESTIMATE YEAR	2014

INITIAL ESTIMATE CREATED BY:	REVISED ESTIMATE CREATED BY:	REVISED ESTIMATE CHECKED BY:
HALFF ASSOCIATES	FREESE & NICHOLS, INC.	HDR ENGINEERING, INC.

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION LINE ITEMS					
1	MOBILIZATION/SITE PREP (5% OF CONSTRUCTION SUBTOTAL)	1	LS	$ 140,560	$ 140,560
2	REMOVE EXISTING 18 IN STORM DRAIN PIPE	65	LF	$ 20	$ 1,300
3	REMOVE EXISTING 24 IN STORM DRAIN PIPE	264	LF	$ 20	$ 5,280
4	REMOVE EXISTING 36 IN STORM DRAIN PIPE	393	LF	$ 20	$ 7,860
5	REMOVE EXISTING 42 IN STORM DRAIN PIPE	763	LF	$ 20	$ 15,260
6	REMOVE EXISTING 48 IN STORM DRAIN PIPE	240	LF	$ 20	$ 4,800
7	24 IN CL III RCP STORM DRAIN PIPE	103	LF	$ 75	$ 7,725
8	36 IN CL III RCP STORM DRAIN PIPE	382	LF	$ 85	$ 32,470
9	48 IN CL III RCP STORM DRAIN PIPE	379	LF	$ 140	$ 53,060
10	CONCRETE BOX CULVERT (5 FT X 4 FT)	835	LF	$ 230	$ 192,050
11	CONCRETE BOX CULVERT (5 FT X 4 FT)	3837	LF	$ 215	$ 824,955
12	CONCRETE BOX CULVERT (5 FT X 4 FT)	2224	LF	$ 245	$ 544,880
13	CAST IN PLACE JUNCTION BOX	6	EA	$ 20,000	$ 120,000
14	STANDARD CURB INLET (10 FT)	40	EA	$ 5,000	$ 200,000
15	HEADWALL	1	EA	$ 10,000	$ 10,000
16	GROUTED RIPRAP ON FILTER FABRIC (12 IN THICK - 50 SY OR MORE)	150	CY	$ 150	$ 22,500
17	PAVEMENT REMOVE & REPLACE (9 IN ASPHALT)	10347	SY	$ 55	$ 569,085
18	SWPPP	1	LS	$ 10,000	$ 10,000
19	TRAFFIC CONTROL	1	LS	$ 40,000	$ 40,000
20	UTILITY ADJUSTMENT - MINOR (12 IN OR SMALLER)	15	EA	$ 10,000	$ 150,000

SUBTOTAL	(2014 COSTS)	$ 2,951,790
CONTINGENCY	20%	$ 590,360
SUBTOTAL	(2014 COSTS)	$ 3,542,150
ENGINEERING AND MATERIALS TESTING	15%	$ 531,330
SUBTOTAL		$ 4,073,480
COST ESCALATION FACTOR	17%	$ 692,492

PROJECT TOTAL (2020 COSTS)	**$ 4,765,972**
RECURRING COSTS	
Debt Service Total (*add interest rate % and term years*)	$ -
Operations & Maintenance Total (*30-year project life*)	$ -
ANNUAL RECURRING TOTAL (2020 COSTS)	**$**
TOTAL (2020 COSTS)	**$ 4,765,972**

Opinions of probable costs have been developed in accordance with the Rules and Technical Guidelines governing Flood Planning provided by the TWDB. The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs.

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REGION 1: CANADIAN - UPPER RED REGIONAL FLOOD PLANNING GROUP

OPINION OF PROBABLE CONSTRUCTION COST

FMP ID	01000006	SPONSOR ID	010000001
FMP NAME	TEE ANCHOR STORM DRAIN - ROSS/OSAGE	SPONSOR NAME	CITY OF AMARILLO
REPORT NAME	TEE ANCHOR LAKE DRAINAGE MASTER PLAN	INITIAL ESTIMATE YEAR	2014

INITIAL ESTIMATE CREATED BY:	REVISED ESTIMATE CREATED BY:	REVISED ESTIMATE CHECKED BY:
HALFF ASSOCIATES	FREESE & NICHOLS, INC.	HDR ENGINEERING, INC.

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION LINE ITEMS					
1	MOBILIZATION/SITE PREP (5% OF CONSTRUCTION SUBTOTAL)	1	LS	$ 83,490	$ 83,490
2	REMOVE EXISTING 24 IN STORM DRAIN PIPE	1681	LF	$ 20	$ 33,620
3	24 IN CL III RCP STORM DRAIN PIPE	465	LF	$ 75	$ 34,875
4	30 IN CL III RCP STORM DRAIN PIPE	361	LF	$ 80	$ 28,880
5	36 IN CL III RCP STORM DRAIN PIPE	358	LF	$ 85	$ 30,430
6	CONCRETE BOX CULVERT (4 FT X 3 FT)	360	LF	$ 140	$ 50,400
7	CONCRETE BOX CULVERT (5 FT X 3 FT)	3518	LF	$ 195	$ 686,010
8	CONCRETE BOX CULVERT (6 FT X 3 FT)	549	LF	$ 215	$ 118,035
9	CAST IN PLACE JUNCTION BOX	4	EA	$ 20,000	$ 80,000
10	STANDARD CURB INLET (10 FT)	36	EA	$ 5,000	$ 180,000
11	HEADWALL	1	EA	$ 10,000	$ 10,000
12	PAVEMENT REMOVE AND REPLACE (9 IN ASPHALT)	5136	SY	$ 55	$ 282,480
13	SWPPP	1	LS	$ 10,000	$ 10,000
14	TRAFFIC CONTROL	1	LS	$ 25,000	$ 25,000
15	UTILITY ADJUSTMENT - MINOR (12 IN OR SMALLER)	10	EA	$ 10,000	$ 100,000

SUBTOTAL	(2014 COSTS)	$	1,753,220
CONTINGENCY	20%	$	350,650
SUBTOTAL	(2014 COSTS)	$	2,103,870
ENGINEERING AND MATERIALS TESTING	15%	$	315,590
SUBTOTAL		$	2,419,460
COST ESCALATION FACTOR	17%	$	411,308

PROJECT TOTAL (2020 COSTS)	**$**	**2,830,768**
RECURRING COSTS		
Debt Service Total (*add interest rate % and term years*)	$	-
Operations & Maintenance Total (*30-year project life*)	$	-
ANNUAL RECURRING TOTAL (2020 COSTS)	**$**	
TOTAL (2020 COSTS)	**$**	**2,830,768**

Opinions of probable costs have been developed in accordance with the Rules and Technical Guidelines governing Flood Planning provided by the TWDB. The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs.

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Memorandum - Draft

Date:	Wednesday, March 30, 2022
Project:	Canadian – Upper Red Regional Flood Plan
To:	Scott Hubley, PE, Freese and Nichols, Inc.
From:	David Dunn, PE Toby Li, EIT
Subject:	Canyon Flood Mitigation Project Pilot Study

HDR Engineering, Inc. (HDR) has completed an update to the flood mitigation projects recommended for the City of Canyon, TX in a 2011 U.S. Army Corps of Engineers (USACE) report[1]. This analysis was completed to provide data for the 2023 Canadian – Upper Red Regional Flood Plan (the Plan) concerning potential Flood Mitigation Projects (FMPs) to be recommended in the 2023 Plan. This analysis was performed as a "pilot" study to identify relative levels of effort needed to bring analyses of FMPs up to a common standard necessary for inclusion in a regional flood plan per Texas Water Development Board (TWDB) guidelines.

The study area is a flood-prone residential area between FM 2590 and Highway 87 in the City of Canyon, TX. The area is prone to repetitive riverine flooding from Palo Duro Creek. In May 2011, USACE performed a flood mitigation study to propose various alternatives to mitigate the flooding problems in the study area. The study recommended a combination of two upstream flood detention structures coupled with enlargement of a flood diversion channel located in an adjacent golf course.

On March 2, 2022, representatives from HDR and Freese and Nichols, Inc. (FNI) met with representatives from the City of Canyon to discuss the project and confirm the City's desire to include the projects recommended by the USACE in the 2023 Plan. The City confirmed their desire to include the projects in the 2023 Plan, and requested that three low-water crossings in the golf course be enlarged to reduce the frequency of road overtopping.

The locations of the upstream (US) and midstream (MS) detention ponds, channel enlargement, and low-water crossings are shown in Figure 1.

[1] US Army Corps of Engineers, Tulsa District, Flood Mitigation Study, Canyon, Randall County, Texas, 1004831053 Final Report, May 2011.

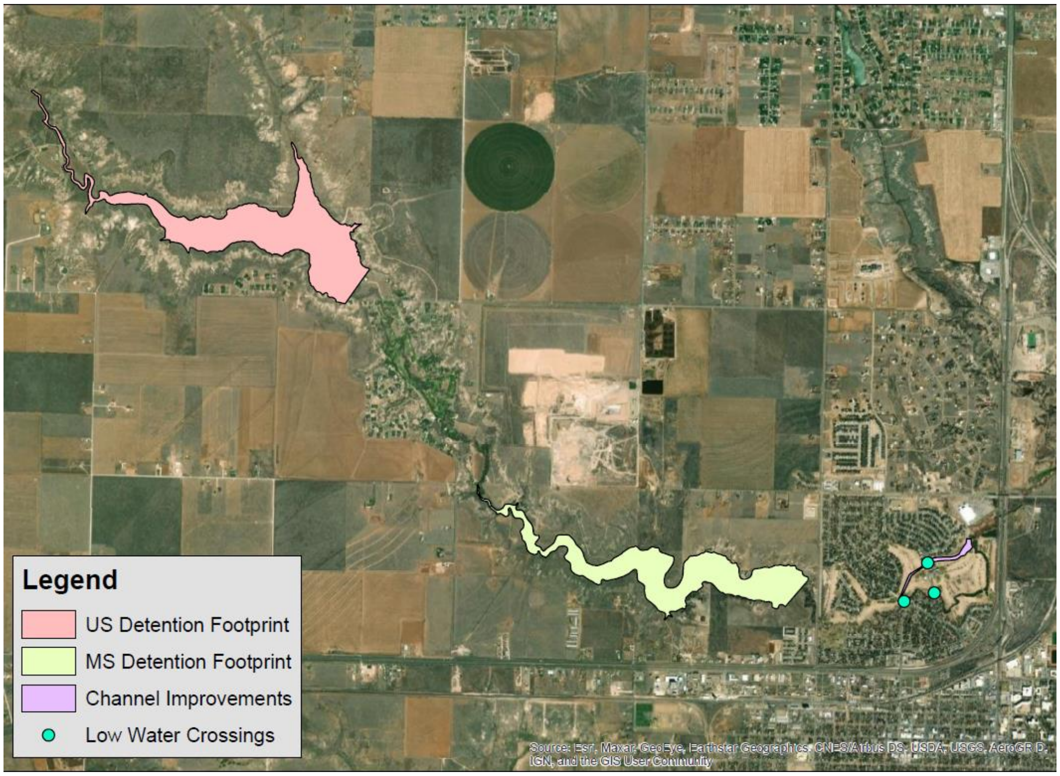

Figure 1. Locations of flood detention, channel enlargement, and low-water crossings

Information and Tools Available

2011 USACE Report and HEC-RAS Model for Canyon Project Alternatives

HDR was provided the report from the 2011 USACE study and the HEC-HMS and HEC-RAS models from the USACE study. The HEC-RAS model was later used to conduct flood mitigation effects analysis in section 3.a.i of this TM.

TWDB BCA Input Tool and FEMA BCA Toolkit 6.0

TWDB requires each project included as an FMP in a regional flood plan to have a benefit/cost analysis (BCA) performed. Many flood mitigation studies document a computed benefit/cost ratio (BCR) and those can be incorporated into the regional flood plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool[2] to facilitate calculations of costs and benefits. It estimates flood damages for residential buildings before and after construction of the flood mitigation project for three return periods; the 25-yr, 100-yr, and 500-yr return periods were used for this analysis. The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0[3]. It uses the flood reduction during three design flood events (In this study: 25-yr, 100-yr, and 500-yr). The FEMA BCA Toolkit calculates annual benefits from the information compiled in the TWDB BCA Input Tool.

[2] https://www.twdb.texas.gov/flood/planning/planningdocu/2023/doc/BCA%20Workbook.zip
[3] https://www.fema.gov/grants/guidance-tools/benefit-cost-analysis

The TWDB BCA Input Tool then computes the resulting BCR for the project.

Randall County Central Appraisal Data (2021 Certified)

HDR downloaded the Randall County Central Appraisal District (CAD) Data (2021 Certified) from the Randall County CAD's website to locate properties potentially impacted by flooding from the Palo Duro Creek and to estimate buyout costs for properties expected to be inundated within the pools of the flood detention ponds.

TXDOT Construction Project Average Low Bid

HDR utilized the 12-months Average Low Bid dated March 2022 obtained from the Texas Department of Transportation (TXDOT) to estimate costs for culverts, roadway repair, and mass concrete for the detention basin spillways.

Analyses Performed

Flood Mitigation Impacts

The HEC-RAS model from the 2011 study incorporates the recommended diversion channel enlargement and upstream detention. HDR utilized the model to duplicate those simulations and estimate the extents of flooding for the 25-year, 100-year, and 500-year storm events[4] for existing conditions and after implementation of the FMP.

HDR used the flooding extents from the HEC-RAS simulations and available LIDAR data to identify 162 residences and one commercial building affected by at least the 500-year event, as shown in Figure 2 (existing) and Figure 3 (with FMP) for the 100-year flood event. HDR assigned flood depths at the center points to each property before and after implementation of the FMP, based on data from the Randall County Central Appraisal District.

Note that the FMP removes very few structures from 100-year floodplain but does reduce flood depths.

[4] Note that these storm events were determined prior to the Atlas 14 update.

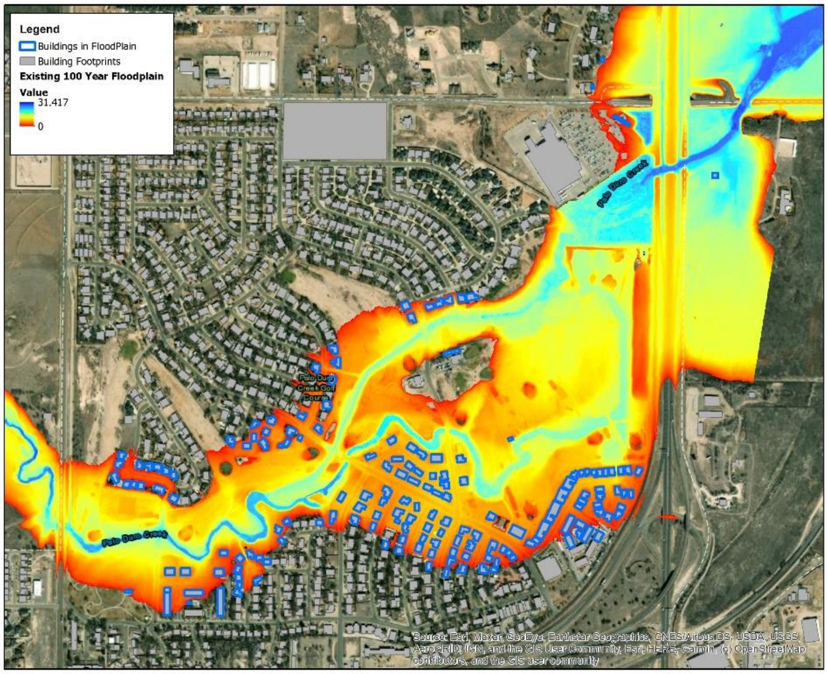

Figure 2. Structures inside the 100-year floodplain under existing conditions

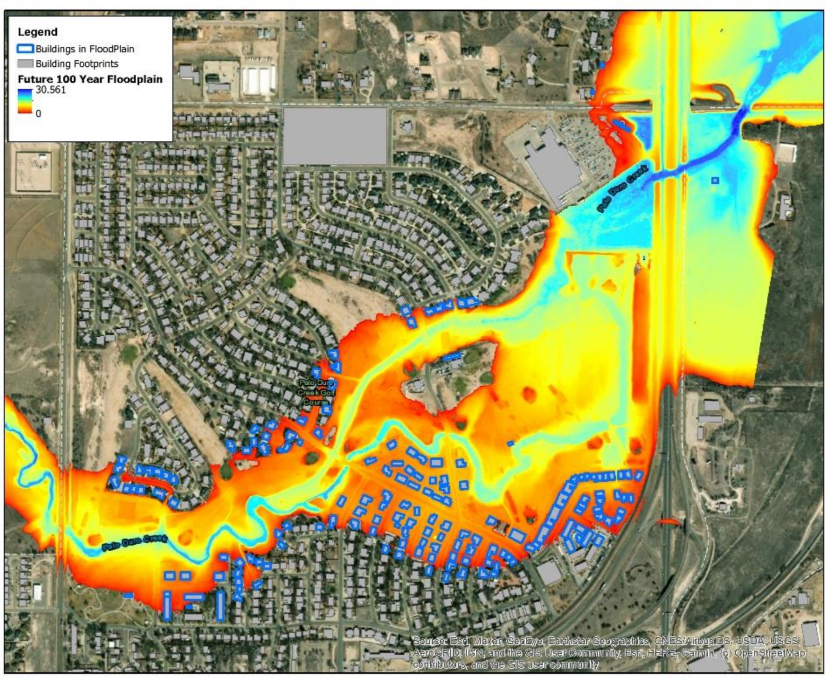

Figure 3. Structures within the 100-year floodplain after implementation of the FMP

Flood Damages Before and After Implementation of the FMP

Depth of flooding for each structure was entered into the TWDB BCA Input Workbook for the 25-year, 100-year, and 500-year events for existing and with-FMP conditions.

The TWDB BCA Input Workbook includes flood damage-by-depth values for residential homes and commercial buildings in Texas. With each flood depth, there is a corresponding flood damage associated with the type of structure. The workbook sums the individual damages for all structures to provide a comparison of damages before and after implementation of the FMP for each of the three flood events.

Costing

CHANNEL ENLARGEMENT AND LOW WATER CROSSINGS

USACE HEC-RAS model from the 2011 study included the channel configuration after the excavation at 16 cross-sections within the project area. HDR has measured the depths, channel bottom widths, top widths, side lengths at each cross-section. Excavation was estimated at each cross section using the depths, bottom and top widths, and side lengths in the model, which were combined with cross section spacing to estimate the volume of channel excavation.

Volumes of riprap stone protection were estimated. It was assumed that the entire bottom width of the excavated channel would be armored with riprap up to 1/3 of the side slope. Based on the channel velocity the riprap would be sized with a D50 of 18 inches.

Unit costs for channel excavation, riprap stone, and concrete were assumed to estimate the total costs of the channel enlargement.

At the request of the City of Canyon as the project sponsor, costs to enlarge three low-water crossings were also estimated, based on replacing each existing crossing with two 6 ft by 6ft concrete box culverts with associated headwalls and roadway repairs. Actual design of the improved low-water crossings would need to be completed in a more detailed fashion during a later project development stage.

DETENTION PONDS

The 2011 USACE report recommended two side-channel detention ponds constructed with 350-feet long embankment weirs that would engage at specific flood levels to divert flows into the structures and reduce peak discharges. The USACE report noted that traditional flow-through structures might also be feasible. The USACE information regarding the conceptual side-channel ponds was very limited and it is not clear how the structures would be constructed within the relatively narrow confines of the valley containing Palo Duro Creek. Accordingly, the project team decided to modify the detention concept to include more traditional detention pond dam embankments to impound flood flows. The intent of the ponds is to only detain larger flood flows, so a series of ten, 5’x5’ box culverts would convey flows through the embankments up to about the 10-year flood peak discharge. Discharges greater than the flood peak discharge would surcharge into the detention pond pools. The entire embankment would be concrete lined as a spillway to convey larger discharges over the tops of the dams without damaging them.

The embankment heights of the detention dams were set consistent with the embankment heights of the original side-channel structures, at 3579 ft (upstream) and 3530 ft (midstream), respectively. The embankments were aligned roughly perpendicular to the valley flow at approximately the same locations as the downstream sides of the original side-channel detention ponds. The storage volumes that would be detained at the top of the embankment were determined to be 2,122 acre-feet for the upstream structure and 1,472 acre-feet for the midstream structure, with the footprints shown in Figure 1.

The estimated volumes of the earthen embankments, concrete spillways, and riprap protection were estimated, and assumed unit costs were applied to these quantities along with costs for the culverts.

PROPERTY ACQUISITION

The two detention ponds would require that property to be inundated during operation of the ponds be purchased. Randall County CAD data were used for the parcels overlying the footprints of the inundated areas to estimate buyout costs, including structures and the impacted portions of the land.

TOTAL PROJECT COST

Costs for the channel improvement, detention ponds, and low-water crossings were accumulated and summed to arrive at a total construction cost for the FMP in 2022 dollars. Mobilization and contingency were estimated at 30% of construction costs and engineering and surveying were estimated to be 10% of the total cost. After application of contingency and mobility and engineering and surveying cost factors, the total project cost is estimated to be $34,760,000. The construction was set to begin and end in 2022 to simplify the calculation of the BCR.

Benefit/Cost Analysis Results

The total cost was entered into the TWDB BCA Input Tool with annual operation and maintenance costs of 2.5% of capital costs, for the assumed 30-year lifetime of the project. The tool computes total costs for the project over the 30-year assumed lifespan. The total annualized benefits as determined by the FEMA BCA Toolkit 6.0 were also entered. The data are summarized in Figure 4, which is a screen capture of the Results tab from the TWDB BCA Input Tool. Note that the green shaded value of $1,773,661 represents the sum of the estimated total benefits computed over the 30-year useful life at a discount rate of 7 percent, per FEMA standards.

The final BCR computed by the TWDB BCA Input Tool for the City of Canyon FMP is 0.04, using the damages and benefits referenced to the 25-year, 100-year, and 500-year events. This can be considered a very low BCR, and it attributed to the relatively small number of structures actually removed from flooding by FMP. It may be possible to increase the benefits by utilizing a set of more frequent flood events such as the 5-year, 10-year and 25-year flood events, and this can be explored if desired by the flood planning group.

Figure 4. Results tab from the TWDB BCA Input Tool

Input Into BCA Toolkit		
Project Useful Life	**30**	
Event Damages	**Baseline**	**Project**
25 - year storm	**$7,965,065**	**$5,781,388**
100 - year storm	**$14,915,972**	**$10,501,453**
500 - year storm	**$27,895,752**	**$22,777,754**

Total Benefits from BCA Toolkit	$1,773,661
Other Benefits (Not Recreation)	$0
Recreation Benefits	$0
Total Costs	$45,543,457
Net Benefits	-$43,769,796
Net Benefits with Recreation	-$43,769,796
Final BCR	**0.04**
Final BCR with Recreation	**0.04**

801 Cherry Street, Suite 2800 + Fort Worth, Texas 76102 + 817-735-7300 + FAX 817-735-7491

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TO:	Region 1 Canadian-Upper Red Regional Flood Planning Group
FROM:	Scott Hubley, PE, CFM – Vice President
SUBJECT:	Brenda Hursh FMP Evaluation
PROJECT:	Canadian-Upper Red Regional Flood Plan (FNI Proj. No. PPC21323)
DATE:	April 21, 2022
CC:	David Dunn – HDR Engineering, Inc., Russell Schreiber – City of Wichita Falls

PROJECT OVERVIEW

Brenda Hursh Channel and Brenda Hursh Creek in Wichita Falls, Texas are concrete lined channels located within the FEMA Zone AE floodplain on FIRM panels 48485C0320G, 48485C0340G, 48485C0435G, and 48485C0455G. Multiple properties along Brenda Hursh Creek are currently located within the 1% annual chance FEMA floodplain. To alleviate flood risk, it is proposed to divert flow from Brenda Hursh Creek and Brenda Hursh Channel at the Weeks Street crossings and convey runoff through a proposed pipe system that will outfall into a grass-lined channel. This channel will go through The Champions Course at Weeks Park golf course to the west until meeting Holliday Creek. The initial evaluation for this project was conducted in 2011 as a part of the Wichita Falls Drainage Master Plan by Freese and Nichols, Inc.

BENEFIT-COST RATIO

Within the Benefit-Cost Analysis (BCA) workbook provided, several types of project impacts can be considered. For the Brenda Hursh project, residential structure damage reduction, commercial structure damage reduction, critical facility loss of function reduction, and reduction in street flooding were considered for the Brenda Hursh project. Additionally, green infrastructure elements were present in the project.

As a part of the original study, 100 potentially inundated structures were identified for the 1% annual chance (100-year) event and 90 were identified for the 4% annual chance (25-year) event. All identified structures were marked as residential or unknown in the TWDB buildings layer data. Therefore, these structures were all used for the residential structure damage reduction. No buildings were marked as commercial structures or critical facilities, so analysis for these damage reductions was not completed.

Since there were slight differences, such as additional buildings, in the building datasets between the original study and the provided building layer from TWDB, an additional analysis was completed to find further potential inundated structures for the 100-year storm event. For buildings in Wichita Falls, the elevation at the centroid of the building from 2018 LiDAR was obtained and an additional 0.5 foot was added to account for slab height and estimate the finished floor elevation (FFE), as in the original report. Water surface elevation (WSEL) was assigned to each building point based on the closest cross section within 300 feet, which was then compared to FFE to find which structures had potential to be inundated. This identified 14 additional structures. These fourteen buildings were added to the BCA for the 100-year storm. While one structure was marked as a critical facility, it was a school, which is not one of the types considered as critical for the BCA (police station, fire station, and hospital).

In post-project conditions, 64 properties were removed from the 1% annual chance (100-year) event and flood damages at 7 were reduced. This resulted in a decrease in residential structure damage from $6.3 million to $2.9 million, and a decrease in residential loss of function from $4.3 million to $1.8 million. From the 4% annual chance (25-year) event, 59 structures were removed, and flood damages at 2 were reduced. This resulted in a decrease in residential structure damage from $4.8 million to $1.8 million, and a decrease in residential loss of function from $4.3 million to $1.8 million.

At some cross sections, there was an increase of 0.01 feet in the 100-year WSEL between proposed and existing conditions. This is within the acceptable range of increase, as described further in the no negative impact analysis below. Despite this being an insignificant increase, this occasionally resulted in structure inundation increasing by an inch due to rounding requirements in the BCA spreadsheet calculations. The Wichita Falls NFIP ordinance requires that no insured structures experience an increase in flooding, so this project will undergo further design as it progresses to ensure no significant increases occur. Structures that experience an increase in inundation were rounded down one inch in anticipation of future design conditions. Water surface elevations and damages are shown below in **Table 1**.

Table 1: Water Surface Elevations and Expected Damages for Residential Properties

Structure Information			25 - year storm				100 - year storm			
Location	Structure Type	Number of Structures	Baseline Flood Depth	Baseline Damages	Project Flood Depth	Project Damages	Baseline Flood Depth	Baseline Damages	Project Flood Depth	Project Damages
PARK PLACE CT #1	Average Home	1	2"	$29,091	0		2"	$29,091	0	
PARK PLACE CT #2	Average Home	1	2"	$29,091	0		2"	$29,091	0	
PARK PLACE CT #3	Average Home	1	2"	$29,091	0		2"	$29,091	0	
PARK PLACE CT #4	Average Home	1	2"	$29,091	0		2"	$29,091	0	
PARK PLACE CT #5	Average Home	1	2"	$29,091	0		2"	$29,091	0	
PARK PLACE CT #6	Average Home	1	2"	$29,091	0		2"	$29,091	0	
PARK PLACE CT #7	Average Home	1	2"	$29,091	0		2"	$29,091	0	
NORMAN #1	Average Home	1	6"	$56,292	6"	$56,292	7"	$59,921	7"	$59,921
MELODY #1	Average Home	1	0		0		3"	$31,682	3"	$31,682
MELODY #2	Average Home	1	0		0		3"	$31,682	3"	$31,682
MELODY #3	Average Home	1	0		0		3"	$31,682	3"	$31,682
MELODY #4	Average Home	1	0		0		3"	$31,682	3"	$31,682
NORMAN #2	Average Home	1	43"	$107,833	43"	$107,833	44"	$108,628	44"	$108,628
NORMAN #3	Average Home	1	25"	$95,117	25"	$95,117	26"	$95,768	26"	$95,768
NORMAN #4	Average Home	1	0		0		4"	$41,705	4"	$41,705
WEEKS #1	Average Home	1	3"	$31,682	0		9"	$67,178	0	
WEEKS #2	Average Home	1	3"	$31,682	0		9"	$67,178	0	
PARK PLACE CT #1	Average Home	1	2"	$29,091	0		2"	$29,091	0	
WOODLAND CREEK #1	Average Home	1	8"	$63,550	0		8"	$63,550	4"	$41,705
WEEKS #3	Average Home	1	3"	$31,682	0		9"	$67,178	0	
WEEKS #4	Average Home	1	8"	$63,550	0		14"	$80,797	0	
WEEKS #5	Average Home	1	35"	$101,619	0		41"	$106,243	0	
WEEKS #6	Average Home	1	15"	$82,164	4"	$41,705	21"	$90,366	3"	$31,682
WEEKS #7	Average Home	1	13"	$79,430	0		19"	$87,632	0	
BARNA #1	Average Home	1	5"	$49,047	0		6"	$56,292	1"	$28,999
CLUB VIEW #1	Average Home	1	14"	$80,797	5"	$49,047	15"	$82,164	11"	$74,435
MIDWESTERN #1	Average Home	1	15"	$82,164	6"	$56,292	17"	$84,898	14"	$80,797
BARNA #2	Average Home	1	2"	$29,091	0		2"	$29,091	0	
CLUB VIEW #2	Average Home	1	2"	$29,091	0		2"	$29,091	0	
BARNA #3	Average Home	1	2"	$29,091	0		2"	$29,091	0	
CLUB VIEW #3	Average Home	1	2"	$29,091	0		2"	$29,091	0	
BARNA #4	Average Home	1	2"	$29,091	0		2"	$29,091	0	
CLUB VIEW #4	Average Home	1	2"	$29,091	0		2"	$29,091	0	
CLUB VIEW #4	Average Home	1	2"	$29,091	0		2"	$29,091	0	
BARNA #5	Average Home	1	2"	$29,091	0		2"	$29,091	0	

	Structure Information		25 - year storm				100 - year storm			
Location	Structure Type	Number of Structures	Baseline Flood Depth	Baseline Damages	Project Flood Depth	Project Damages	Baseline Flood Depth	Baseline Damages	Project Flood Depth	Project Damages
CLUB VIEW #5	Average Home	1	2"	$29,091	0		2"	$29,091	0	
BARNA #6	Average Home	1	2"	$29,091	0		2"	$29,091	0	
BARNA #7	Average Home	1	2"	$29,091	0		2"	$29,091	0	
BARNA #8	Average Home	1	2"	$29,091	0		2"	$29,091	0	
BARNA #9	Average Home	1	2"	$29,091	0		2"	$29,091	0	
BARNA #10	Average Home	1	2"	$29,091	0		2"	$29,091	0	
BARNA #11	Average Home	1	2"	$29,091	0		2"	$29,091	0	
BARNA #12	Average Home	1	2"	$29,091	0		2"	$29,091	0	
BARNA #13	Average Home	1	2"	$29,091	0		2"	$29,091	0	
PARK PLACE CT #2	Average Home	1	2"	$29,091	0		2"	$29,091	0	
LAKE PARK #1	Average Home	1	2"	$29,091	0		2"	$29,091	0	
BRENNA #1	Average Home	1	5"	$49,047	0		5"	$49,047	0	
LAKE PARK #2	Average Home	1	4"	$41,705	0		4"	$41,705	0	
LAKE PARK #3	Average Home	1	10"	$70,806	0		10"	$70,806	0	
LAKE PARK #4	Average Home	1	24"	$94,467	0		25"	$95,117	0	
SCOTTSDALE #1	Average Home	1	16"	$83,531	0		17"	$84,898	0	
SCOTTSDALE #2	Average Home	1	12"	$78,063	0		13"	$79,430	0	
LAKE PARK #5	Average Home	1	28"	$97,068	0		29"	$97,718	0	
SCOTTSDALE #3	Average Home	1	3"	$31,682	0		3"	$31,682	0	
SCOTTSDALE #4	Average Home	1	18"	$86,265	0		19"	$87,632	0	
SCOTTSDALE #5	Average Home	1	9"	$67,178	0		10"	$70,806	0	
SCOTTSDALE #6	Average Home	1	17"	$84,898	0		17"	$84,898	0	
LAKE PARK #5	Average Home	1	36"	$102,269	0		37"	$103,064	0	
SCOTTSDALE #7	Average Home	1	11"	$74,435	0		16"	$83,531	0	
LAKE PARK #6	Average Home	1	33"	$100,319	0		34"	$100,969	0	
LAKE PARK #7	Average Home	1	45"	$109,423	0		>48"	$183,902	0	
CASTON #1	Average Home	1	0		0		2"	$29,091	0	
DUNBARTON #1	Average Home	1	9"	$67,178	9"	$67,178	13"	$79,430	13"	$79,430
DUNBARTON #2	Average Home	1	9"	$67,178	9"	$67,178	13"	$79,430	13"	$79,430
HOLLANDALE #1	Average Home	1	3"	$31,682	2"	$29,091	4"	$41,705	3"	$31,682
HOLLANDALE #2	Average Home	1	1"	$28,999	0		3"	$31,682	2"	$29,091
DUNBARTON #3	Average Home	1	9"	$67,178	9"	$67,178	13"	$79,430	13"	$79,430
HOLLANDALE #3	Average Home	1	2"	$29,091	1"	$28,999	4"	$41,705	4"	$41,705
DUNBARTON #4	Average Home	1	25"	$95,117	25"	$95,117	30"	$98,368	30"	$98,368
DUNBARTON #5	Average Home	1	9"	$67,178	9"	$67,178	13"	$79,430	13"	$79,430
MELODY #5	Average Home	1	9"	$67,178	9"	$67,178	13"	$79,430	13"	$79,430
MELODY #6	Average Home	1	9"	$67,178	9"	$67,178	13"	$79,430	13"	$79,430
HOLLANDALE #4	Average Home	1	0		0		2"	$29,091	2"	$29,091
MELODY #7	Average Home	1	9"	$67,178	9"	$67,178	13"	$79,430	13"	$79,430
MELODY #8	Average Home	1	9"	$67,178	9"	$67,178	13"	$79,430	13"	$79,430

Structure Information			25 - year storm				100 - year storm			
Location	Structure Type	Number of Structures	Baseline Flood Depth	Baseline Damages	Project Flood Depth	Project Damages	Baseline Flood Depth	Baseline Damages	Project Flood Depth	Project Damages
HOLLANDALE #5	Average Home	1	0		0		2"	$29,091	2"	$29,091
MELODY #9	Average Home	1	7"	$59,921	7"	$59,921	10"	$70,806	10"	$70,806
MELODY #10	Average Home	1	4"	$41,705	4"	$41,705	6"	$56,292	6"	$56,292
HOLLANDALE #6	Average Home	1	0		0		2"	$29,091	2"	$29,091
MELODY #11	Average Home	1	7"	$59,921	7"	$59,921	10"	$70,806	10"	$70,806
MELODY #12	Average Home	1	7"	$59,921	7"	$59,921	10"	$70,806	10"	$70,806
DUNBARTON #6	Average Home	1	9"	$67,178	9"	$67,178	13"	$79,430	13"	$79,430
FLORIST #1	Average Home	1	10"	$70,806	10"	$70,806	12"	$78,063	12"	$78,063
FLORIST #2	Average Home	1	14"	$80,797	14"	$80,797	15"	$82,164	15"	$82,164
FLORIST #3	Average Home	1	9"	$67,178	9"	$67,178	11"	$74,435	11"	$74,435
FLORIST #4	Average Home	1	0		0		2"	$29,091	2"	$29,091
FLORIST #5	Average Home	1	2"	$29,091	2"	$29,091	3"	$31,682	3"	$31,682
FLORIST #6	Average Home	1	3"	$31,682	3"	$31,682	5"	$49,047	5"	$49,047
FLORIST #7	Average Home	1	5"	$49,047	5"	$49,047	7"	$59,921	7"	$59,921
FLORIST #8	Average Home	1	12"	$78,063	12"	$78,063	13"	$79,430	13"	$79,430
FLORIST #9	Average Home	1	2"	$29,091	2"	$29,091	3"	$31,682	3"	$31,682
FLORIST #10	Average Home	1	3"	$31,682	3"	$31,682	6"	$56,292	5"	$49,047
BRENNA #2	Average Home	1	5"	$49,047	0		5"	$49,047	0	
PARK PLACE CT #3	Average Home	1	2"	$29,091	0		2"	$29,091	0	
PARK PLACE CT #4	Average Home	1	2"	$29,091	0		2"	$29,091	0	
PILLARS #1	Average Home	1	24"	$94,467	0		25"	$95,117	0	
BRENNA #3	Average Home	1	2"	$29,091	0		2"	$29,091	0	
PARK PLACE CT #5	Average Home	1	2"	$29,091	0		2"	$29,091	0	
PILLARS #2	Average Home	1	20"	$88,999	0		21"	$90,366	0	
PARK PLACE CT #6	Average Home	1	2"	$29,091	0		2"	$29,091	0	
#1931638	Average Home	1					7"	$59,921	7"	$59,921
#1947610	Average Home	1					3"	$31,682	3"	$31,682
#1951006	Average Home	1					2"	$29,091	0	
#1952126	Average Home	1					29"	$97,718	29"	$97,718
#1953162	Average Home	1					8"	$63,550	8"	$63,550
#1953215	Average Home	1					1"	$28,999	0	
#1957767	Average Home	1					1"	$28,999	0	
#1958085	Average Home	1					8"	$63,550	0	
#1970811	Average Home	1					4"	$41,705	0	
#1970817	Average Home	1					2"	$29,091	0	
#1972860	Average Home	1					3"	$31,682	0	
#1977649	Average Home	1					15"	$82,164	15"	$82,164
#1979404	Average Home	1					3"	$31,682	3"	$31,682
#1984269	Average Home	1					6"	$56,292	6"	$56,292

For street flooding, TxDOT does not have data available for the AADT of streets within the project area. Therefore, roadway impacts could not be quantified for the BCA. Nonetheless, miles of roadway were obtained by intersecting the flooding polygon with the road layer, and differences in mileage and time were obtained from Google Maps.

For the green infrastructure consideration, the proposed channel is naturally lined and will increased the amount of riparian habitat in this area. This value of increased habitat was obtained using the flow line as length, 941.1 feet, and the largest potential top width, 71 feet, to get 1.53 acres.

The total benefits calculated by the FEMA BCA toolkit measured at $2,812,782, which was combined with environmental benefits from the TWDB BCA spreadsheet of $576,511, leading to a total benefit of $3,389,293.

The original report listed the total project cost as $3,268,800. To bring this number to 2020 dollars, a factor of 1.27 was applied to bring the cost to $4,151,376. This cost was then annualized across three years of construction in the spreadsheet for a total cost of $2,964,392.

After all costs and benefits were determined, the final BCA was determined to be 1.1.

NO NEGATIVE IMPACT ANALYSIS

Each identified Flood Management Strategy (FMS) and Flood Mitigation Project (FMP) must demonstrate that there would be no negative impacts on a neighboring area due to its implementation.

For the purposes of flood planning effort, a determination of no negative impact can be established if stormwater does not increase inundation of infrastructure such as residential and commercial buildings and structures. Additionally, all of the following requirements, per TWDB *Technical Guidelines*, should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement
2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity
3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section
4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 ft) measured at each computation cell
5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis

For the Brenda Hursh project, a HEC-HMS model and a 1D HEC-RAS model were used to assess and develop the project. Since there was no 2D HEC-RAS model, only requirements #**1**, **#2**, **#3**, and #**5** are relevant.

Of the plans within the HEC-RAS model, the ExistingFD_FNI and Proposed plans were compared. Both plans use flows which reflect fully developed conditions, with any differences in the flow file being due to the proposed bypass. There are no cross sections where the increase in water surface elevation is greater than

0.05 feet for the 100-year storm, meeting requirement **#3**. There are four cross sections that experience a slight increase, but as this is a conceptual alternative and the increases are insignificant and will be addressed during further design. As design continues, a full floodplain impacts study would be performed, and the design would be adjusted to avoid adverse impacts. Therefore, it can be concluded that these potential increases will be mitigated and not impacts areas beyond public right-of-way, project property, or easement, particularly as the design is refined for construction, meeting requirement **#1**. The WSEL at cross sections for existing and proposed conditions are shown below in **Table 2**.

Table 2: WSEL at Cross Sections under Proposed and Existing Conditions

River Station	Plan	WSEL (ft)	Difference in WSEL (ft)
4054	Proposed	975.61	0
	Exist_FD	975.61	
3342	Proposed	972.96	0
	Exist_FD	972.96	
2942	Proposed	972.6	-0.09
	Exist_FD	972.69	
2894	Proposed	972.72	-0.07
	Exist_FD	972.79	
2819	Proposed	970.74	-0.01
	Exist_FD	970.75	
2759	Proposed	970.53	0
	Exist_FD	970.53	
2461	Proposed	970.33	-0.05
	Exist_FD	970.38	
2117	Proposed	970.23	-0.06
	Exist_FD	970.29	
2017	Proposed	970.24	-0.05
	Exist_FD	970.29	
1967	Proposed	970.11	-0.06
	Exist_FD	970.17	
1179	Proposed	962.7	0.01
	Exist_FD	962.69	
1129	Proposed	961.5	0.01
	Exist_FD	961.49	
987	Proposed	960.85	0
	Exist_FD	960.85	
854	Proposed	960.72	-0.1
	Exist_FD	960.82	
756	Proposed	958.5	-0.16
	Exist_FD	958.66	
621	Proposed	957.9	-1.09

River Station	Plan	WSEL (ft)	Difference in WSEL (ft)
	Exist_FD	958.99	
455	Proposed	957.84	-1.34
	Exist_FD	959.18	
320	Proposed	957.78	-1.48
	Exist_FD	959.26	
206	Proposed	954.76	-4.49
	Exist_FD	959.25	
200	Proposed	954.32	-2.4
	Exist_FD	956.72	
9634	Proposed	972.42	0
	Exist_FD	972.42	
9163	Proposed	972.29	-0.01
	Exist_FD	972.3	
8900	Proposed	972.29	0
	Exist_FD	972.29	
8722	Proposed	972.28	-0.01
	Exist_FD	972.29	
8629	Proposed	967.82	0
	Exist_FD	967.82	
8427	Proposed	964.79	0
	Exist_FD	964.79	
8144	Proposed	961.95	-0.02
	Exist_FD	961.97	
7988	Proposed	962.35	-0.02
	Exist_FD	962.37	
7921	Proposed	959.7	0
	Exist_FD	959.7	
7736	Proposed	959.62	0
	Exist_FD	959.62	
7186	Proposed	959.34	0
	Exist_FD	959.34	
6897	Proposed	959.57	0
	Exist_FD	959.57	
6750	Proposed	959.61	0
	Exist_FD	959.61	
6694	Proposed	959.59	0.01
	Exist_FD	959.58	
6613	Proposed	958.75	-0.01
	Exist_FD	958.76	
6553	Proposed	958.26	-0.16

River Station	Plan	WSEL (ft)	Difference in WSEL (ft)
	Exist_FD	958.42	
6494	Proposed	957.63	-0.44
	Exist_FD	958.07	
6382	Proposed	954.19	-3.63
	Exist_FD	957.82	
6274	Proposed	953.25	-4.01
	Exist_FD	957.26	
6099	Proposed	952.27	-5.08
	Exist_FD	957.35	
5717	Proposed	951.51	-3.48
	Exist_FD	954.99	
5423	Proposed	951.61	-3.34
	Exist_FD	954.95	
5265	Proposed	951.61	-1.76
	Exist_FD	953.37	
4927	Proposed	951.43	-0.63
	Exist_FD	952.06	
4599	Proposed	951.44	-0.68
	Exist_FD	952.12	
4507	Proposed	950.95	-1.26
	Exist_FD	952.21	
4018	Proposed	950.79	-0.31
	Exist_FD	951.1	
3587	Proposed	950.71	-0.35
	Exist_FD	951.06	
3275	Proposed	950.23	-0.47
	Exist_FD	950.7	
2690	Proposed	950.08	-0.23
	Exist_FD	950.31	
2459	Proposed	950.08	-0.34
	Exist_FD	950.42	
2318	Proposed	949.38	-1.01
	Exist_FD	950.39	
2249	Proposed	948.9	-1.43
	Exist_FD	950.33	
2223	Proposed	948.83	-1.47
	Exist_FD	950.3	
2058	Proposed	948.57	-1.53
	Exist_FD	950.1	
1735	Proposed	948.67	-1.4

River Station	Plan	WSEL (ft)	Difference in WSEL (ft)
	Exist_FD	950.07	
1566	Proposed	948.37	-1.64
	Exist_FD	950.01	
1522	Proposed	947.86	-2.02
	Exist_FD	949.88	
1398	Proposed	947.83	-2.1
	Exist_FD	949.93	
1285	Proposed	947.63	-2.12
	Exist_FD	949.75	
1254	Proposed	946.34	-0.69
	Exist_FD	947.03	
1102	Proposed	945.76	-0.62
	Exist_FD	946.38	
395	Proposed	943.84	-0.65
	Exist_FD	944.49	
336	Proposed	942.49	-0.54
	Exist_FD	943.03	
312	Proposed	943.19	0.02
	Exist_FD	943.17	
77	Proposed	943.25	0
	Exist_FD	943.25	

According to the original study, none of the road crossings have sufficient capacity to be in compliance with the City's drainage ordinance. In proposed conditions, overtopping depth remains the same or decreases at all locations. Therefore, requirement **#2** is met. These road crossings and overtopping information are shown in **Table 3** below.

Table 3: Road Overtopping Details

Station	Crossing	Existing		Proposed	
		Event in which overtopping occurs	100-year overtopping depth, ft	Event in which overtopping occurs	100-year overtopping depth, ft
Brenda Hursh Channel					
2860	Easy Street	2-year	0.79	2-year	0.79
1500	Fain School	2-year	1.17	2-year	1.17
800	Arlington Street	2-year	0.82	2-year	0.75
260	Weeks Street	2-year	2.36	2-year	0.84
Brenda Hursh Creek					

Station	Crossing	Existing		Proposed	
		Event in which overtopping occurs	100-year overtopping depth, ft	Event in which overtopping occurs	100-year overtopping depth, ft
8700	Norman Street	5-year	0.29	5-year	0.29
7950	Dunbarton Drive #1	10-year	0.37	10-year	0.37
6700	Dunbarton Drive #2	2-year	1.61	2-year	1.61
6400	Weeks Street	5-year	1.07	5-year	0.62
4550	Brenda Hursh Drive	2-year	2.12	25-year	1.44
2400	Midwestern Pkwy	2-year	0.42	50-year	0.16

Within the HEC-HMS model, the 100-year peak flows were compared for ultimate conditions in existing and proposed basins. Flows decreased at all computation nodes present in both models, meeting the requirement for **#5** that the maximum increase must be less than 0.5%. The peak flows are shown below in **Table 4**.

Table 4: Peak Flows at Computation Nodes

Hydrologic Element	Existing Peak Discharge	Proposed Peak Discharge	Percent Change
BH-1	143.8	143.8	0.00%
BH-2	354.7	354.7	0.00%
BH-3	514.4	514.4	0.00%
BH-4	545.4	545.4	0.00%
BH-5	694.8	694.8	0.00%
BH-6	566.8	566.8	0.00%
BH-7	252.5	252.5	0.00%
BH-8	315.4	315.4	0.00%
Bypass		2452	
Diversion-1	833.8	833.7	-0.01%
Diversion-2	1641.9	289	-82.40%
Diversion-3	1933.7	822	-57.49%
Diversion-4	1903.9	1296	-31.93%
Diversion-5	1662.4	1380.6	-16.95%
J-1	2452	1573.4	-35.83%
J-BH	315.4	315.4	0.00%
J-BH1	426.1	426.1	0.00%
J-BH2	916.1	916.1	0.00%

Hydrologic Element	Existing Peak Discharge	Proposed Peak Discharge	Percent Change
J-BH4	1958.8	822	-58.04%
J-BH5	2325.3	1296	-44.27%
J-BH6	1950.5	1411.8	-27.62%
J-BH7	1618.3	1375.7	-14.99%
J-T1	1089.9	1089.6	-0.03%
J-Trib	808.6	808.6	0.00%
overflow		289	
R-BH1	237.4	237.4	0.00%
R-BH2	417.7	417.7	0.00%
R-BH3	902.2	902.2	0.00%
R-BH4	1519.7	276.6	-81.80%
R-BH5	1877.7	809.1	-56.91%
R-BH6	1734.3	1092.4	-37.01%
R-BH7	1583.1	1257	-20.60%
R-Trib1	765.8	765.8	0.00%
R-Trib2	706.4	706.4	0.00%
T-1	241.3	241.3	0.00%
T-2	405.1	404.8	-0.07%
T-3	808.6	808.6	0.00%

Since the diversion sends flow into Holliday Creek, the capacity of Holliday Creek to handle this diversion was also examined. Peak flows into Holliday Creek are controlled by Lake Wichita, which is located upstream of Holliday Creek. According to the FIS study, the 1% annual chance event flow from Lake Wichita is 9,297 cfs. The design flows for Holliday Creek range from 10,320 to 10,780 cfs, greater than the anticipated 100-year event from Lake Wichita. Within the channel, there are cross sections of varying size. The cross section at the proposed diversion outlet is smaller than at the location of the existing outlet. Since the proposed outlet will experience about 2,400 cfs of increased flow, it is suggested that this area be given further evaluation. The time to peak outflow from Lake Wichita and from the proposed outlet for Brenda Hursh will be very different, so it is unlikely that there will peaks at the same time. Further study can be done with an expansion of the HEC-RAS model for the Wichita River, which ends just after the project area, and by creating a HEC-HMS model to model all drainage areas leading to these outlet points. Based on the results of these analyses, alternatives could be developed based around the location of the proposed channel and pipe. However, at this level of analysis, it is reasonable to assume that any negative impacts can be mitigated through further design.

Since this evaluation is at a planning level, further analysis will be required as the project progresses to final design. At this stage, the Brenda Hursh project **meets all requirements** for the no adverse impact analysis.

Memorandum

Date:	Thursday, June 16, 2022
Project:	Canadian – Upper Red Regional Flood Plan
To:	Scott Hubley, PE, Freese and Nichols, Inc.
From:	David Dunn, PE (Texas PE No. 82630) Toby Li, EIT
Subject:	Echo/Neta Lane Drainage Project FMP

The initial evaluation for this project was conducted in 2011 as a part of the Wichita Falls Drainage Master Plan Update by Freese and Nichols, Inc. (FNI)[1]. Excerpts from that study are included as Exhibit 1.

There have been multiple reports near the Echo/Neta project area about standing water. The Big State Grinding Company (4725 Jacksboro Hwy) and a resident at 5001 Joyce Blvd both report standing water at their locations. The standing water is connected with an existing pipe system, which conveys runoff from the east side of Jacksboro Hwy to the west under buildings and across Neta Lane before discharging into an open channel north of the Edgemere Church of Christ parking lot.

Model Analysis

FNI created an EPA SWMM model composed of 40 junction nodes, 51 conduit links and three (3) outfalls. Street sections and natural drainage swales were modeled with irregular conduits reflecting the geometry of the feature. Data for the existing pipe systems located within the project area were taken from storm drain CAD files acquired from the City of Wichita Falls.

Summary of Improvements

FNI proposed an upgraded storm drain system with curb and gutter along Jacksboro Highway beginning south of Echo Lane and reaching north to Norman Street. The system would then turn to the west and run along Norman Street parallel to an existing storm drain system. This system outfalls into a concrete-lined tributary of Brenda Hursh Creek. This system would intercept discharge from the Ditto Lane watershed and eliminate spillover, which contributes to flooding near Edgemere Church of Christ. The new system would have the capability to eliminate flooding at 14 out of 18 structures for the 100-year storm event[2]. The following is an excerpt of the detailed proposed improvements.

[1] Wichita Falls, Texas, *Drainage Master Plan Update, Project: ECHO/NETA LANE DRAINAGE PROJECT,* Freese and Nichols, Inc., 2011.
[2] Note that the precipitation depths of these storm events were determined prior to the Atlas 14 update. The 100-year 24-hour storm depth has not changed significantly in Wichita Falls, TX. [NOAA Atlas 14 (weather.gov)](), figure 7.4

After the existing conditions study of the Echo Neta project area was completed, FNI presented the results to the City along with proposed alternatives for discussion. It was recommended that the proposed solution would be a storm drain system running from south to north along Jacksboro Highway, then west on Norman Street and north on Westridge Drive where it outfalls into the tributary of Brenda Hursh Creek at the same location as the existing system in this area.

To improve flooding problems in the residential area along Echo and Ditto Lanes, the proposed improvements would also include the excavation and regrading of the ditches along these streets.

The proposed storm drain system for the Echo Neta project area begins on Jacksboro Highway about 1050 LF south of Echo Lane. The proposed pipe begins with 1050 LF of 30" RCP and then transitions to a 1000 LF of 6'X3' RCB at Echo Lane where four (4) 15-foot inlets capture flow from the ditches on Echo and Ditto Lanes. In existing conditions, flow on Echo Lane from the east side of Jacksboro Highway accumulates and spills over Jacksboro Highway to the west, causing flooding problems. The proposed inlets at this intersection are intended to capture flow from the ditches on Echo Lane before it spills over Jacksboro Highway. As the proposed pipe reaches further north on Jacksboro Highway, it transitions to 1000 LF 6'X4' RCB that extends to the outfall. This section of 6'X4' RCB begins on Jacksboro Highway about 310 LF south of Norman Street, runs 540 LF west on Norman Street and then 150 LF to the north on Westridge Drive where it outfalls at the Brenda Hursh Tributary. The proposed pipe will share this outfall location with the existing system that is located in the area. Exhibit 2 shows the alignment and characteristics of this proposed pipe system.

In addition to the proposed pipe system described above, FNI also investigated the extent of regrading that would be required in the ditches along Echo and Ditto Lanes to provide sufficient capacity to reduce structure and road flooding in this residential development. Using user defined cross sections in SWMM, iterations were performed to determine what size the ditches in this area would need to be to provide adequate drainage capacity. FNI recommends expanding the ditches along Echo and Ditto Lanes to have a depth two feet, bottom with of two feet, and 4:1 side slopes, and regrading them to fall to the north on Ditto Lane and then to the west on Echo Lane.

Modeling Results

In the original 2011 analysis, the hydraulic modeling results from EPA SWMM 5.0 show that the proposed storm drain system for the Echo/Neta Lane project area would eliminate flooding for 14 out of 18 structures during the 1 percent annual chance (100-year) storm event. It would also eliminate flooding for 11 out of 12 structures during the 10 percent annual chance (10-year) storm event or smaller. Table 1 is from the 2011 report and summarizes results for the existing and proposed conditions.

Table 1. Echo/Neta Lane Drainage Project FMP inundation summary comparison

		Summary of Inundation Depth by Frequency Event (ft)					
		2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
No. structures	Existing	12	12	12	15	16	18
	Proposed	1	1	1	1	2	4
Max depth	Existing	1.72	1.81	1.86	1.92	1.98	2.02
	Proposed	0.49	0.65	0.74	0.87	0.98	1.08
Min depth	Existing	0.36	0.56	0.63	0.12	0.14	0.14
	Proposed	0.49	0.65	0.74	0.87	0.12	0.12
Average depth	Existing	0.85	1.06	1.12	1.05	1.12	1.12
	Proposed	0.49	0.65	0.74	0.87	0.55	0.39

Benefit-Cost Analysis

TWDB requires each project included as an FMP in a regional flood plan to have a benefit/cost analysis (BCA) performed. Many flood mitigation studies document a computed benefit/cost ratio (BCR) and those can be incorporated into the regional flood plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool[3] to facilitate calculations of costs and benefits. It estimates flood damages for residential buildings before and after construction of the flood mitigation project for up to three recurrence interval flood events. Because the TWDB BCA Workbook calculates costs and benefits for only three recurrence intervals, a combination of two workbooks were used to complete calculations for six recurrence interval events (2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0[4], which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then entered back into the TWDB BCA Input Tool which then computes the resulting BCR for the project.

Project Costs

FNI estimated the total project cost to be $1,998,400 in the 2011 Drainage Master Plan[5]. A Construction Cost Index (CCI) factor of 1.27 was applied to convert the costs from 2011 to 2020 dollars, resulting in a project cost of $2,537,968. The construction was set to begin and end in 2020 to simplify the calculation of the BCR.

Flood Damages Before and After Implementation of the FMP

Based on Table 1, average depths of flooding at 10 residential structures and 8 commercial structures were entered into the TWDB BCA Input Workbook for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events for both the existing and the proposed conditions.

The TWDB BCA Input Workbook includes flood damage-by-depth values for residential homes and commercial buildings in Texas. With each flood depth, there is a corresponding flood damage associated with the type of structure. The workbook sums damages for all structures to

[3] https://www.twdb.texas.gov/flood/planning/planningdocu/2023/doc/BCA%20Workbook.zip
[4] https://www.fema.gov/grants/guidance-tools/benefit-cost-analysis
[5] *Drainage Master Plan Update Project: ECHO/NETA Lane*, page 6

provide a comparison of damages before and after implementation of the FMP for each flood event. The damages were then entered into the FEMA BCA Toolkit 6.0. By calculating the annualized difference between the baseline and project damages for various return periods, The FEMA BCA Tool produces the total annualized benefits of the project's lifetime.

The total cost was entered into the TWDB BCA Input Workbook with estimated annual operation and maintenance costs of 1% of the total capital cost for the assumed 30-year lifetime of the project. The tool then was used to compute total costs for the project over the 30-year assumed lifespan. The total annualized benefits as determined by the FEMA BCA Toolkit 6.0 were also entered. The data are summarized in Figure 2, which is a screen capture of the Results tab from the TWDB BCA Input Tool.

Note that the green shaded value of $2,956,975 represents the sum of the estimated total benefits computed over the 30-year useful life at a discount rate of 7 percent, per FEMA standards. **The final BCR computed by the TWDB BCA Input Tool for the Echo/Neta Lane Road Drainage Project FMP is 3.7**, using the damages and benefits referenced to the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events. The FMP removes 14 structures from the 100-year floodplain, 14 structures from the 25-year floodplain, and just 11 structures from flooding by 10-year and smaller events.

Input Into BCA Toolkit		
Project Useful Life	**30**	
Event Damages	**Baseline**	**Project**
25 - year storm	**$2,097,515**	**$76,589**
50 - year storm	**$2,113,856**	**$79,402**
100 - year storm	**$2,238,969**	**$166,170**
Total Benefits from BCA Toolkit	$10,618,491	
Other Benefits (Not Recreation)	$0	
Recreation Benefits	-	
Total Costs	$2,852,905	
Net Benefits	$7,765,586	
Net Benefits with Recreation	$7,765,586	
Final BCR	**3.7**	
Final BCR with Recreation	**3.7**	

Figure 2. BCA Workbook Results – Echo/Neta Lane Drainage Project FMP

No Negative Impact Analysis

No Negative Impact of Flood Risk

An FMP must have no negative impacts on its neighboring area due to its implementation. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 1 percent annual chance (100-year) event water surface elevation and peak discharge, using the best available data. It is recommended that no rise in water surface elevation or discharge should be permissible, and that the analysis extent must be vast enough to prove proposed project conditions are equal to or less than the existing conditions.

For the purposes of regional flood planning efforts, a determination of no negative impact can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial buildings and structures. Additionally, all of the following requirements, per TWDB Technical Guidelines, should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 ft) measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

For the Echo/Neta Lane Drainage Project FMP, the EPA SWMM 5.0 model developed by FNI was used to assess and develop the project. Since no 1D or 2D models are available, only requirements #1, #2, and #5 apply. However, computed depths at all nodes in the SWMM model decrease from existing to proposed conditions, meeting the intent of criteria #3 and #4.

In Table 1, the existing conditions were compared to conditions with the proposed improvements. In addition, in the Drainage Master Plan, flood depths at all 18 structures during a 100-year flood are compared for existing and proposed conditions.[6] The comparison shows that the project does not increase flooding at any location, meeting criteria **#1**. In the existing conditions, 18 structures are flooded by overflows. However, in the proposed conditions,

[6] *Drainage Master Plan Update Project: Echo/Neta Lane*, Table 4.

overtopping depths decrease at all structures, and this meets criteria **#2**. Within the project limits, there is no location where water surface elevations for the 100-year flood rises.

A comparison of flows at the outlet between the existing and proposed conditions in the SWMM model shows that the peak discharge at the system outlet would increase from 878 cfs to 928 cfs during a 100-year flood, which is an increase of 5.6 percent. While this is an increase greater than the 0.5 percent allowed under criteria #5, during final design of the project a full hydrologic and hydraulic study would be completed with the possibility of including some detention in the project to decrease peak discharges. The final project would be designed and constructed to conform to the City's drainage/floodplain management criteria and flood planning requirements. Therefore, no negative impacts are anticipated and criteria **#5** is met.

No Environmental Impacts

TWDB requires that environmental impacts be assessed for all eligible FMPs. Environmental impact categories include

a. water quality;
b. cultural heritage;
c. habitat, biodiversity and ecology;
d. air quality;
e. natural resources; and
f. agricultural resources/properties.[7]

With the nature of the urban drainage improvement project, none of the above is applicable for the Echo/Neta Lane Drainage Project FMP.

Populating the RFPG required Tables 13 & 16

TWDB requires that Tables 13[8] & 16[9] be populated along with the submission of the report and geodatabase. The required attributes are populated as follows. First, basic project information (name, description, etc.) are extracted from the 2011 FNI study[10]. Second, the project extents are drawn into GIS, and after doing so, spatial attributes are obtained by overlapping spatial layers (HUC12s, watersheds, etc.). Third, floodplain inundation information is extracted from the modeling results of the 2011 study (area in 100-yr floodplain, number of structures at 100-yr flood risk, etc.) for both pre-project and post-project conditions. Finally, benefit-and-cost related attributes are derived from the BCA performed in this study (cost, benefit-cost ratio, etc.).

Table 2 is a summary of key information in Tables 13 and 16 for the Echo/Neta Lane Drainage Project. The estimated number of structures at 100-year risk equals the number of structures in the 100-year floodplain. Population is estimated based on three persons per structure. The estimated length of roads at 100-year flood risk is measured from the length of roads inundated within the 100-year floodplain. The post-project level-of-service is determined by the recurrence

[7] Exhibit C Technical Guidelines for Regional Flood Planning, page 127.
[8] Exhibit C Technical Guidelines for Regional Flood Planning, page 63.
[9] Exhibit C Technical Guidelines for Regional Flood Planning, page 75.
[10] Wichita Falls, Texas, *Drainage Master Plan Update, Project: ECHO/NETA LANE DRAINAGE PROJECT,* Freese and Nichols, Inc., 2011.

interval of the flood event in which no structures would be flooded. Finally, the cost/structure removed equals the total cost divided by the total number of structures.

Table 2. Project highlights from Tables 13 and 16

FMP Name	Echo/Neta Lane Drainage Project
Associated Goals	2001, 2002
Watershed Name	Holliday Creek
Project Area (sq mi)	0.2696
Area in 100-yr (1% annual chance) Floodplain (sq mi)	0.0079
Estimated number of structures at 100-yr flood risk	18
Estimated Population at 100-year flood risk	54
Estimated length of roads at 100-year flood risk (miles)	0.09
Number of Structures removed from 100-yr (1% annual chance) flood risk	14
Pre-Project Level-of-Service	Unknown
Post-Project Level-of-Service	50% annual
Cost/Structure removed	$203,779
Social Vulnerability Index (SVI)	0.237
Benefit-Cost Ratio	3.7

Exhibit 1: Excerpts from Wichita Falls Drainage Master Plan, Project: Echo/Neta Lane

Project: ECHO/NETA LANE DRAINAGE PROJECT

Project Information

Project ID:	Area_18	**Status:**	Studied
Project Name:	ECHO/NETA LANE DRAINAGE PROJECT	**Council District:**	4
Project Type:	Pipe System	**Panel #:**	85D
Date Identified:	1997	**# Structures Impacted:**	18

Problem Description:

Reports of standing water have been received from the Big State Grinding company located at 4725 Jacksboro Hwy. The report states that ponding water covers the entire parking lot. The resident at 5001 Joyce reported ponding water in road side ditches along Ditto Lane. An existing pipe system conveys runoff from the east side of Jacksboro Hwy to the west under buildings and across Neta Lane before discharging into an open channel north of the Edgemere Church of Christ parking lot. This project was studied in 2011 FNI Master Plan Update.

Proposed Improvements:

Install a storm drain system with curb and gutter along Jacksboro Highway beginning south of Echo Lane and reaching north to Norman Street. The system would then turn to the west and run along Norman Street parallel to an existing storm drain system, outfalling into a concrete-lined tributary of Brenda Hurch Creek. This system would intercept from from the Ditto Lane watershed and eliminate spillover which is contributing to flooding near Edgemere Church of Christ.

Project Photos

Looking north along Ditto Lane.

Looking north on Jacksboro Highway

CIP Ranking Criteria

Weight		Score
11.83	**Life Safety/Road Flooding:**	3
8.84	**Property Damage:**	3
8.66	**Frequency of Flooding:**	5
5.34	**Project Cost:**	2
5.33	**Maintenance Cost/Work Orders:**	1
	Total Weighted Point Score:	121.3
	CIP Rank:	9

Project Costs

Conceptual Cost Range:	$1,000,000 to $2,000,000
Est. Construction Cost:	$1,998,400.00

ECHO NETA

Background

The Echo/Neta project area is located north of Southwest Parkway and along Jacksboro Highway. The project area is comprised of single family residential on the west of Jacksboro Highway and mostly commercial development on the east. The area was developed with bar ditches as the primary means of conveying runoff. Runoff in the Echo/Neta drainage area is designed to drain to two separate tributaries of Brenda Hursh Creek, a naturally lined tributary west of Neta Lane and a concrete lined channel north of Norman Street. Runoff on the east of Ditto Lane is located on the Kickapoo Airport property is conveyed north through large drainage ditches between runways and culverts before being intercepted by an existing pipe system at the Jacksboro Highway and Norman Street intersection and discharging into the concrete lined tributary west of Westridge Drive.

Problem Description

Reports of flooding were received in various locations within the project area including buildings at Neta Lane and Jarmon Street intersection, at Echo Lane and Jacksboro Highway, and on the east of Jacksboro Highway at the Norman Street intersection. Photo 1 below shows the bar ditches along Ditto Lane.

Photo 1 - Looking south at bar ditches on Ditto Lane.

Existing Conditions Analysis

FNI performed an existing conditions analysis of the Echo/Neta drainage area and the drainage swales and existing pipe systems to determine the extents of flooding in the area. EPA SWMM 5.0 was used for the hydrologic and hydraulic analyses of this area.

Hydrology

The drainage area that discharges into the naturally lined tributary is approximately 56 acres and consists of mainly medium density residential development with some commercial development along the west side of Jacksboro Highway. The drainage area is bordered by Jacksboro Highway on the east, Southwest Parkway on the south, and roughly by Hollandale Avenue on the west. For the hydrologic study, the drainage area was broken up into ten (10) subcatchments ranging in size from 2.06 to 9.55 acres. Curve numbers for each sub basin were calculated based on soil type and future land use provided by the City.

Runoff from this area drains through the curb and gutter street to the north and then intercepted by 2-5' curb inlets on Neta Lane north of the Greenbriar Road intersection. A 42" RCP conveys the runoff approximately 270 feet northwest across a church parking lot and outfalls into a natural channel on an empty lot which is the beginning of Brenda Hursh Creek. A small portion of the drainage area, 7.76 acres, located north of Jarmon Street flows south down Neta Lane and is conveyed west by a flume at the intersection of Neta Lane and Jarmon Street and outfalls into the natural channel.

The drainage area that discharges into the concrete lined tributary is approximately 139 acres and consists of mainly commercial development and the Kickapoo Airport with some medium residential development along Echo Lane and west of Ditto Lane. The drainage area is bordered by the airport on the east, Southwest Parkway on the south, and roughly by Jacksboro Highway on the west and Glendale Drive on the north. For the hydrologic study, the drainage area was broken up into twelve (12) subcatchments ranging in size from 4.58 to 18.56 acres. Curve numbers for each sub basin were calculated based on soil type and future land use provided by the City.

Runoff from this area drains north through bar ditches or drainage swales. On the east side of the drainage area runoff from the airport is conveyed through drainage swales between the runways. Culverts convey the runoff from runway to runway and outfall into a detention pond on the airport property that was constructed in 2006 based on as built plans obtained from the City. The detention pond outfalls into a drainage swale that is intercepted by a 5'x3' RCB headwall located east of the Norman Street and Jacksboro Highway intersection. The pipe system conveys flow to the west and outfalls into a concrete lined channel north of Norman

Street that flows west and discharges into Brenda Hursh Creek north of Norman Street. Along Ditto Lane runoff is conveyed through bar ditches of varying sizes. At the Echo Lane intersection flow is conveyed west on Echo Lane towards an 18" RCP at the Jacksboro Highway intersection that is meant to convey the flow north and into the Jacksboro Highway bar ditches that are eventually intercepted by the Norman Street pipe system mentioned earlier. However, the 18" RCP has a capacity of approximately 8 cfs and the 100-year storm flow to the culvert is approximately 219 cfs. The inadequacy of the culvert results in approximately 125 cfs overtopping Jacksboro Highway and sheet flowing to the west into the adjacent drainage area of the naturally lined culvert.

Hydraulics

Along with the hydrologic model, FNI also constructed a hydraulic model using SWMM for the Echo/Neta study area. The system was modeled to determine the depths of flow at critical areas in order to identify locations of inundated structures as well as exceeded right-of-way. A hydraulic model made up of 40 junctions, 51 links, and 3 outfalls was developed to represent storm water runoff through this area. The street sections and natural drainage swales were modeled as irregular channels with appropriate Manning's n-values to show the geometry of the feature and any overbank flow that might occur. Data for the existing pipe systems located within the project area were taken from storm drain CAD files acquired from the City of Wichita Falls.

Existing Conditions Results

Existing analysis of the area that discharges into the naturally lined channel shows that runoff in the street is contained within the ROW at a depth of 1 foot until the Neta Lane and Greenbriar Road intersection. Depths at this location are between 1.11 and 1.62 feet and are likely caused by the 125 cfs of overflow across Jacksboro Highway at the Echo Lane intersection which is directed towards this location.

Existing analysis of the area that discharges into the concrete lined channel shows depths in bar ditches ranging from 1.28 to 3.25 feet. The highest depths are along Ditto Lane and Echo Lane. When the bar ditches are exceeded they will overflow into the surrounding residential properties that are at the same elevation as the road in most areas and could cause potential flooding. The detention pond on the airport property has adequate capacity for the 100-year storm event. The pipe system at Norman Street and Jacksboro Highway is adequate but the intercepting headwalls located on the east side of Jacksboro Highway in front of 4701 Jacksboro Highway and on the side of 4625 Jacksboro Highway result in headwater elevations of 1.93 and 3.8 feet respectively that could cause potential flooding for surrounding properties.

Based on the existing analysis and the node depths in Table 2 there are eighteen (18) structures that have the potential to be flooded during the 100-year storm event for the Echo/Neta project area. Table 4 shows the properties flooding during the 100-year storm event and that are shown on Exhibit 1. A summary of flooded structures by storm event is shown in Table 3. Finished floors were estimated at 0.5 feet above the lowest adjacent grade based on site visit observation and two-foot topography.

Proposed Improvements

After the existing conditions study of the Echo Neta project area was completed, FNI presented the results to the City along with proposed alternatives for discussion. It was recommended that the proposed solution would be a storm drain system running from south to north along Jacksboro Highway, then west on Norman Street and north on Westridge Drive where it outfalls into the tributary of Brenda Hursh Creek at the same location as the existing system in this area.

To improve flooding problems in the residential area along Echo and Ditto Lanes, the proposed improvements would also include the excavation and regrading of the ditches along these streets.

Proposed Storm Drain System

The proposed storm drain system for the Echo Neta project area begins on Jacksboro Highway about 1050 LF south of Echo Lane. The proposed pipe begins with 1050 LF of 30" RCP and then transitions to a 1000 LF of 6'X3' RCB at Echo Lane where four (4) 15-foot inlets capture flow from the ditches on Echo and Ditto Lanes. In existing conditions, flow on Echo Lane from the east side of Jacksboro Highway accumulates and spills over Jacksboro Highway to the west, causing flooding problems. The proposed inlets at this intersection are intended to capture flow from the ditches on Echo Lane before it spills over Jacksboro Highway. As the proposed pipe reaches further north on Jacksboro Highway, it transitions to 1000 LF 6'X4' RCB that extends to the outfall. This section of 6'X4' RCB begins on Jacksboro Highway about 310 LF south of Norman Street, runs 540 LF west on Norman Street and then 150 LF to the north on Westridge Drive where it outfalls at the Brenda Hursh Tributary. The proposed pipe will share this outfall location with the existing system that is located in the area. Exhibit 2 shows the alignment and characteristics of this proposed pipe system.

In addition to the proposed pipe system described above, FNI also investigated the extent of regrading that would be required in the ditches along Echo and Ditto Lanes to provide sufficient capacity to reduce structure and road flooding in this residential development. Using user defined cross sections in SWMM, iterations were performed to determine what size the ditches in this area would need to be to provide adequate drainage capacity. FNI recommends expanding the ditches along Echo and Ditto Lanes to have a depth two feet, bottom with of two feet, and 4:1 side slopes, and regrading them to fall to the north on Ditto Lane and then to the west on Echo Lane.

Results

An analysis of the proposed improvements described above was performed to determine the amount of flooding that would be eliminated after implementation. Tables 3 and 4 provide a summary of the difference in flooding from existing to proposed conditions. The results show that the proposed storm drain system for the Echo Neta project area would eliminate potential flooding in 14 out of 18 homes for the area in the 100-year storm event. The flooding risk in the remaining four homes is independent of the Echo Neta drainage area, but instead is caused by backwater in the storm drain system on Neta Lane. The SWMM model developed by FNI showed that in existing conditions, approximately 125 cfs of runoff flows across Jackboro Highway on Neta Lane, flooding homes to the west of the highway. According to the proposed model, the proposed inlets and pipe system on eliminate all runoff that flows over Jacksboro Highway and redirects it to the north.

An opinion of probable construction cost was developed for the proposed improvements to the Echo Neta study area. The estimated construction cost for the improvements described in this section is approximately $1,998,400. A detailed breakdown of the cost analysis for the Echo Neta project area is shown in Table 1. FNI suggests that the City implement the proposed solutions as described above to resolve flooding problems in the area.

AREA 18 - ECHO/NETA

OPINION OF PROBABLE CONSTRUCTION COST

PROPOSED STORM DRAIN SYSTEM

CITY OF WICHITA FALLS - DRAINAGE MASTERPLAN UPDATE

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
WCH09429	BAM		April 9, 2011

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
General					
	Traffic Control	6.0	MO	$5,000.00	$30,000.00
	Site Preparation	1.0	AC	$25,000.00	$25,000.00
	Erosion Control and SWPPP Implementation	1.0	LS	$5,000.00	$5,000.00
			General Item Subtotal		**$60,000.00**
Storm Drain					
	Trench Safety	3,100.0	LF	$2.00	$6,200.00
	Install 30" RCP	1,050.0	LF	$50.00	$52,500.00
	Install 6'X3' RCB	1,000.0	LF	$170.00	$170,000.00
	Install 6'X4' RCB	1,000.0	LF	$180.00	$180,000.00
	Install 18" RCP Lateral	160.0	LF	$35.00	$5,600.00
	Install Manhole	4.0	EA	$3,000.00	$12,000.00
	Install 10' Curb Inlet	8.0	EA	$3,500.00	$28,000.00
	Install 15' Curb Inlet	8.0	EA	$4,000.00	$32,000.00
	Install Headwall	1.0	EA	$20,000.00	$20,000.00
			Storm Drain Subtotal		**$506,300.00**
Utility Adjustments					
	Remove and Replace 8" PVC Water Line	1,160.0	LF	$48.00	$55,680.00
	Remove and Replace 6" PVC Water Line	1,250.0	LF	$36.00	$45,000.00
	Remove and Replace 2" PVC Water Line	1,250.0	LF	$12.00	$15,000.00
	Remove and Replace 6" PVC Sewer Line	3,000.0	LF	$36.00	$108,000.00
	Trench Safety for Water Line	3,660.0	LF	$1.00	$3,660.00
	Trench Safety for Sewer Line	3,175.0	LF	$1.00	$3,175.00
	Connections to Existing Water Line	2.0	EA	$1,000.00	$2,000.00
	Connections to Existing Sewer Line	2.0	EA	$1,000.00	$2,000.00
			Utility Adj. Subtotal		**$234,515.00**
Paving					
	Asphalt Pavement Saw, Remove and Dispose	10,400.0	SY	$6.00	$62,400.00
	6" Stabilized Subgrade Install	10,400.0	SY	$2.50	$26,000.00
	6" Asphalt Pavement	10,400.0	SY	$33.00	$343,200.00
	Concrete Curb remove and replace	6,200.0	LF	$4.00	$24,800.00
	Ditch Regrading	2,500.0	LF	$12.00	$30,000.00
			Paving Subtotal		**$486,400.00**
		SUBTOTAL:			**$1,287,215.00**
	MOBILIZATION	5	%	$64,360.75	$64,360.75
	CONTINGENCY	30	%	$386,164.50	$386,164.50
		SUBTOTAL:			**$1,737,740.00**
	ENGINEERING FEES	15	%	$260,661.00	$260,661.00
PROJECT TOTAL					**$1,998,400.00**

Table 2 - Hirschi-Huskie existing conditions maximum node depths

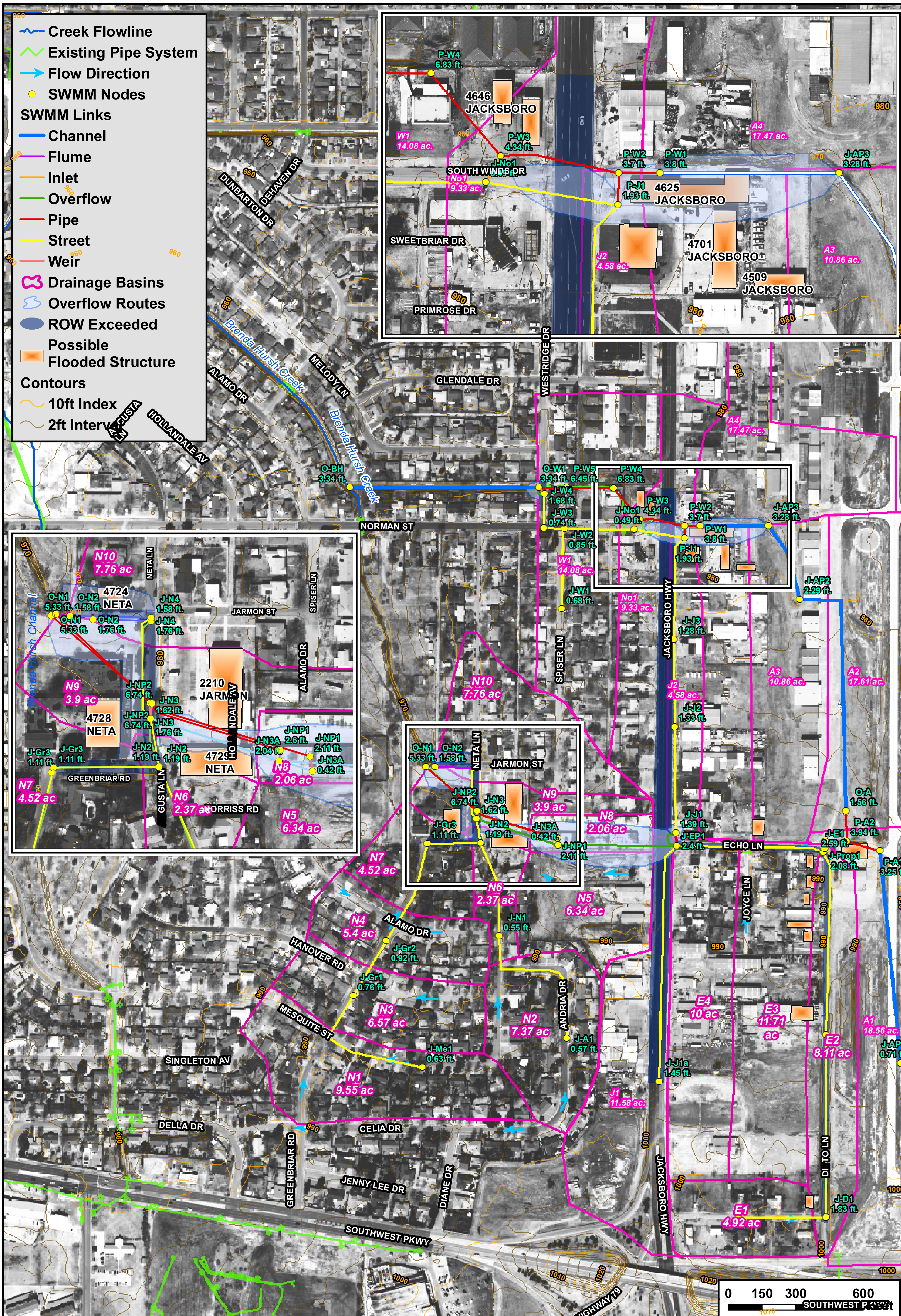
Node	Type	Maximum Depth (feet)					
		2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
J-A1	JUNCTION	0.36	0.42	0.46	0.50	0.54	0.57
J-AP1	JUNCTION	0.34	0.44	0.49	0.58	0.65	0.71
J-AP2	JUNCTION	1.09	1.31	1.43	1.59	1.73	1.84
J-AP3	JUNCTION	1.28	1.96	2.36	2.94	3.40	3.78
J-D1	JUNCTION	1.04	1.22	1.32	1.42	1.48	1.52
J-D2	JUNCTION	0.93	1.06	1.13	1.23	1.29	1.34
J-E1	JUNCTION	1.38	1.48	1.50	1.60	1.69	1.75
J-E2	JUNCTION	1.22	1.31	1.36	1.42	1.47	1.52
J-EP1	JUNCTION	2.67	2.76	2.81	2.89	2.96	3.02
J-Gr1	JUNCTION	0.48	0.56	0.61	0.67	0.72	0.76
J-Gr2	JUNCTION	0.58	0.68	0.73	0.80	0.88	0.92
J-Gr3	JUNCTION	0.71	0.83	0.90	0.97	1.04	1.11
J-J1	JUNCTION	1.44	1.47	1.52	1.59	1.63	1.66
J-J1a	JUNCTION	1.16	1.26	1.30	1.35	1.40	1.44
J-J2	JUNCTION	1.21	1.29	1.31	1.39	1.45	1.48
J-J3	JUNCTION	1.08	1.24	1.26	1.33	1.39	1.44
J-Me1	JUNCTION	0.40	0.46	0.50	0.55	0.59	0.63
J-Mi1	JUNCTION	0.64	0.70	0.73	0.78	0.81	0.85
J-N1	JUNCTION	0.35	0.41	0.44	0.48	0.52	0.55
J-N2	JUNCTION	0.76	0.90	0.96	1.05	1.13	1.19
J-N3	JUNCTION	1.18	1.31	1.39	1.52	1.64	1.74
J-N3A	JUNCTION	0.86	1.57	1.69	1.84	1.93	2.01
J-N4	JUNCTION	0.99	1.15	1.24	1.40	1.58	1.73
J-No1	JUNCTION	0.32	0.37	0.40	0.49	0.56	0.64
J-NP1	JUNCTION	1.06	1.82	2.28	2.53	2.56	2.59
J-NP2	JUNCTION	5.27	6.15	6.56	6.74	6.74	6.74
J-W1	JUNCTION	0.45	0.51	0.55	0.60	0.65	0.68
J-W2	JUNCTION	0.55	0.63	0.68	0.75	0.81	0.88
J-W3	JUNCTION	0.48	0.55	0.60	0.66	0.70	0.76
J-W4	JUNCTION	1.29	1.43	1.52	1.64	1.74	1.88
O-A	JUNCTION	0.65	0.78	0.83	0.89	0.93	0.96
O-W1	JUNCTION	1.56	1.79	1.90	2.06	2.20	2.42
P-A1	JUNCTION	1.28	1.75	1.98	2.37	2.71	3.03
P-A2	JUNCTION	1.35	1.82	2.02	2.36	2.61	2.79
P-J1	JUNCTION	1.56	1.92	1.98	2.08	2.15	2.21
P-W1	JUNCTION	3.33	4.28	4.69	5.27	5.73	6.11
P-W2	JUNCTION	2.67	3.17	3.31	3.50	3.64	3.75
P-W3	JUNCTION	2.22	2.47	2.57	2.71	2.79	2.85
P-W4	JUNCTION	2.50	2.84	2.99	3.20	3.35	3.46
P-W5	JUNCTION	1.97	2.22	2.32	2.48	2.66	2.81
O-BH	OUTFALL	1.80	1.80	1.90	2.06	2.20	2.42
O-N1	OUTFALL	5.33	5.33	5.33	5.33	5.33	5.33
O-N2	OUTFALL	0.99	1.14	1.24	1.40	1.58	1.73

Table 3 – Echo Neta Summary Comparison of Inundation Depths

		Summary of Inundation Depth by Frequency Event (ft)					
		2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
No. structures	Existing	12	12	12	15	16	18
	Proposed	1	1	1	1	2	4
Max depth	Existing	1.72	1.81	1.86	1.92	1.98	2.02
	Proposed	0.49	0.65	0.74	0.87	0.98	1.08
Min depth	Existing	0.36	0.56	0.63	0.12	0.14	0.14
	Proposed	0.49	0.65	0.74	0.87	0.12	0.12
Average depth	Existing	0.85	1.06	1.12	1.05	1.12	1.12
	Proposed	0.49	0.65	0.74	0.87	0.55	0.39

Table 4 - Echo Neta Inundation Depth Comparison

Address		100-yr Existing Inundation Depth	100-yr Proposed Inundation Depth
5000	DITTO	1.25	
5001	DITTO	1.25	
5002	DITTO	1.25	
5004	DITTO	1.25	
5006	DITTO	1.25	
5008	DITTO	1.25	
5018	DITTO	0.84	
1310	ECHO	2.02	0.18
2210	JARMON	1.51	
1400	MICHNA	2.02	
4724	NETA	1.23	1.08
4728	NETA	0.24	0.12
1412	MICHNA	0.35	
4509	JACKSBORO	0.28	
4625	JACKSBORO	1.28	
4701	JACKSBORO	1.28	
4729	JACKSBORO	0.25	
4646	JACKSBORO	0.14	0.18
Number of Homes Flooded		18	4



FREESE AND NICHOLS
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
P: 817-735-7300 F: 817-735-7491

N W E S

AREA 18 - ECHO/NETA

EXISTING CONDITIONS: 100-YEAR RESULTS

FN JOB NO	WCH09429
FILE	H:\STORMWATER\FINAL_EXHIBITS\StudyAreas
DATE	March, 2011
SCALE	1:1,800
DRAFTED	BAM

Exhibit 1

FREESE AND NICHOLS
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
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N W E S

AREA 18 - ECHO NETA

PROPOSED IMPROVEMENTS: JACKSBORO PIPE SYSTEM

FN JOB NO	WCH09429
FILE	H:\STORMWATER\FINAL_EXHIBITS\StudyAreas
DATE	March, 2011
SCALE	1:4,800
DRAFTED	BAM

Exhibit 2

Memorandum

Date:	Thursday, June 16, 2022
Project:	Canadian – Upper Red Regional Flood Plan
To:	Scott Hubley, PE, Freese and Nichols, Inc.
From:	David Dunn, PE (Texas PE No. 82630) Toby Li, EIT
Subject:	Hirschi-Huskie FMP

The initial evaluation for this project was conducted in 2011 as a part of the Wichita Falls Drainage Master Plan Update by Freese and Nichols, Inc. (FNI)[1]. Excerpts from that study are included as Exhibit 1.

Owner of 1011 Hirschi complained about poor drainage and weeds in the street. The area is within a FEMA Zone AE floodplain and partially within the floodway. Box culverts containing East Plum Creek from Iowa Park Road to Ridgeway Drive have partially collapsed. In addition, study and field survey determined that the box culverts are on a local high point and do not carry any drainage area. This project was studied in 2011 FNI Master Plan Update.

Model Analysis

FNI created an EPA SWMM model composed of 18 junction nodes and four (4) outfalls. Street flow was modeled with irregular conduits reflecting the geometry of the street. All outfalls are connected to a tributary of East Plum Creek. Note that no model analysis was performed for the proposed conditions, only the existing conditions.

Summary of Improvements

FNI proposed to extend the existing storm drain system on Huskie Drive to reach to the north and south on Hirschi Lane. Additionally, FNI also proposed to acquire properties along the north side of Iowa Park Road between Hirschi Lane and Ridgeway Drive. The existing box culverts that are meant to drain this property are damaged and do not carry any drainage from this area. These boxes would be left in place. The following is an excerpt of the detailed proposed improvements.

After the existing conditions study of the Hirschi-Huskie project area was completed, FNI presented the results to the City along with proposed alternatives for discussion. FNI proposed to the City that to alleviate the flooding problems in this study area, one or both of the following options should be considered.

[1] Wichita Falls, Texas, *Drainage Master Plan Update, Project: HIRSCHI-HUSKIE,* Freese and Nichols, Inc., 2011.

Solution A: Extend the existing storm drain system located on Huskie Drive to reach further to the west along Hirschi Lane. Many complaints of flooding in the area are due to water ponding around the intersection of these two streets causing vegetation growth in the street.

Solution B: Acquire the three properties that are negatively impacted by the East Plum Creek culvert and leave the system as is. These two solutions are separate in part from each other and either one can be implemented independently of the other.

Further detailed descriptions of solutions A and B can be found in the Wichita Falls Drainage Master Plan Update: Hirschi-Huskie, page 4 (Exhibit 1). The FNI report recommends both options be implemented.

Modeling Results

In the original 2011 analysis, the hydraulic modeling results from EPA SWMM 5.0 show that for existing conditions, the Hirschi-Huskie area would have 35 structures flooded during a 100-year[2] storm event with an inundation depth of 0.29 feet or less for all but one structure. No modeling results were documented for post-project conditions. Table 1 is from the 2011 report and summarizes results for the existing conditions.

Table 1. Hirschi-Huskie FMP inundation summary comparison

	Summary of Inundation Depth by Frequency Event (ft)					
	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
No. structures	0	0	0	1	25	35
Max depth	0.00	0.00	0.00	0.37	0.72	1.10
Min depth	0.00	0.00	0.00	0.37	0.12	0.15
Average depth	0.00	0.00	0.00	0.37	0.17	0.28

[2] Note that the precipitation depths of these storm events were determined prior to the Atlas 14 update. The 100-year 24-hour storm depth has not changed significantly in Wichita Falls, TX. NOAA Atlas 14 (weather.gov), figure 7.4

Benefit-Cost Analysis

TWDB requires each project included as an FMP in a regional flood plan to have a benefit/cost analysis (BCA) performed. Many flood mitigation studies document a computed benefit/cost ratio (BCR) and those can be incorporated into the regional flood plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool[3] to facilitate calculations of costs and benefits. It estimates flood damages for residential buildings before and after construction of the flood mitigation project for up to three recurrence interval flood events. Three recurrence events with houses flooded are analyzed in this BC analysis: 25-year, 50-year, and 100-year.

The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0[4], which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then entered back into the TWDB BCA Input Tool which then computes the resulting BCR for the project.

Project Costs

FNI estimated the total project cost to be $479,800 in the 2011 Drainage Master Plan[5]. 2020 appraisal values are used for the three proposed property acquisitions[6]. Table 2 presents the appraised values of the three properties in 2011 and 2020. A Construction Cost Index (CCI) factor of 1.27 was applied to convert the non-acquisition costs from 2011 to 2020 dollars, resulting in a project cost of $562,666. The construction was set to begin and end in 2020 to simplify the calculation of the BCR.

Table 2. Proposed Properties to Acquire with Appraised Values 2011 vs. 2020

Address	2011	2020
2808 Iowa Park	$40,536.	$4,288.[1]
2812 Iowa Park	$33,058.	$37,725.
2830 Iowa Park	$74,830.	$99,805.
Total	$148,424.	$141,818.
1. Structure appears to have been demolished.		

Flood Damages Before and After Implementation of the FMP

Based on Table 1, average depths of flooding at 35 residential structures were entered into the TWDB BCA Input Workbook for the 25-year, 50-year, and 100-year events for the existing conditions. Since there is no modeling for proposed conditions available, this analysis assumes that the project mitigates flooding for all structures.

The TWDB BCA Input Workbook includes flood damage-by-depth values for residential homes and commercial buildings in Texas. With each flood depth, there is a corresponding flood damage associated with the type of structure. The workbook sums damages for all structures to

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[3] https://www.twdb.texas.gov/flood/planning/planningdocu/2023/doc/BCA%20Workbook.zip
[4] https://www.fema.gov/grants/guidance-tools/benefit-cost-analysis
[5] *Drainage Master Plan Update Project: HIRSCHI-HUSKIE*, page 7
[6] Wichita County Central Appraisal District

provide a comparison of damages before and after implementation of the FMP for each flood event. The damages were then entered into the FEMA BCA Toolkit 6.0. By calculating the annualized difference between the baseline and project damages for various return periods, The FEMA BCA Tool produces the total annualized benefits of the project's lifetime.

The total cost was entered into the TWDB BCA Input Workbook with estimated annual operation and maintenance costs of 1% of the total costs for the assumed 30-year lifetime of the project. The tool then was used to compute total costs for the project over the 30-year assumed lifespan. The total annualized benefits as determined by the FEMA BCA Toolkit 6.0 were also entered. The data are summarized in Figure 2, which is a screen capture of the Results tab from the TWDB BCA Input Tool.

Note that the green shaded value of $491,659 represents the sum of the estimated maximum benefits computed over the 30-year useful life at a discount rate of 7 percent, per FEMA standards. **This estimation assumes the maximum effects of flood reduction, where all structures are removed from the 100-year floodplain. The final BCR computed by the TWDB BCA Input Tool for the Hirschi-Huskie FMP is 0.8**, using the damages and benefits referenced to the 25-year, 50-year, and 100-year events. The FMP is assumed to remove 35 structures from the 100-year floodplain, 25 structures from the 50-year floodplain, and one structure from flooding by 25-year events and smaller.

No Negative Impact Analysis

No Negative Impact of Flood Risk

An FMP must have no negative impacts on its neighboring area due to its implementation. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 1 percent annual chance (100-year) event water surface elevation and peak discharge, using the best available data. It is recommended that no rise in water surface elevation or discharge should be permissible, and that the analysis extent must be vast enough to prove proposed project conditions are equal to or less than the existing conditions.

Input Into BCA Toolkit		
Project Useful Life	30	
Event Damages	**Baseline**	**Project**
25 - year storm	**$57,625**	**$0**
50 - year storm	**$1,287,028**	**$0**
100 - year storm	**$1,867,191**	**$0**
Total Benefits from BCA Toolkit	$491,659	
Other Benefits (Not Recreation)	$0	
Recreation Benefits	-	
Total Costs	$632,487	
Net Benefits	-$140,828	
Net Benefits with Recreation	-$140,828	
Final BCR	**0.8**	
Final BCR with Recreation	**0.8**	

Figure 2. BCA Workbook Results – Hirschi-Huskie FMP

For the purposes of regional flood planning efforts, a determination of no negative impact can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial buildings and structures. Additionally, all of the following requirements, per TWDB Technical Guidelines, should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 ft) measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

For the Hirschi-Huskie FMP, the EPA SWMM 5.0 model developed by FNI was used to assess and develop the project. Since no 2D model is available, only requirements #1, #2, $3, and #5 apply. Given the limited data available and the limited extents of the proposed improvements, criteria #1, #2, #3, and #5 would be met by the project.

No Environmental Impacts

TWDB requires that environmental impacts be assessed for all eligible FMPs. Environmental impact categories include

a. water quality;
b. cultural heritage;
c. habitat, biodiversity and ecology;
d. air quality;
e. natural resources; and
f. agricultural resources/properties.[7]

With the nature of the urban drainage improvement project, none of the above is applicable for the Hirschi-Huskie FMP.

Populating the RFPG required Tables 13 and 16

TWDB requires that Tables 13[8] and 16[9] to be populated along with the submission of the report and geodatabase. The required attributes are populated as follows. First, basic project information (name, description, etc.) are extracted from the 2011 FNI study[10]. Second, the project extents are drawn into GIS, and after doing so, spatial attributes are obtained by overlapping spatial layers (HUC12s, watersheds, etc.). Third, floodplain inundation information is extracted from the modeling results of the 2011 study (area in 100-yr floodplain, number of structures at 100-yr flood risk, etc.) for both pre-project and estimated post-project conditions. Finally, benefit-and-cost related attributes are derived from the BCA performed in this study (cost, benefit-cost ratio, etc.)

Table 2 is a summary of key information in Tables 13 and 16 for Hirschi-Huskie. The estimated number of structures at 100-year risk equals the number of structures in the 100-year floodplain. Population is estimated based on three persons per structure. The estimated length of roads at 100-year flood risk is measured from the length of roads inundated within the 100-year floodplain. The post-project level-of-service is determined by the recurrence interval of the flood

[7] Exhibit C Technical Guidelines for Regional Flood Planning, page 127.
[8] Exhibit C Technical Guidelines for Regional Flood Planning, page 63.
[9] Exhibit C Technical Guidelines for Regional Flood Planning, page 75.
[10] Wichita Falls, Texas, *Drainage Master Plan Update, Project: HIRSCHI - HUSKIE,* Freese and Nichols, Inc., 2011.

event in which no structures would be flooded. Finally, the cost/structure removed equals the total cost divided by the total number of structures.

Table 2. Project highlights from Tables 13 and 16

FMP Name	Hirschi Huskie
Associated Goals	2001, 2002
Watershed Name	Buffalo Creek-Wichita River
Project Area (sq mi)	0.0359
Area in 100-yr (1% annual chance) Floodplain (sq mi)	0.0086
Estimated number of structures at 100yr flood risk	35
Estimated Population at 100-year flood risk	105
Estimated length of roads at 100-year flood risk (miles)	0.27
Number of Structures removed from 100-yr (1% annual chance) flood risk	35
Pre-Project Level-of-Service	Unknown
Post-Project Level-of-Service	1% annual
Cost/Structure removed	$18,071
Social Vulnerability Index (SVI)	0.763
Benefit-Cost Ratio	0.8

Exhibit 1: Excerpts from Wichita Falls Drainage Master Plan, Project: Hirschi-Huskie

Project Information

Project ID:	Area_23	**Status:**	Studied
Project Name:	HIRSCHI - HUSKIE	**Council District:**	1
Project Type:	Pipe System / Channel	**Panel #:**	6A, 5B
Date Identified:	2008	**# Structures Impacted:**	35

Problem Description:

Owner of 1011 Hirschi complained about poor drainage and weeds in the street. The area is within a FEMA Zone AE floodplain and partially within the floodway. Box culverts containing East Plum Creek from Iowa Park Road to Ridgeway Drive have partially collapsed. In addition, study and field survey determined that the box culverts are on a local high point and do not carry any drainage area. This project was studied in 2011 FNI Master Plan Update.

Proposed Improvements:

Extend the existing storm drain system on Huskie Drive to reach to the north and south on Hirschi Lane. Additionally, acquire properties along the north side of Iowa Park Road between Hirschi Lane and Ridgeway Drive. The existing box culverts that are meant to drain this property are damaged and do not carry any drainage from this area. These boxes may be left in place.

CIP Ranking Criteria

Weight		Score
11.83	**Life Safety/Road Flooding:**	2
8.84	**Property Damage:**	4
8.66	**Frequency of Flooding:**	1
5.34	**Project Cost:**	4
5.33	**Maintenance Cost/Work Orders:**	2
	Total Weighted Point Score:	99.7
	CIP Rank:	16

Project Costs

Conceptual Cost Range:	$250,000 to $500,000
Est. Construction Cost:	$479,800.00

Project Photos

Outfall of East Plum Creek with 2-36" RCPs on the east side of Ridgeway Dr.

Collapsed box culverts north of Iowa Park Rd.

HIRSCHI-HUSKIE

Background

The Hirschi-Huskie study area is located just to the north of Iowa Park Rd in the residential development bounded on the east and west by Ridgeway Drive and Hirschi Lane, respectively. The area under study is a combination of single family residential, commercial, and agricultural developments with a total drainage area of 96.7 acres. Runoff from this area is conveyed mostly by street flow that drains toward East Plum Creek. A small storm drain system runs from west to east along Huskie Drive where it outfalls to a tributary of East Plum Creek.

Photo 1- Looking east toward the intersection of Hirschi Lane and Huskie Drive

Problem Description

The Hirschi-Huskie project area is under study due complaints received by The City of inadequate drainage around the intersection of Hirschi Lane and Huskie Drive, shown in Photo 1. These complaints reported standing water and weed growth in the streets. Separate from the drainage system on Huskie Drive, there is a concrete box culvert that runs along 2812 Iowa Park Road connecting East Plum Creek between Iowa Park Road and Ridgeway Drive. The culvert has been reported to consistently contain standing water and in addition, the culvert is collapsed in multiple locations and contains large amounts of silt and debris throughout the length of the structure. Photo 2 shows the East Plum Creek culvert in one location where it has collapsed.

Photo 2 – East Plum Creek culvert located on 2812 Iowa Park Road.

Existing Conditions Analysis

FNI performed an existing conditions analysis of the Hirschi-Huskie drainage area to determine the extents of flooding in the area. EPA SWMM 5.0 was used for the hydrologic and hydraulic analysis of this area.

Hydrology

The existing hydrologic analysis of the Hirschi-Huskie project area was performed by separately analyzing the two problems areas. First, FNI performed an in depth investigation of the East Plum Creek culvert that is located on 2812 Iowa Park Road. All available data for this culvert was collected from sources including City CAD files, FEMA FIS, and a United States Army Corps of Engineers (USACE) hydrologic study of East Plum Creek. After an initial comparison of this data, no consistent evidence was found to determine the actual flow direction of the culvert. Table 1 shows the flowline data available for this culvert.

Table 1 - Flowline data for East Plum Creek culvert

	Flowline Location	
Source	West	East
FEMA Effective Model	946.2	945.37
City CAD Files	944.9	945.36

FNI then requested field survey of the flow lines at each end of the culvert. Since various points throughout the culvert are exposed, actual flow line elevations were taken within the length of the culvert in addition to the flow lines at each opening. According to data acquired from this field survey, FNI concluded that there is actually a high point located within the reach of the culvert about 300 feet to the west of the culvert's outfall into East Plum Creek. FNI also performed on-site inspection of this culvert which revealed that a large portion of the culvert was constructed flush with the surrounding ground surface with multiple points where the culvert breaks to form makeshift inlets along the property. A hydrologic analysis was performed for this culvert that included 7.4 acres of area from north of Iowa Park Road that drains directly to the culvert, and 68.3 acres from the south of Iowa Park Road that drains to a culvert under Iowa Park Road and then to the north to the culvert being analyzed. FNI used SWMM to create a basic model of this area to determine what, if any, flooding problems are created by this culvert.

A hydrologic analysis of the northern part of this study area was performed by dividing the 21 acre drainage area into five (5) subcatchments ranging in size from 2.8 to 7.0 acres. These subcatchments were strategically placed within the drainage area to isolate the intersection of Hirschi Lane and Huskie Drive, as well as the existing storm drain system along Huskie Drive. Each of the subcatchments contains medium density residential development. The percentage of impervious area used for these catchments was 50 percent. Curve numbers for each sub basin were calculated based on soil type and future land use provided by the City. The hydrologic model created using SWMM was used to calculate runoff for each of the subcatchments that and was then used to perform a hydraulic analysis of the area.

Hydraulics

Along with the hydrologic model, FNI also constructed a hydraulic model using SWMM for the Hirschi-Huskie study area. Flow depths were modeled at critical nodes throughout the watershed to provide hydraulic data for flooding analysis along Huskie Drive and Hirschi Lane. The hydraulic model is composed of six junction nodes and four conduit links. Street flow along Hirschi and Huskie was modeled using irregular conduits reflecting the observed geometry of the street. The existing storm drain system located on Huskie Drive begins 135 feet east of the intersection of Hirschi and Huskie with one 15-foot inlet connected to a 24" RCP. The pipe then runs approximately 650 feet to the east along Huskie where it picks up flow from another five (5) foot inlet located 140 feet to the west of the Huskie and Ridgeway intersection. The pipe diameter then increases to 27" and continues on to the east for another 422 feet until it outfalls at a tributary of East Plum Creek. Any flow from that reaches the intersection of Huskie and Ridgeway that is not picked up by this system was modeled as weir flow over the curb of Ridgeway, flowing overland to East Plum Creek.

Existing Conditions Results

Based on the existing conditions SWMM model that was developed, an evaluation of runoff depth was performed to determine right-of-way flooding and structure inundation. Flooding was determined based on criteria explained in the Methodology section. The depth of runoff exceeds the FFE's of 35 total structures within the study area. Out of these 35 structures, only three (3) were determined to be flooding due to the East Plum Creek culvert, while the remaining 32 structures are affected by flooding along Hirschi Lane, Huskie Drive, and Ridgeway Drive. Approximately 2600 LF of ROW is exceeded due to flooding in the northern portion of this study area. Refer to table 3 for the node depth output from SWMM. Referring to Table 4, significant flooding does not begin until the 50-year storm and the maximum depth of flooding in the 100-year storm is 1.10 feet at 2830 Iowa Park Road. This is the only structure within the area whose inundation depth exceeds six inches and it is one of three properties whose flooding is caused by the East Plum Creek culvert. Of the remaining 34 flooded structures the maximum inundation depth is 0.29 feet. Table 5 shows the calculated inundation depth for each of the flooded structures.

Proposed Improvements

After the existing conditions study of the Hirschi-Huskie project area was completed, FNI presented the results to the City along with proposed alternatives for discussion. FNI proposed to the City that to alleviate the flooding problems in this study area, one or both of the following options should be considered.

Solution A: Extend the existing storm drain system located on Huskie Drive to reach further to the west along Hirschi Lane. Many complaints of flooding in the area are due to water ponding around the intersection of these two streets causing vegetation growth in the street.

Solution B: Acquire the three properties that are negatively impacted by the East Plum Creek culvert and leave the system as is.

These two solutions are separate in part from each other and either one can be implemented independently of the other.

Solution A: Extend existing pipe system

FNI investigated the benefits of extending the existing pipe system along Huskie Drive further to the west along Hirschi Lane. Since the drainage complaints in this area specify poor street drainage, the goal of this proposed improvement is to provide more drainage relief to the streets of this study area. According to the existing hydraulic analysis, there are 32 homes that flood in the 100-year storm, but with a maximum inundation depth of 0.29 feet. Therefore, the focus of these proposed improvements is not to eliminate structure flooding in the area, but rather provide additional inlet capacity in the area to remove water from the street before it reaches Huskie Drive. The proposed storm drain extension would include extending the existing 24” RCP along Huskie Drive to Hirschi Lane and to the north and south along Hirschi. FNI proposes adding approximately 300 LF of 18” RCP and 4 – 10-ft curb inlets to allow Hirschi Lane to drain before runoff reaches Huskie Drive. The estimated construction cost for the improvements described for Solution A is $214,900.

Solution B: Property Acquisition for East Plum Creek Culvert

FNI also investigated the acquisition of three (3) properties that are impacted by the East Plum Creek culvert. These properties include 2808, 2812, and 2830 Iowa Park Road. The culvert that runs across these properties was determined to be inadequate to transport the flow of East Plum Creek from Iowa Park Road to Ridgeway Drive. However, the existing conditions study determined that other than these three properties flooding, there are no other negative impacts to the area caused by this culvert. Therefore, FNI recommends that the City leave the culvert in place and acquire these three properties to prevent flood damages in the future. Table 2 shows the value of each of these properties provided by the Wichita County Appraisal District. The total cost of acquiring these three properties is $148,424.

Table 2 - Appraised value of proposed properties to acquire

Address	Appraised Value	
2808 Iowa Park	$	40,536.00
2812 Iowa Park	$	33,058.00
2830 Iowa Park	$	74,830.00
Total	**$**	**148,424.00**

Results

The two alternatives detailed above were analyzed to determine the most cost effective solution for the proposed improvements of the Hirschi-Huskie study area. FNI recommends that both Option A and Option B are implemented to alleviate the flooding problems that are currently present within the Hirschi-Huskie study area. The total cost of to implement both of these options is $479,800. A detailed breakdown of the cost analysis for the Hirschi-Huskie project area is shown in Table 3.

AREA 23 - HIRSCHI-HUSKIE

OPINION OF PROBABLE CONSTRUCTION COST

PROPOSED STORM DRAIN SYSTEM

CITY OF WICHITA FALLS - DRAINAGE MASTERPLAN UPDATE

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
WCH09429	BAM		April 9, 2011

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
General					
	Traffic Control	1.0	MO	$5,000.00	$5,000.00
	Site Preparation	0.3	AC	$25,000.00	$6,250.00
	Erosion Control and SWPPP Implementation	1.0	LS	$5,000.00	$5,000.00
	Property Acquisition (3 Lots)	1.0	LS	$223,484.00	$223,484.00
			General Item Subtotal		**$239,734.00**
Storm Drain					
	Trench Safety	320.0	LF	$2.00	$640.00
	Install 18" RCP	320.0	LF	$35.00	$11,200.00
	Install 10' Curb Inlet	4.0	EA	$3,500.00	$14,000.00
			Storm Drain Subtotal		**$25,840.00**
Utility Adjustments					
	Remove and Replace 15" PVC Sewer Line	140.0	LF	$90.00	$12,600.00
	Remove and Replace 8" PVC Water Line	175.0	LF	$48.00	$8,400.00
	Remove and Replace 4" PVC Water Line	140.0	LF	$24.00	$3,360.00
	Trench Safety for Water Line	315.0	LF	$1.00	$315.00
	Trench Safety for Sewer Line	140.0	LF	$1.00	$140.00
	Connections to Existing Water Line	2.0	EA	$1,000.00	$2,000.00
	Connections to Existing Sewer Line	2.0	EA	$1,000.00	$2,000.00
				Utility Adj. Subtotal	**$28,815.00**
Paving					
	Asphalt Pavement Saw, Remove and Dispose	1,000.0	SY	$6.00	$6,000.00
	6" Stabilized Subgrade Install	1,000.0	SY	$2.50	$2,500.00
	6" Asphalt Pavement	1,000.0	SY	$33.00	$33,000.00
	Concrete Curb remove and replace	500.0	LF	$4.00	$2,000.00
			Paving Subtotal		**$43,500.00**
		SUBTOTAL:			**$309,074.00**
	MOBILIZATION	5	%	$15,453.70	$15,453.70
	CONTINGENCY	30	%	$92,722.20	$92,722.20
		SUBTOTAL:			**$417,250.00**
	ENGINEERING FEES	15	%	$62,587.50	$62,587.50
PROJECT TOTAL					**$479,800.00**

NOTES: PROPERTY ACQUISITION VALUES TAKEN FROM THE WICHITA COUNTY APPRAISAL DISTRICT. THESE COSTS INCLUDE $25,000 PER HOUSE FOR DEMOLITION, MOVING, AND CLOSING COST

Table 4 - Hirschi-Huskie existing conditions maximum WSEL output by node

Node	Type	Invert (feet)	Maximum HGL					
			2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
I-1	JUNCTION	1008.90	948.62	948.62	948.67	948.90	949.24	949.62
I-2	JUNCTION	1008.73	949.14	949.14	949.22	949.34	949.53	949.86
I-3	JUNCTION	1008.55	948.25	948.25	948.53	948.94	949.31	949.76
J-1	JUNCTION	1008.38	947.95	947.95	947.99	948.05	948.17	948.29
J-2	JUNCTION	1008.20	947.73	947.73	947.83	948.00	948.15	948.28
J-3	JUNCTION	1007.98	947.72	947.72	947.83	947.99	948.15	948.28
J-4	JUNCTION	1007.94	947.63	947.63	947.74	947.91	948.08	948.21
J-5	JUNCTION	1005.50	947.71	947.71	947.80	947.97	948.13	948.25
J-P1	JUNCTION	1005.00	947.59	947.59	947.70	947.86	948.06	948.19
J-P2	JUNCTION	1004.70	945.51	945.51	945.64	945.86	946.70	946.84
J-PS1	JUNCTION	1003.96	946.84	946.84	946.95	947.12	947.26	947.42
J-PS2	JUNCTION	1003.23	946.61	946.61	946.72	946.87	946.99	947.10
J-PS4	JUNCTION	1003.21	947.69	947.69	947.86	948.08	948.27	948.48
J-S1	JUNCTION	1003.18	947.65	947.65	947.68	947.71	947.74	947.77
J-S2	JUNCTION	1003.16	948.31	948.31	948.32	948.35	948.37	948.39
J-S3	JUNCTION	1003.10	946.37	946.37	946.45	946.57	946.65	946.74
J-S4	JUNCTION	1002.00	948.53	948.53	948.55	948.59	948.62	948.65
J-S5	JUNCTION	1000.01	948.21	948.21	948.47	948.87	949.22	949.60
O-1	OUTFALL	999.76	943.29	943.29	943.31	943.35	944.50	944.50
O-1a	OUTFALL	999.75	941.65	941.90	942.20	942.50	944.50	944.50
O-2	OUTFALL	999.37	946.18	946.18	946.26	946.38	946.46	946.55
O-3	OUTFALL	999.33	948.00	948.00	948.00	948.00	948.00	948.00
TrashPit	STORAGE	999.25	950.02	950.02	950.03	950.07	950.10	950.16
CulvertStorage	STORAGE	999.25	948.21	948.21	948.47	948.87	949.22	949.61
Detention	STORAGE	999.25	948.25	948.25	948.53	948.94	949.31	949.76

Table 5 – Hirschi-Huskie summary comparison of inundation depths.

	Summary of Inundation Depth by Frequency Event (ft)					
	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
No. structures	0	0	0	1	25	35
Max depth	0.00	0.00	0.00	0.37	0.72	1.10
Min depth	0.00	0.00	0.00	0.37	0.12	0.15
Average depth	0.00	0.00	0.00	0.37	0.17	0.28

Table 6 – Hirschi-Huskie inundation depths

Address	100 Year WSEL	FFE	Inundation Depth
1024 Hirschi Ln	948.29	948.00	**0.29**
1023 Hirschi Ln	948.29	948.00	**0.29**
1021 Hirschi Ln	948.29	948.00	**0.29**
1019 Hirschi Ln	948.29	948.00	**0.29**
1017 Hirschi Ln	948.28	948.00	**0.28**
1015 Hirschi Ln	948.28	948.00	**0.28**
1013 Hirschi Ln	948.28	948.00	**0.28**
1011 Hirschi Ln	948.28	948.00	**0.28**
1010 Hirschi Ln	948.29	948.00	**0.29**
1009 Hirschi Ln	948.28	948.00	**0.28**
1008 Hirschi Ln	948.28	948.00	**0.28**
1006 Hirschi Ln	948.29	948.00	**0.29**
1004 Hirschi Ln	948.28	948.00	**0.28**
3021 Huskie Dr	948.28	948.00	**0.28**
3020 Huskie Dr	948.28	948.00	**0.28**
3019 Huskie Dr	948.28	948.00	**0.28**
3018 Huskie Dr	948.28	948.00	**0.28**
3017 Huskie Dr	948.25	948.00	**0.25**
3016 Huskie Dr	948.25	948.00	**0.25**
3015 Huskie Dr	948.25	948.00	**0.25**
3014 Huskie Dr	948.25	948.00	**0.25**
3013 Huskie Dr	948.25	948.00	**0.25**
3012 Huskie Dr	948.25	948.00	**0.25**
3011 Huskie Dr	948.21	948.00	**0.21**
3009 Huskie Dr	948.21	948.00	**0.21**
3008 Huskie Dr	948.21	948.00	**0.21**
3007 Huskie Dr	948.21	948.00	**0.21**
3005 Huskie Dr	948.21	948.00	**0.21**
2830 Iowa Park Rd	949.60	948.50	**1.10**
2808 Iowa Park Rd	948.65	948.50	**0.15**
1025 Ridgeway	948.21	948.00	**0.21**
1022 Ridgeway	948.21	948.00	**0.21**
1020 Ridgeway	948.21	948.00	**0.21**
1017 Ridgeway	948.21	948.00	**0.21**
1014 Ridgeway	948.21	948.00	**0.21**
*WSEL estimated based on nearest adjacent XS	**Number of Homes Flooded**		**35**

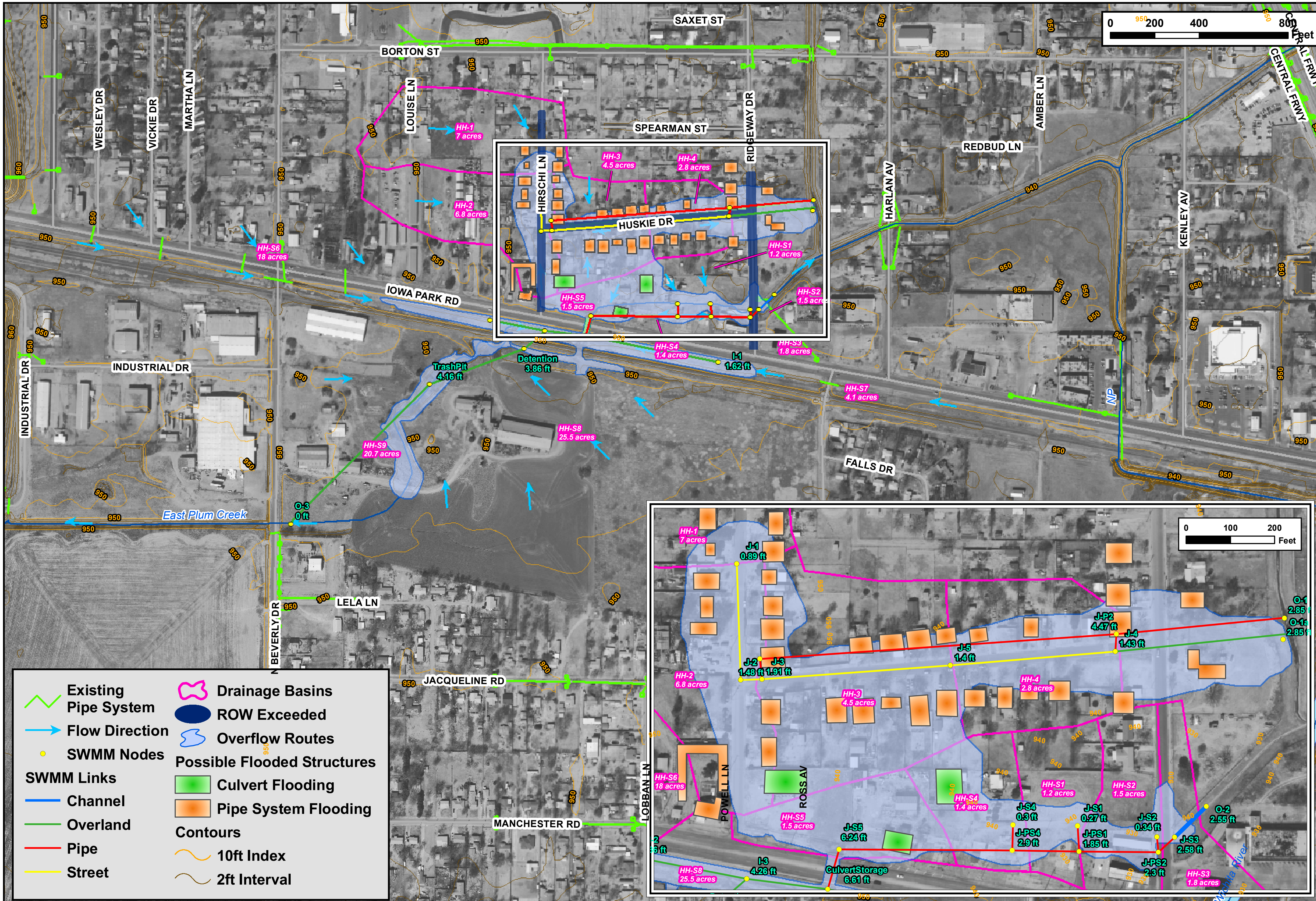

Exhibit 1

FN JOB NO	WCH09429
FILE	H:\STORMWATER\GEODATABASE\StudyAreas
DATE	March, 2011
SCALE	1:4,800
DRAFTED	BAM

AREA 23 - HIRSCHI-HUSKIE

EXISTING CONDITIONS: 100 - Year Results

FREESE NICHOLS
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
P: 817-735-7300 F: 817-735-7491

Exhibit 2

FN JOB NO	WCH09429
FILE	H:\STORMWATER\GEODATABASE\StudyAreas
DATE	March, 2011
SCALE	1:1,800
DRAFTED	BAM

AREA 23 - HIRSCHI-HUSKIE

PROPOSED IMPROVEMENTS

FREESE AND NICHOLS
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
P: 817-735-7300 F: 817-735-7491

Memorandum

Date:	Thursday, June 16, 2022
Project:	Canadian – Upper Red Regional Flood Plan
To:	Scott Hubley, PE, Freese and Nichols, Inc.
From:	David Dunn, PE (Texas PE No. 82630) Toby Li, EIT
Subject:	Landon, Duty and Sunset Drainage Improvements FMP

The initial evaluation for this project was conducted in 2011 as a part of the Wichita Falls Drainage Master Plan Update by Freese and Nichols, Inc. (FNI) [1]. Excerpts from that study are included as Exhibit 1.

The project area is in the vicinity of Duty Lane, Sunset Lane and Landon Road, north of Iowa Lane in Wichita Falls, TX. The area is flat, with slopes as low as 0.4% in some locations. Runoff is conveyed along Duty Lane, Landon Road and Sunset Lane through shallow bar ditches, which are inconsistent and shallow throughout the area. Many of the houses in the area are susceptible to flooding due to their elevations at or below the street elevation. Runoff overflows the bar ditches along Duty Lane and creates sheet flow south of Duty Lane across much of the project area. Fifty-two properties south of Duty Lane are located within the FEMA-designated AO floodplain and subject to ponding from sheet flow runoff. However, the modeling completed by FNI identifies only 43 structures impacted by flooding; it is assumed the nine other structures have finished floor elevations above the 100-yr base flood elevation.

Model Analysis

FNI created an EPA SWMM model of the network of roadside ditches, which is composed of 22 junction nodes, 27 conduit links and five (5) outfalls. The bar ditches and channels were modeled as irregular channels, with appropriate Manning's n-values to show geometry and potential overflow. FNI applied the SWMM model to determine existing conditions and to evaluate proposed solutions to the flooding.

Summary of Improvements

FNI proposed an upgraded storm drain system and curb and gutter improvements along Landon Road, Duty Lane and Sunset Lane. The following is an excerpt of the detailed proposed improvements.

[1] Wichita Falls, Texas, *Drainage Master Plan Update, Project: LANDON, DUTY AND SUNSET ST DRAINAGE PROJECT,* Freese and Nichols, Inc., 2011.

It was recommended that the proposed solution would be a combination of curb and gutter street improvements for Duty Lane, Landon Road, and Sunset Lane south of Duty Lane, a pipe system installed on Duty Lane that would outfall into the Loop 11 drainage channels, a pipe system for a portion of Sunset Lane and along Iowa Park Road that would also outfall into the Loop 11 drainage channels, and a new parallel pipe at the intersection of Landon Road and Iowa Park Road to convey runoff from the north side of Iowa Park Road to the south.

The proposed curb and gutter improvements would consist of a 30 foot wide street section with typical 6 inch curbs. The elevations of the road should be lowered to at or below the finished floor elevations of the surrounding properties. This requires the lowering of Duty Lane by an average of 2.15 feet and lowering Landon Road by approximately 1 foot. Only the southern portion of Sunset Lane at the intersection of Iowa Park Road would need to be lowered by approximately 1 foot.

The storm drain system for Duty Lane begins at the Landon Road intersection with 300 LF of 36" RCP, then 477 LF of 48" RCP and finally 755 LF of 6'x4' RCB that conveys approximately 211 cfs past Sunset Lane and through a proposed drainage easement between 1103 and 1029 Sunset Lane before discharging into the Loop 11 drainage channel. The proposed Sunset Lane pipe system would start approximately 580 feet north of the Iowa Park Road intersection and would consist of a 24" RCP. The proposed Iowa Road pipe system would consist of a 4'x4' drop inlet that intercepts runoff in the bar ditch and conveys the runoff east in 175 LF of 2'x2' RCB. The Sunset Lane pipe system and the Iowa Park Road pipe system would join at the intersection of the two roads. The existing 6'x2' RCB that conveyed the flow across Iowa Park Road would be plugged and a new 6'x2' RCB will be constructed to convey the flow in the existing right-of-way easement of Iowa Park Road to the east and discharge in the Loop 11 drainage channel. For the Landon Road system it is proposed that a parallel 4'x2' RCB be installed along the existing 4'x2' RCB and both will outfall in the ditch on the south side of Iowa Park Road. Exhibit 2 shows the location and features of the proposed pipe system for the Landon, Duty, Sunset project area.

Modeling Results

In the original 2011 analysis, the hydraulic modeling results from EPA SWMM 5.0 show that the proposed storm drain system for the project area would eliminate flooding for 41 out of 43 structures during the 1 percent annual chance (100-year) storm event (and all smaller events)[2]. Table 1 is from the 2011 report and summarizes results for the existing and proposed conditions.

[2] Note that the precipitation depths of these storm events were determined prior to the Atlas 14 update. The 100-year 24-hour storm depth has not changed significantly in Wichita Falls, TX. [NOAA Atlas 14 (weather.gov)](), Figure 7.4

Table 1. Landon, Duty and Sunset Drainage Improvements FMP inundation summary comparison

		Summary of Inundation Depth by Frequency Event (ft)					
		2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
No. structures	Existing	35	37	38	43	43	43
	Proposed	0	0	0	2	2	2
Max depth	Existing	4.00	4.07	4.1	4.16	4.21	4.24
	Proposed	0.00	0.00	0.00	0.12	0.13	0.27
Min depth	Existing	0.19	0.23	0.11	0.16	0.21	0.24
	Proposed	0.00	0.00	0.00	0.12	0.13	0.27
Average depth	Existing	1.93	1.93	1.92	1.79	1.85	1.89
	Proposed	0.00	0.00	0.00	0.12	0.13	0.27

Benefit-Cost Analysis

TWDB requires each project included as an FMP in a regional flood plan to have a benefit/cost analysis (BCA) performed. Many flood mitigation studies document a computed benefit/cost ratio (BCR) and those can be incorporated into the regional flood plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool[3] to facilitate calculations of costs and benefits. It estimates flood damages for residential buildings before and after construction of the flood mitigation project for up to three recurrence interval flood events. Because the TWDB BCA Workbook calculates costs and benefits for only three recurrence intervals, a combination of two workbooks were used to complete calculations for six recurrence interval events (2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0[4], which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then entered back into the TWDB BCA Input Tool which then computes the resulting BCR for the project.

Project Costs

FNI estimated the total project cost to be $1,485,000 in the 2011 Drainage Master Plan[5]. A Construction Cost Index (CCI) factor of 1.27 was applied to convert the costs from 2011 to 2020 dollars, resulting in a project cost of $1,885,950. The construction was set to begin and end in 2020 to simplify the calculation of the BCR.

Flood Damages Before and After Implementation of the FMP

Based on Table 1, average depths of flooding at 43 structures were entered into the TWDB BCA Input Workbook for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events for both the existing and the proposed conditions.

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[3] https://www.twdb.texas.gov/flood/planning/planningdocu/2023/doc/BCA%20Workbook.zip
[4] https://www.fema.gov/grants/guidance-tools/benefit-cost-analysis
[5] *Drainage Master Plan Update Project: Landon, Duty, and Sunset St*, page 6

The TWDB BCA Input Workbook includes flood damage-by-depth values for residential homes and commercial buildings in Texas. With each flood depth, there is a corresponding flood damage associated with the type of structure. The workbook sums damages for all structures to provide a comparison of damages before and after implementation of the FMP for each flood event. The damages were then entered into the FEMA BCA Toolkit 6.0. By calculating the annualized difference between the baseline and project damages for various return periods, the FEMA BCA Tool produces the total annualized benefits of the project's lifetime.

The total cost was entered into the TWDB BCA Input Workbook with estimated annual operation and maintenance costs of 1% of the total capital cost for the assumed 30-year lifetime of the project. The tool then was used to compute total costs for the project over the 30-year assumed lifespan. The total annualized benefits as determined by the FEMA BCA Toolkit 6.0 were also entered. The data are summarized in Figure 2, which is a screen capture of the Results tab from the TWDB BCA Input Tool.

Note that the green shaded value of $22,538,045 represents the sum of the estimated total benefits computed over the 30-year useful life at a discount rate of 7 percent, per FEMA standards. **The final BCR computed by the TWDB BCA Input Tool for the Landon, Duty and Sunset Drainage Improvements FMP is 10.6**, using the damages and benefits referenced to the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events. This large BCR can be attributed to the large number of structures removed from flooding by the FMP. The FMP removes 41 of the 43 structures from the 100-year floodplain, and all 38 structures from flooding at the 10-year and smaller events.

Input Into BCA Toolkit		
Project Useful Life	**30**	
Event Damages	**Baseline**	**Project**
25 - year storm	**$4,054,607**	**$99,170**
50 - year storm	**$4,123,171**	**$101,194**
100 - year storm	**$4,192,003**	**$105,016**

Total Benefits from BCA Toolkit	$22,537,983
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs	$2,119,978
Net Benefits	$20,418,005
Net Benefits with Recreation	$20,418,005
Final BCR	**10.6**
Final BCR with Recreation	**10.6**

Figure 2. BCA Workbook Results – Landon, Duty and Sunset Drainage Improvements FMP

No Negative Impact Analysis

No Negative Impact of Flood Risk

An FMP must have no negative impacts on its neighboring area due to its implementation. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 1 percent annual chance (100-year) event water surface elevation and peak discharge, using the best available data. It is recommended that no rise in water surface elevation or discharge should be permissible, and that the analysis extent must be vast enough to prove proposed project conditions are equal to or less than the existing conditions.

For the purposes of regional flood planning efforts, a determination of no negative impact can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial buildings and structures. Additionally, all of the following requirements, per TWDB Technical Guidelines, should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 ft) measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

For the Landon, Duty, and Sunset Drainage Improvements FMP, the EPA SWMM 5.0 model developed by FNI was used to assess and develop the project. Since no 2D model is available, only requirements #1, #2, #3, and #5 apply. Computed depths at all nodes in the SWMM model decrease from existing to proposed conditions, meeting the intent of criteria #4.

In Table 1, the existing conditions were compared to conditions with the proposed improvements. In addition, in the Drainage Master Plan, flood depths at all 43 structures during a 100-year flood are compared for existing and proposed conditions.[6] The comparison shows that the project does not increase flooding at any location, meeting criteria #1 and #3. In the existing conditions, 43 houses are flooded by overflows. However, in the proposed conditions, overtopping depths decrease at all houses, and this meets criteria #2. Within the project limits, there is no location where water surface elevations for the 100-year flood rises.

A comparison of flows at the outlet between the existing and proposed conditions in the SWMM model shows that the total peak outfall would decrease from 681 cfs to 368 cfs during a 100-year storm event. Therefore, as the peak outfall flow decreases, no negative impacts are anticipated and criteria #5 is met. During final design of the project, a full hydrologic and hydraulic study would be completed to determine conformance with the City's drainage/floodplain management criteria and flood planning requirements.

No Environmental Impacts

TWDB requires that environmental impacts be assessed for all eligible FMPs. Environmental impact categories include

a. water quality;
b. cultural heritage;
c. habitat, biodiversity and ecology;
d. air quality;
e. natural resources; and
f. agricultural resources/properties.[7]

[6] *Drainage Master Plan Update Project: LANDON, DUTY AND SUNSET ST*, Table 4.
[7] Exhibit C Technical Guidelines for Regional Flood Planning, page 127.

With the nature of the urban drainage improvement project, none of the above is applicable for the Landon, Duty, and Sunset Drainage Improvements FMP.

Populating the RFPG required Tables 13 and 16

TWDB requires that Tables 13[8] and 16[9] to be populated along with the submission of the report and geodatabase. The required attributes are populated as follows. First, basic project information (name, description, etc.) are extracted from the 2011 FNI study[10]. Second, the project extents are drawn into GIS, and after doing so, spatial attributes are obtained by overlapping spatial layers (HUC12s, watersheds, etc.). Third, floodplain inundation information is extracted from the modeling results of the 2011 study (area in 100-yr floodplain, number of structures at 100-yr flood risk, etc.) for both pre-project and post-project conditions. Finally, benefit-and-cost related attributes are derived from the BCA performed in this study (cost, benefit-cost ratio, etc.).

Table 2 is a summary of key information in Tables 13 and 16 for Landon, Duty and Sunset Drainage Improvements. The estimated number of structures at 100-year risk equals the number of structures determined to be impacted by the 100-year flood. Population is estimated based on three persons per structure. The estimated length of roads at 100-year flood risk is measured from the length of roads inundated within the 100-year floodplain. The post-project level-of-service is determined by the recurrence interval of the flood event in which no structures would be flooded. Finally, the cost/structure removed equals the total cost divided by the total number of structures.

[8] Exhibit C Technical Guidelines for Regional Flood Planning, page 63.
[9] Exhibit C Technical Guidelines for Regional Flood Planning, page 75.
[10] Wichita Falls, Texas, *Drainage Master Plan Update, Project: LANDON, DUTY AND SUNSET DRAINAGE IMPROVEMENTS,* Freese and Nichols, Inc., 2011.

Table 2. Project highlights from Tables 13 and 16

FMP Name	Landon, Duty and Sunset St Drainage Project
Associated Goals	2001, 2002
Watershed Name	Buffalo Creek-Wichita River
Project Area (sq mi)	0.0483
Area in 100-yr (1% annual chance) Floodplain (sq mi)	0.0344
Estimated number of structures at 100yr flood risk	43
Estimated Population at 100-year flood risk	129
Estimated length of roads at 100-year flood risk (miles)	0.27
Number of Structures removed from 100-yr (1% annual chance) flood risk	41
Pre-Project Level-of-Service	Unknown
Post-Project Level-of-Service	10% annual
Cost/Structure removed	$51,707
Social Vulnerability Index (SVI)	0.763
Benefit-Cost Ratio	10.6

Exhibit 1: Excerpts from Wichita Falls Drainage Master Plan, Project: Landon, Duty, and Sunset

Project Information

Project ID:	Area_31	**Status:**	Studied
Project Name:	LANDON, DUTY, AND SUNSET ST DRAINAGE PROJECT	**Council District:**	5
Project Type:	Road and Pipe System	**Panel #:**	18C, 18D
Date Identified:	1994	**# Structures Impacted:**	43

Problem Description:

Fifty-two properties south of Duty Lane are located within the AO floodplain and subject to ponding from sheet flow runoff. Duty Lane is a two lane road with bar ditches that provide inadequate drainage. The drainage bar ditches are inconsistent and shallow throughout the area. Many of the houses in the area are at or below the street elevation which makes them susceptible to flooding. The area is exceedingly flat with slopes as low as 0.4% in some locations. This project was studied in 2011 FNI Master Plan Update.

Proposed Improvements:

The proposed solution is be a combination of curb and gutter street improvements for Duty Lane, Landon Road, and Sunset Lane south of Duty Lane, a pipe system installed on Duty Lane that outfalls into the Loop 11 drainage channels, a pipe system for a portion of Sunset Lane and along Iowa Park Road that also outfalls into the Loop 11 drainage channels, and a new parallel pipe at the intersection of Landon Road and Iowa Park Road to convey runoff from the north side of Iowa Park Road to the south.

CIP Ranking Criteria

Weight		Score
11.83	**Life Safety/Road Flooding:**	3
8.84	**Property Damage:**	4
8.66	**Frequency of Flooding:**	5
5.34	**Project Cost:**	2
5.33	**Maintenance Cost/Work Orders:**	1
	Total Weighted Point Score:	130.2
	CIP Rank:	6

Project Costs

Conceptual Cost Range:	$1,000,000 to $2,000,000
Est. Construction Cost:	$1,485,000.00

Project Photos

Looking east down Duty Ln from the Landon Rd intersection.

Possible outfall location at Loop 11 frontage road.

LANDON, DUTY, SUNSET

Background

The Landon, Duty, Sunset project area is located north of Iowa Park Road. The area south of Duty Lane is in the FEMA Zone AO of Plum Creek which indicates shallow sheet flow of 2 feet with a velocity of 2.1 feet per second. Local runoff is conveyed east along Duty Lane and south on Landon Road and Sunset Lane through shallow bar ditches along the roads and then south across Iowa Park Road through culvert crossings at the Landon Road and Sunset Lane intersections. Large areas of local runoff sheet flow across lots before entering bar ditches.

Problem Description

The drainage bar ditches described above are inconsistent and shallow throughout the area. Many of the houses in the area are at or below the street elevation which makes them susceptible to flooding in the event that the bar ditches are overtopped. The area is exceedingly flat with slopes as low as 0.4% in some locations. Photo 1 below shows the shallow bar ditches on either side of Duty Lane looking west.

Photo 1 - Looking west at the bar ditches along Duty Lane.

Existing Conditions Analysis

FNI performed an analysis of the existing street section capacity including the bar ditches and the culverts under Iowa Park Road. EPA SWMM 5.0 was used for the hydrologic and hydraulic analyses of this area.

Hydrology

The drainage area that discharges to Iowa Park Road is approximately 99.6 acres and consists of low density residential development. The drainage area is bordered by Covington Drive on the west, an irrigation canal on the north, Iowa Park Road on the south, and Sunset Lane on the east. For the hydrologic study, the drainage area was broken up into seven (7) subcatchments ranging in size from 8.37 to 19.19 acres. Curve numbers for each sub basin were calculated based on soil type and future land use provided by the City.

An additional drainage area adjacent to the project was analyzed to the east for its possible use in proposed alternatives. The area includes the Loop 11 access road and channels. The Loop 11 drainage area is approximately 52 acres. For the hydrologic study, the drainage area was broken up into three (3) subcatchments ranging in size from 12.62 to 24.58 acres. Curve numbers for each sub basin were calculated based on soil type and future land use provided by the City.

Runoff on Duty Lane is conveyed east toward Sunset Lane for approximately 2,000 feet. It is then carried south on Sunset Lane for approximately 1,350 feet where it is intercepted by a 6'x2' RCB according to the City's CAD storm drain database. Flow from the west side of Sunset Lane is also intercepted at this location from the bar ditches along Iowa Park Road. Overflow from the Duty Lane bar ditches is conveyed south across adjacent lots before being intercepted by bar ditches on Landon Road or Iowa Park Road. Runoff on Landon Road is conveyed south toward Iowa Park Road for approximately 700 feet and is intercepted by a 4'x2' RCB according to the City's CAD storm drain database. Both culvert crossings discharge on the south side of Iowa Park Road into another bar ditch that eventually discharges into East Plum Creek. Only local runoff was used to model the existing system with the intention that any runoff from the Zone AO of Plum Creek will be eliminated in the event that Plum Creek is improved.

The trapezoidal bar ditches varied in size throughout the area but on average consisted of 1 foot bottom width and a 2 foot depth with an 8 foot top width. The capacity of the bar ditches range from 23 to 44 cfs based on the slope and the 100-year flow to a bar ditch ranges from 58 to 378 cfs, which means the bar ditches are insufficient and flood the nearby homes. Much of the flow on Duty Lane, approximately 254 cfs, overtops the shallow bar ditches and sheet flows south towards Landon Road or Iowa Park. With the flat grade of the land and the limited height of surrounding structures these depths could cause structural flooding.

The Loop 11 drainage channel is approximately 8 feet deep with a 10 foot bottom width and 4:1 side slopes. Flow in the channel is conveyed south to two (2) 48" RCPs that convey the flow south of Iowa Park. The capacity of the drainage channel is 1,418 cfs and the 100-year flow to the drainage channel is 207 cfs, which means the drainage channel is adequately sized for the 100-year storm event.

Hydraulics

Along with the hydrologic model, FNI also constructed a hydraulic model using SWMM for the Landon, Duty, Sunset study area. The system was modeled to determine the depths of flow at critical areas in order to identify locations of inundated structures as well as exceeded right-of-way. A hydraulic model made up of 22 junctions, 27 links, and 5 outfalls was developed to represent storm water runoff through this area. The bar ditches and channels were modeled as irregular channels with appropriate Manning's n-values to show the geometry of the feature and any overbank flow that might occur. Data for the existing culverts located at the Landon Road and Sunset Lane intersections of Iowa Park Road were taken from storm drain CAD files acquired from the City of Wichita Falls.

Existing Conditions Results

Existing analysis shows that bar ditches in the area have depths ranging from 0.88 to 2.12 feet for the 100-year storm event. The culvert headwall locations have the highest depths with the Landon Road and Sunset Lane headwalls reaching 4.72 and 3.98 feet, respectively. The Landon Road culvert overtops Iowa Park Road with approximately 48 cfs at a depth of 0.7 feet during the 100-year storm event. The Sunset Lane culvert overtops Iowa Park Road with approximately 318 cfs at a depth of 0.97 feet during the 100-year storm event. As mentioned in the *Hydrology* section of the report, Duty Lane bar ditches are overtopped and approximately 254 cfs of excess runoff sheet flows south to the Landon Road or Iowa Park Road bar ditches.

Existing analysis of the Loop 11 drainage channel shows that the channel currently has adequate capacity for the 100-year storm event. The depth of the channel is 8 feet and the maximum depth of flow in the channel under existing conditions is 5.89 feet. The headwater at the culvert on the south end of the drainage channel reaches a maximum depth of 5.69 feet.

Based on the existing analysis and the node depths in Table 1 there are forty-three (43) structures that have the potential to be flooded during the 100-year storm event for the Landon, Duty, Sunset project area. Table 2 shows the properties flooding during the 100-year storm event and that are shown on Exhibit 1. A summary of flooded structures by storm event is shown in Table 3. Finished floors were estimated at 0.5 feet above the lowest adjacent grade based on site visit observation and two-foot topography.

Proposed Improvements

After the existing conditions study of the Landon, Duty, Sunset project area was completed, FNI presented the results to the City along with proposed alternatives for discussion. It was recommended that the proposed solution would be a combination of curb and gutter street improvements for Duty Lane, Landon Road, and Sunset Lane south of Duty Lane, a pipe system installed on Duty Lane that would outfall into the Loop 11 drainage channels, a pipe system for a portion of Sunset Lane and along Iowa Park Road that would also outfall into the Loop 11 drainage channels, and a new parallel pipe at the intersection of Landon Road and Iowa Park Road to convey runoff from the north side of Iowa Park Road to the south.

Proposed Storm Drain System

The proposed curb and gutter improvements would consist of a 30 foot wide street section with typical 6 inch curbs. The elevations of the road should be lowered to at or below the finished floor elevations of the surrounding properties. This requires the lowering of Duty Lane by an average of 2.15 feet and lowering Landon Road by approximately 1 foot. Only the southern portion of Sunset Lane at the intersection of Iowa Park Road would need to be lowered by approximately 1 foot.

The storm drain system for Duty Lane begins at the Landon Road intersection with 300 LF of 36" RCP, then 477 LF of 48" RCP and finally 755 LF of 6'x4' RCB that conveys approximately 211 cfs past Sunset Lane and through a proposed drainage easement between 1103 and 1029 Sunset Lane before discharging into the Loop 11 drainage channel. The proposed Sunset Lane pipe system would start approximately 580 feet north of the Iowa Park Road intersection and would consist of a 24" RCP. The proposed Iowa Road pipe system would consist of a 4'x4' drop inlet that intercepts runoff in the bar ditch and conveys the runoff east in 175 LF of 2'x2' RCB. The Sunset Lane pipe system and the Iowa Park Road pipe system would join at the intersection of the two roads. The existing 6'x2' RCB that conveyed the flow across Iowa Park Road would be plugged and a new 6'x2' RCB will be constructed to convey the flow in the existing right-of-way easement of Iowa Park Road to the east and discharge in the Loop 11 drainage channel. For the Landon Road system it is proposed that a parallel 4'x2' RCB be installed along the existing 4'x2' RCB and both will outfall in the ditch on the south side of Iowa Park Road. Exhibit 2 shows the location and features of the proposed pipe system for the Landon, Duty, Sunset project area.

Results

An analysis of the proposed improvements described above was performed to determine the amount of flooding that would be eliminated after implementation. Tables 3 and 4 provide a summary of the difference in flooding from existing to proposed conditions. The results show that the proposed storm drain systems and street improvements for the Landon, Duty, Sunset project area would eliminate potential structure flooding on all but two (2) properties located on Iowa Park Drive during the 100-year storm event.

An opinion of probable construction cost was developed for the proposed improvements to the Landon, Duty, Sunset study area. The estimated construction cost for the improvements described in this section is approximately $1,485,000. A detailed breakdown of the cost analysis for the Landon, Duty, Sunset project area is shown in Table 1. FNI suggests that the City implement the proposed solutions as described above to resolve flooding problems in the area.

AREA 31 LANDON, DUTY, SUNSET
OPINION OF PROBABLE CONSTRUCTION COST
PROPOSED STORM DRAIN SYSTEM
CITY OF WICHITA FALLS - DRAINAGE MASTERPLAN UPDATE

ACCOUNT NO.	ESTIMATOR	CHECKED BY		DATE	
WCH09429	BAM			April 9, 2011	
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
General					
	Traffic Control	3.0	MO	$5,000.00	$15,000.00
	Site Preparation	0.5	AC	$25,000.00	$12,500.00
	Erosion Control and SWPPP Implementation	1.0	LS	$5,000.00	$5,000.00
			General Item Subtotal		**$32,500.00**
Storm Drain					
	Trench Safety	2,700.0	LF	$2.00	$5,400.00
	Install 24" RCP	580.0	LF	$40.00	$23,200.00
	Install 36" RCP	300.0	LF	$68.00	$20,400.00
	Install 48" RCP	477.0	LF	$85.00	$40,545.00
	Install 2'X2' RCB	175.0	LF	$90.00	$15,750.00
	Install 4'X2' RCB	100.0	LF	$110.00	$11,000.00
	Install 6'X2' RCB	305.0	LF	$140.00	$42,700.00
	Install 6'X4' RCB	755.0	LF	$180.00	$135,900.00
	Install 18" RCP Lateral	160.0	LF	$35.00	$5,600.00
	Install Manhole	6.0	EA	$3,000.00	$18,000.00
	Install 4'X4' Drop Inlet	1.0	EA	$2,000.00	$2,000.00
	Install 15' Curb Inlet	16.0	EA	$4,000.00	$64,000.00
	Install Headwall	4.0	EA	$5,000.00	$20,000.00
			Storm Drain Subtotal		**$404,495.00**
Utility Adjustments					
	Remove and Replace 6" PVC Water Line	2,320.0	LF	$36.00	$83,520.00
	Remove and Replace 12" PVC Water Line	575.0	LF	$72.00	$41,400.00
	Trench Safety For Water Line	2,895.0	LF	$1.00	$2,895.00
	Connections to Existing Water Line	2.0	EA	$1,000.00	$2,000.00
			Utility Adj. Subtotal		**$129,815.00**
Paving					
	Asphalt Pavement Saw, Remove and Dispose	9,000.0	SY	$6.00	$54,000.00
	6" Stabilized Subgrade Install	9,000.0	SY	$2.50	$22,500.00
	6" Asphalt Pavement	9,000.0	SY	$33.00	$297,000.00
	Install Concrete Curb and Gutter	5,400.0	LF	$3.00	$16,200.00
			Paving Subtotal		**$389,700.00**
		SUBTOTAL:			**$956,510.00**
	MOBILIZATION	5	%	$47,825.50	$47,825.50
	CONTINGENCY	30	%	$286,953.00	$286,953.00
		SUBTOTAL:			**$1,291,290.00**
	ENGINEERING FEES	15	%	$193,693.50	$193,693.50
PROJECT TOTAL					**$1,485,000.00**

Table 2- Landon, Duty, Sunset existing conditions maximum WSEL output by node

Node	Type	Maximum Depth (feet)					
		2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
J-Du1	JUNCTION	0.79	0.82	0.83	0.85	0.87	0.88
J-Du2	JUNCTION	0.84	0.88	0.90	0.93	0.95	0.98
J-Du3	JUNCTION	0.84	0.87	0.89	0.92	0.94	0.96
J-Io1	JUNCTION	1.57	1.73	1.81	1.93	2.03	2.12
J-Io2	JUNCTION	1.42	1.54	1.60	1.69	1.77	1.84
J-L1	JUNCTION	1.31	1.50	1.56	1.66	1.74	1.76
J-P-L1	JUNCTION	2.91	3.67	4.03	4.67	5.22	5.71
J-P-L2	JUNCTION	2.09	2.63	2.90	3.30	3.64	3.90
J-S1	JUNCTION	1.21	1.28	1.31	1.37	1.42	1.45
J-S2	JUNCTION	1.60	1.74	1.78	1.85	1.90	1.94
J-S3	JUNCTION	1.19	1.24	1.27	1.33	1.37	1.40
J-S4	JUNCTION	1.59	1.59	1.59	1.62	1.67	1.74
Loop11-A	JUNCTION	1.45	2.02	2.35	2.93	3.45	3.91
Loop11-B	JUNCTION	2.38	3.08	3.43	4.03	4.56	5.03
Loop11-C	JUNCTION	2.77	3.50	3.85	4.47	5.01	5.49
Loop11-D	JUNCTION	3.17	3.91	4.26	4.89	5.43	5.91
Loop11-E	JUNCTION	2.89	3.64	4.00	4.63	5.17	5.66
L-P1	JUNCTION	1.51	2.82	3.64	4.29	4.53	4.72
O-P-D1	JUNCTION	1.93	2.62	2.96	3.55	4.07	4.54
S-P1	JUNCTION	3.22	3.44	3.54	3.71	3.85	3.98
J-EastLoop	JUNCTION	1.12	1.33	1.44	1.70	2.19	2.93
J-P-EastLoop	JUNCTION	1.63	2.08	2.34	2.78	3.36	4.13
O-L1	OUTFALL	0.91	1.51	1.76	1.91	1.96	2.00
O-OvF1	OUTFALL	0.00	0.00	0.00	0.00	0.00	0.00
O-OvF2	OUTFALL	0.00	0.00	0.00	0.00	0.00	0.00
O-Loop11	OUTFALL	1.45	1.77	1.92	2.13	2.29	2.40
O-S1	OUTFALL	1.68	1.74	1.77	1.82	1.85	1.89

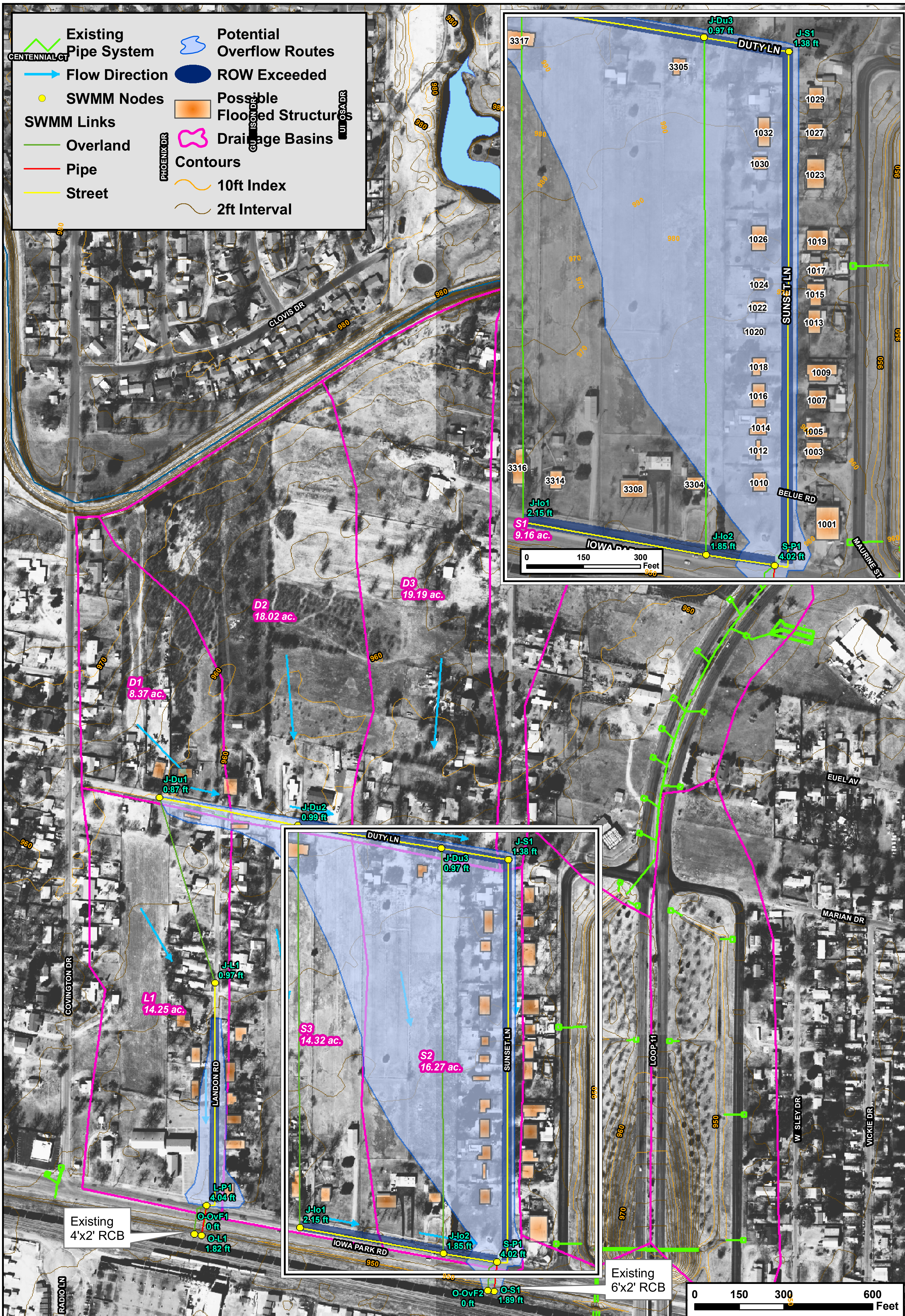
Table 3 – Landon, Duty, Sunset inundation summary comparison

		Summary of Inundation Depth by Frequency Event (ft)					
		2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
No. structures	Existing	35	37	38	43	43	43
	Proposed	0	0	0	2	2	2
Max depth	Existing	4.00	4.07	4.1	4.16	4.21	4.24
	Proposed	0.00	0.00	0.00	0.12	0.13	0.27
Min depth	Existing	0.19	0.23	0.11	0.16	0.21	0.24
	Proposed	0.00	0.00	0.00	0.12	0.13	0.27
Average depth	Existing	1.93	1.93	1.92	1.79	1.85	1.89
	Proposed	0.00	0.00	0.00	0.12	0.13	0.27

Table 4 – Landon, Duty, Sunset inundation depth comparison

Address		100-yr Existing Inundation Depth	100-yr Proposed Inundation Depth
1034	Landon	**1.01**	
1035	Landon	**1.01**	
3317	Duty	**0.58**	
3305	Duty	**0.67**	
1036	Sunset	**0.24**	
1103	Sunset	**0.24**	
1029	Sunset	**1.24**	
1034	Sunset	**0.24**	
1032	Sunset	**1.24**	
1027	Sunset	**1.24**	
1030	Sunset	**2.24**	
1023	Sunset	**2.24**	
1026	Sunset	**2.24**	
1019	Sunset	**2.24**	
1017	Sunset	**2.24**	
1024	Sunset	**2.24**	
1015	Sunset	**2.24**	
1022	Sunset	**3.24**	
1020	Sunset	**3.24**	
1013	Sunset	**3.24**	
1018	Sunset	**3.74**	
Address		**100-yr**	**100-yr**

		Existing Inundation Depth	Proposed Inundation Depth
1009	Sunset	**3.74**	
1016	Sunset	**3.74**	
1007	Sunset	**3.74**	
1014	Sunset	**3.74**	
1005	Sunset	**3.74**	
1012	Sunset	**4.24**	
1003	Sunset	**4.24**	
1010	Sunset	**4.24**	
1016	Landon	**0.64**	
1015	Landon	**0.64**	
1014	Landon	**0.64**	
1013	Landon	**0.64**	
1012	Landon	**0.64**	
1011	Landon	**1.64**	
1009	Landon	**1.64**	
1007	Landon	**1.64**	
3320	Iowa Park	**1.19**	
3316	Iowa Park	**0.62**	**0.27**
3314	Iowa Park	**0.62**	**0.27**
3308	Iowa Park	**1.62**	
3304	Iowa Park	**0.34**	
3228	Iowa Park	**0.34**	
Number of Homes Flooded		**43**	**2**



FREESE AND NICHOLS

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N W E S

AREA 31 - LANDON, DUTY, SUNSET

EXISTING CONDITIONS: 100-YEAR RESULTS

FN JOB NO	WCH09429
FILE	H:\STORMWATER\GEODATABASE\StudyAreas
DATE	March, 2011
SCALE	1:3,600
DRAFTED	BAM

Exhibit 1

FREESE AND NICHOLS
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Area 31 - Landon, Duty, Sunset

PROPOSED CONDITIONS: 100-YEAR RESULTS

FN JOB NO	WCH09429
FILE	H:\STORMWATER\GEODATABASE\StudyAreas
DATE	March, 2011
SCALE	1:2,400
DRAFTED	BAM

Exhibit
2

Memorandum

Date:	Thursday, June 16, 2022
Project:	Canadian – Upper Red Regional Flood Plan
To:	Scott Hubley, PE, Freese and Nichols, Inc.
From:	David Dunn, PE (Texas PE No. 82630) Toby Li, EIT
Subject:	Rhea Road Drainage Project FMP

The initial evaluation for this project was conducted in 2011 as a part of the Wichita Falls Drainage Master Plan Update by Freese and Nichols, Inc. (FNI)[1]. Excerpts from that study are included as Exhibit 1.

The Rhea Road drainage area was designed to convey runoff primarily by street flow to McGrath Creek. Due to the lack of drainage infrastructure in the area, many structures along Rhea Road are subject to significant flooding. Ben Milam Elementary School at 2960 Stearns Avenue is flooded frequently. Additionally, previous studies have determined that McGrath Creek has become insufficient in size to adequately contain runoff from a 100-year storm event.

Model Analysis

FNI created an EPA SWMM model composed of 25 junction nodes, 25 conduit links and one (1) outfall. Street flow was modeled with irregular conduits reflecting the geometry of the street. The five inlets at the downstream end of Rhea were represented using transverse weirs connecting street junctions to pipe junctions.

Summary of Improvements

FNI proposed an upgraded storm drain system along Rhea Rd. The new system would have the capability to eliminate structure flooding for the 100-year storm event[2]. The following is an excerpt of the detailed proposed improvements.

[1] Wichita Falls, Texas, *Drainage Master Plan Update, Project: RHEA ROAD DRAINAGE PROJECT,* Freese and Nichols, Inc., 2011.

[2] Note that the precipitation depths of these storm events were determined prior to the Atlas 14 update. The 100-year 24-hour storm depth has not changed significantly in Wichita Falls, TX. [NOAA Atlas 14 (weather.gov)](), figure 7.4

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The upstream end proposed storm drain system for the Rhea project area begins at the intersection of Rhea Road and Abbott Avenue, just to the west of the Ben Milam Elementary School at 2960 Stearns Avenue. The storm drain reaches 1,825 LF downstream where it outfalls at McGrath Creek, just downstream of the Rhea Road crossing. Because this outfall must maintain a minimum elevation of 967.71 feet, the proposed pipe is subject to limitations on the amount and slope and cover that are available. Therefore, as the amount of flow in the system increases, the number of barrels also must increase to provide adequate capacity. The proposed pipe begins on Rhea Road about 275 LF north of Abbott Avenue with 1- 6' X 3' RCB and four (4) 15-foot curb inlets. The pipe then increases to 2 - 6'X3' RCBs at Abbott Avenue, then to 3 – 6'X3' RCBs at just north of McGaha Avenue until it outfalls at McGrath Creek. The proposed storm drain system includes the installation of sixteen (16) 15-foot inlets and eight (8) 10-foot inlets. The existing storm drain system at Cunningham Drive shall be removed and replaced with the proposed pipe system. The details and alignment of the proposed pipe system are shown in Exhibit 2.

Modeling Results

In the original 2011 analysis, the hydraulic modeling results from EPA SWMM 5.0 show that the proposed storm drain system for the Rhea Rd project area would eliminate flooding for all 27 structures during the 1 percent annual chance (100-year) storm event (and all smaller events). Table 1 is from the 2011 report and summarizes results for the existing and proposed conditions.

Table 1. Rhea Road Drainage Project FMP inundation summary comparison

		Summary of Inundation Depth by Frequency Event (ft)					
		2 yr	**5 yr**	**10 yr**	**25 yr**	**50 yr**	**100 yr**
No. structures	**Existing**	1	1	1	1	4	27
	Proposed	0	0	0	0	0	0
Max depth	**Existing**	0.03	0.16	0.23	0.34	0.43	0.51
	Proposed	0.00	0.00	0.00	0.00	0.00	0.00
Min depth	**Existing**	0.03	0.16	0.23	0.34	0.08	0.21
	Proposed	0.00	0.00	0.00	0.00	0.00	0.00
Average depth	**Existing**	0.00	0.00	0.00	0.00	0.17	0.26
	Proposed	0.00	0.00	0.00	0.00	0.00	0.00

Benefit-Cost Analysis

TWDB requires each project included as an FMP in a regional flood plan to have a benefit/cost analysis (BCA) performed. Many flood mitigation studies document a computed benefit/cost ratio (BCR) and those can be incorporated into the regional flood plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool[3] to facilitate calculations of costs and benefits. It estimates flood damages for residential buildings before and after construction of the flood mitigation project for up to three recurrence interval flood events. Because the TWDB BCA Workbook calculates costs and benefits for only three recurrence intervals, a combination of two workbooks were used to complete calculations for six recurrence interval events (2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0[4], which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then entered back into the TWDB BCA Input Tool which then computes the resulting BCR for the project.

Project Costs

FNI estimated the total project cost to be $2,098,000 in the 2011 Drainage Master Plan[5]. A Construction Cost Index (CCI) factor of 1.27 was applied to convert the costs from 2011 to 2020 dollars, resulting in a project cost of $2,664,460. The construction was set to begin and end in 2020 to simplify the calculation of the BCR.

Flood Damages Before and After Implementation of the FMP

Based on Table 1, average depths of flooding at 26 residential structures and 1 commercial structure were entered into the TWDB BCA Input Workbook for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events for both the existing and the proposed conditions. According to project descriptions, and in conjunction with Table 1, the Ben Milam Elementary School floods at the 2-year through the 100-year events.

The TWDB BCA Input Workbook includes flood damage-by-depth values for residential homes and commercial buildings in Texas. With each flood depth, there is a corresponding flood damage associated with the type of structure. The workbook sums damages for all structures to provide a comparison of damages before and after implementation of the FMP for each flood event. The damages were then entered into the FEMA BCA Toolkit 6.0. By calculating the annualized difference between the baseline and project damages for various return periods, The FEMA BCA Tool produces the total annualized benefits of the project's lifetime. The commercial structure is an elementary school, which is considered to be a critical facility and additional benefits for reducing flood risk to this critical facility were also incorporated into the analysis.

The total cost was entered into the TWDB BCA Input Workbook with estimated annual operation and maintenance costs of 1% of the total capital cost for the assumed 30-year lifetime of the project. The tool then was used to compute total costs for the project over the 30-year assumed lifespan. The total annualized benefits as determined by the FEMA BCA Toolkit 6.0 were also

[3] https://www.twdb.texas.gov/flood/planning/planningdocu/2023/doc/BCA%20Workbook.zip
[4] https://www.fema.gov/grants/guidance-tools/benefit-cost-analysis
[5] *Drainage Master Plan Update Project: RHEA ROAD*, page 5

entered. The data are summarized in Figure 2, which is a screen capture of the Results tab from the TWDB BCA Input Tool.

Note that the green shaded value of $3,361,870 represents the sum of the estimated total benefits computed over the 30-year useful life at a discount rate of 7 percent, per FEMA standards. **The final BCR computed by the TWDB BCA Input Tool for the Rhea Road Drainage Project FMP is 1.1** using the damages and benefits referenced to the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events. This relatively small BCR can be attributed to the small number of structures removed from flooding by the FMP in the smaller return period flood events. The FMP removes 27 structures from the 100-year floodplain, 4 structures from the 50-year floodplain, and 1 critical facility (elementary school) from flooding by 25-year and smaller events.

Input Into BCA Toolkit		
Project Useful Life	**30**	
Event Damages	**Baseline**	**Project**
25 - year storm	**$744,433**	**$0**
50 - year storm	**$1,036,967**	**$0**
100 - year storm	**$2,391,346**	**$0**
Total Benefits from BCA Toolkit	$3,361,870	
Other Benefits (Not Recreation)	$0	
Recreation Benefits	-	
Total Costs	$2,995,094	
Net Benefits	$366,776	
Net Benefits with Recreation	$366,776	
Final BCR	**1.1**	
Final BCR with Recreation	**1.1**	

Figure 2. BCA Workbook Results – Rhea Road Drainage Project FMP

No Negative Impact Analysis

No Negative Impact of Flood Risk

An FMP must have no negative impacts on its neighboring area due to its implementation. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 1 percent annual chance (100-year) event water surface elevation and peak discharge, using the best available data. It is recommended that no rise in water surface elevation or discharge should be permissible, and that the analysis extent must be vast enough to prove proposed project conditions are equal to or less than the existing conditions.

For the purposes of regional flood planning efforts, a determination of no negative impact can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial buildings and structures. Additionally, all of the following requirements, per TWDB Technical Guidelines, should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 ft) measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

For the Rhea Road Drainage Improvements FMP, the EPA SWMM 5.0 model developed by FNI was used to assess and develop the project. Since no 2D model is available, only requirements #1, #2, #3, and #5 apply. Computed depths at all nodes in the SWMM model decrease from existing to proposed conditions, meeting the intent of criteria #4.

In Table 1, the existing conditions were compared to conditions with the proposed improvements. In addition, in the Drainage Master Plan, flood depths at all 27 structures during a 100-year flood are compared for existing and proposed conditions.[6] The comparison shows that the project does not increase flooding at any location, meeting criteria #1. In the existing conditions, 27 structures are flooded by overflows. However, in the proposed conditions, overtopping depths decrease at all structures, and this meets criteria #2. Within the project

[6] *Drainage Master Plan Update Project: RHEA ROAD*, Table 5.

limits, there is no location where water surface elevations for the 100-year flood rises, meeting criteria #3.

A comparison of flows at the outlet between the existing and proposed conditions in the SWMM model shows that the peak discharge at the system outlet would increase from 693 cfs to 704 cfs during a 100-year flood, which is an increase of 1.5 percent. While this is an increase greater than the 0.5 percent allowed under criteria #5, during final design of the project a full hydrologic and hydraulic study would be completed with the possibility of including some detention in the project to decrease peak discharges. The final project would be designed and constructed to conform to the City's drainage/floodplain management criteria and flood planning requirements. Therefore, no negative impacts are anticipated and criteria #5 is met.

No Environmental Impacts

TWDB requires that environmental impacts be assessed for all eligible FMPs. Environmental impact categories include

a. water quality;
b. cultural heritage;
c. habitat, biodiversity and ecology;
d. air quality;
e. natural resources; and
f. agricultural resources/properties.[7]

With the nature of the urban drainage improvement project, none of the above is applicable for the Rhea Road Drainage Improvements FMP.

Populating the RFPG required Tables 13 and 16

TWDB requires that Tables 13[8] and 16[9] to be populated along with the submission of the report and geodatabase. The required attributes are populated as follows. First, basic project information (name, description, etc.) are extracted from the 2011 FNI study[10]. Second, the project extents are drawn into GIS, and after doing so, spatial attributes are obtained by overlapping spatial layers (HUC12s, watersheds, etc.). Third, floodplain inundation information is extracted from the modeling results of the 2011 study (area in 100-yr floodplain, number of structures at 100-yr flood risk, etc.) for both pre-project and post-project conditions. Finally, benefit-and-cost related attributes are derived from the BCA performed in this study (cost, benefit-cost ratio, etc.).

Table 2 is a summary of key information in Tables 13 and 16 for Rhea Road Drainage Project. The estimated number of structures at 100-year risk equals the number of structures in the 100-year floodplain. Population is estimated based on three persons per structure. The estimated length of roads at 100-year flood risk is measured from the length of roads inundated within the

[7] Exhibit C Technical Guidelines for Regional Flood Planning, page 127.
[8] Exhibit C Technical Guidelines for Regional Flood Planning, page 63.
[9] Exhibit C Technical Guidelines for Regional Flood Planning, page 75.
[10] Wichita Falls, Texas, *Drainage Master Plan Update, Project: RHEA ROAD DRAINAGE PROJECT,* Freese and Nichols, Inc., 2011.

100-year floodplain. The post-project level-of-service is determined by the recurrence interval of the flood event in which no structures would be flooded. Finally, the cost/structure removed equals the total cost divided by the total number of structures.

Table 2. Project highlights from Tables 13 and 16

FMP Name	Rhea Road Drainage Project
Associated Goals	2001, 2002
Watershed Name	Holliday Creek
Project Area (sq mi)	0.3298
Area in 100-yr (1% annual chance) Floodplain (sq mi)	0.0188
Estimated number of structures at 100yr flood risk	27
Estimated Population at 100-year flood risk	81
Estimated length of roads at 100-year flood risk (miles)	0.31
Number of Structures removed from 100-yr (1% annual chance) flood risk	27
Pre-Project Level-of-Service	Unknown
Post-Project Level-of-Service	1% annual
Cost/Structure removed	$110,929
Social Vulnerability Index (SVI)	0.603
Benefit-Cost Ratio	1.1

Exhibit 1: Excerpts from Wichita Falls Drainage Master Plan, Project: Rhea Road

Project Information

Project ID:	Area_38B	**Status:**	Studied
Project Name:	RHEA ROAD DRAINAGE PROJECT	**Council District:**	3
Project Type:	Pipe System	**Panel #:**	87A, 87C
Date Identified:	1991	**# Structures Impacted:**	27

Problem Description:

The Rhea Road drainage area was designed to convey runoff primarily by street flow to McGrath Creek. Due to the lack of drainage infrastructure in the area, many structures along Rhea Road are subject to significant flooding. Ben Milam Elementary School at 2960 Stearns Avenue on grade with Rhea Road and is known to flood in more frequent storm events. In addition, previous studies have determined that McGrath Creek has become insufficient in size to adequately contain runoff from a 100-year storm. Based on City records, it appears that TxDOT has plans to improve the channel, but not in the near future. Even though McGrath Creek is undersized, this area is still negatively impacted by the lack of a sufficient storm drain system. This project was studied in 2011 FNI Master Plan Update.

Proposed Improvements:

The proposed improvements call for the installation of a storm drain system along north on Rhea Road that would eliminate structure flooding in the 100-year storm event. The proposed pipe begins at the intersection of Rhea Road and Abbott Avenue, adjacent to the Ben Milam Elementary School and reaches approximately 1,825 LF to the south where it outfalls at McGrath Creek, beginning with 1-6'X3' RCB and increasing to 3-6'X3' RCBs.

CIP Ranking Criteria

Weight		Score
11.83	**Life Safety/Road Flooding:**	3
8.84	**Property Damage:**	4
8.66	**Frequency of Flooding:**	5
5.34	**Project Cost:**	1
5.33	**Maintenance Cost/Work Orders:**	3
	Total Weighted Point Score:	135.5
	CIP Rank:	5

Project Costs

Conceptual Cost Range:	$2,000,000 to $3,000,000
Est. Construction Cost:	$2,098,000.00

Project Photos

Looking west on Rhea Road at existing inlet south of Covington Dr.

Looking south from Covington Drive at alley outfall into McGrath Creek.

RHEA ROAD

Background

The Rhea Road Drainage project is located just north of McGrath Creek which flows parallel to Southwest Parkway in the southwest portion of Wichita Falls, and its drainage area is approximately 132 acres in size and is bounded on the north by Call Field Drive and on the south by Southwest Parkway. The study area primarily consists of single family residential development with a small commercial section in the southern portion of the drainage area. Runoff from this area is conveyed primarily by street flow from the northwest corner of the drainage area to its outfall at the intersection of Rhea Road and McGrath Creek to the south. There is a small storm drain system located at the southern end of Rhea Road that contains five 10-ft inlets that connect to a 3 X 6 ft box, approximately 210 feet in length. Photo 1 and 2 show some of the existing inlets located near the intersections of Rhea Road and Cunningham Drive. In addition, there is a 5 X 5 ft drop inlet on the northeast corner of Rhea Road and Southwest Parkway that drains to McGrath Creek. McGrath Creek is a concrete lined channel that flows from west to east along Southwest Parkway.

Photo 1 - Existing inlet located on Rhea Road

Problem Description

The Rhea Road drainage area was designed to convey runoff primarily by street flow to McGrath Creek. Due to the lack of drainage infrastructure in the area, many structures along Rhea Road are subject to significant flooding. Ben Milam Elementary School at 2960 Stearns Avenue on grade with Rhea Road and is known to flood in more frequent storm events.

In addition, previous studies have determined that McGrath Creek has become insufficient in size to adequately contain runoff from a 100-year storm. Based on City records, it appears that TxDOT has plans to improve the channel, but not in the near future. Even though McGrath Creek is undersized, this area is still negatively impacted by the lack of a sufficient storm drain system.

Photo 2 - Existing inlet on Rhea Road

Existing Conditions Analysis

FNI performed and existing conditions analysis of the Rhea Road drainage area and the natural drainage swale to determine the extents of flooding in the area. EPA SWMM 5.0 was used for the hydrologic and hydraulic analyses of this area.

Hydrology

The analysis of existing conditions was performed by dividing the 132 drainage basin into seventeen (17) subcatchments ranging in size from 5.28 to 11.92 acres. The majority of these subcatchments contain medium density residential development. The percentage of impervious area used for these catchments was 50 percent. Runoff from this drainage area generally flows from northwest to southeast, collecting onto Rhea Road and then traveling south towards McGrath Creek. Before runoff reaches McGrath Creek, some flow is captured by the existing storm drain system that begins near the intersection of Cunningham and Rhea Road. The remainder of flow either enters McGrath Creek through the 5'X5' drop inlet on Southwest Parkway, or ponds and eventually spills over into the creek.

Hydraulics

The hydraulic model is composed of 25 junction nodes, 25 conduit links and one (1) outfall. Street flow was modeled with irregular conduits reflecting the geometry of the street. The five inlets at the downstream end of Rhea were represented using transverse weirs connecting street junctions to pipe junctions. The geometry of the pipe system was taken from storm sewer plans provided by the City of Wichita Falls. A submerged orifice was used to represent the drop inlet at the northeast corner of Rhea Road and Southwest Parkway. Outfall into McGrath Creek was modeled by an outlet node just downstream of the Rhea Road crossing. A fixed stage was given to the outfall to account for tailwater in McGrath Creek using tailwaters for each storm that were determined using the effective hydraulic model provided by the City. Table 1 shows the tailwater in the channel for each storm event.

Table 1- McGrath Creek outlet tailwaters

Storm Event	Tailwater Elevation (ft)
	Outlet 1
2-yr	968.20
5-yr	968.50
10-yr	969.49
25-yr	971.12
50-yr	972.75
100-yr	973.50

Existing Conditions Results

An evaluation of existing conditions was performed to determine ROW flooding and structure inundation. Based on the existing conditions analysis and the node depths in Table 3 there are 26 structures that have the potential to be flooding during the 100-year storm event for the Rhea Road project area. Approximately 5,200 LF of right-of-way are exceeded 100-year storm event. Exhibit 1 shows the geographic location of the possible flooded structures as well as the extents of exceeded right-of-way.

Flood occurrences for the 100-year storm event throughout this study area can be attributed to a lack of subsurface relief as well as an undersized existing storm drain system. In addition, the Federal Emergency Management Agency (FEMA) study of McGrath Creek shows that the channel cannot sufficiently contain runoff from a 100-year storm event.

Proposed Improvements

After the existing conditions study of the Rhea project area was completed, FNI presented the results to the City along with proposed alternatives for discussion. It was recommended that the proposed solution would be a new storm drain system along Rhea that has capacity to eliminate structure flooding for the 100-year storm event.

The upstream end proposed storm drain system for the Rhea project area begins at the intersection of Rhea Road and Abbott Avenue, just to the west of the Ben Milam Elementary School at 2960 Stearns Avenue. The storm drain reaches 1,825 LF downstream where it outfalls at McGrath Creek, just downstream of the Rhea Road crossing. Because this outfall must maintain a minimum elevation of 967.71 feet, the proposed pipe is subject to limitations on the amount and slope and cover that are available. Therefore, as the amount of flow in the system increases, the number of barrels also must increase to provide adequate capacity. The proposed pipe begins on Rhea Road about 275 LF north of Abbott Avenue with 1- 6' X 3' RCB and four (4) 15-foot curb inlets. The pipe then increases to 2 - 6'X3' RCBs at Abbott Avenue, then to 3 – 6'X3' RCBs at just north of McGaha Avenue until it outfalls at McGrath Creek. The proposed storm drain system includes the installation of sixteen (16) 15-foot inlets and eight (8) 10-foot inlets. The existing storm drain system at Cunningham Drive shall be removed and replaced with the proposed pipe system. The details and alignment of the proposed pipe system are shown in Exhibit 2.

Results

An analysis of the proposed improvements described above was performed to determine the amount of flooding that would be eliminated after implementation. Tables 4 and 5 provide a summary of the difference in flooding from existing to proposed conditions. The results show that the proposed storm drain system for the Rhea project area would eliminate all potential structure flooding for the area in the 100-year storm event.

An opinion of probably construction cost was developed for the proposed improvements to the Rhea study area. The estimated construction cost for the improvements described in this section is approximately $2,098,000. A detailed breakdown of the cost analysis for the Rhea Road project area is shown in Table 2. FNI suggests that the City implement the proposed solutions as described above to resolve flooding problems in the area.

AREA 38B - RHEA ROAD

OPINION OF PROBABLE CONSTRUCTION COST

PROPOSED PIPE SYSTEM

CITY OF WICHITA FALLS - DRAINAGE MASTERPLAN UPDATE

ACCOUNT NO.	ESTIMATOR	CHECKED BY		DATE	
WCH09429	BAM			April 6, 2011	
ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
General					
	Traffic Control	3.0	MO	$7,500.00	$22,500.00
	Site Preparation	0.5	AC	$25,000.00	$12,500.00
	Erosion Control and SWPP Implementation	1.0	LS	$10,000.00	$10,000.00
			General Item Subtotal		**$45,000.00**
Storm Drain					
	Trench Safety	1,825.0	LF	$2.00	$3,650.00
	Unclassified Trench Excavation and Haul Off	3,000.0	CY	$6.00	$18,000.00
	Remove Existing 27" RCP	60.0	LF	$11.00	$660.00
	Remove Existing 6'X 3' RCB	180.0	LF	$25.00	$4,500.00
	Remove and Dispose of Existing Inlets and Laterals	1.0	LS	$15,000.00	$15,000.00
	Install 6'x3' RCB	4,325.0	LF	$170.00	$735,250.00
	Install 18" RCP Lateral	240.0	LF	$35.00	$8,400.00
	Install Manhole	3.0	EA	$3,000.00	$9,000.00
	Install Junction Box	2.0	EA	$20,000.00	$40,000.00
	Install 10' Curb Inlet	8.0	EA	$3,500.00	$28,000.00
	Install 15' Curb Inlet	16.0	EA	$4,000.00	$64,000.00
	Install Headwall at McGrath Creek	1.0	EA	$20,000.00	$20,000.00
			Storm Drain Subtotal		**$946,460.00**
Utility Adjustments					
	Remove and Replace 8" PVC Water Line	1,925.0	LF	$48.00	$92,400.00
	Trench Safety for Water Line	1,925.0	LF	$1.00	$1,925.00
	Connections to Existing Water Line	2.0	EA	$1,000.00	$2,000.00
			Utility Adj Subtotal		**$96,325.00**
Paving					
	Asphalt Pavement Saw, Remove and Dispose	6,000.0	SY	$6.00	$36,000.00
	6" Stabilized Subgrade Install	6,000.0	SY	$2.50	$15,000.00
	6" Asphalt Pavement	6,000.0	SY	$33.00	$198,000.00
	Concrete Curb remove and replace	3,650.0	LF	$4.00	$14,600.00
			Paving Subtotal		**$263,600.00**
		SUBTOTAL:			**$1,351,385.00**
	MOBILIZATION	5	%	$67,569.25	$67,569.25
	CONTINGENCY	30	%	$405,415.50	$405,415.50
		SUBTOTAL:			**$1,824,369.75**
	ENGINEERING FEES	15	%	$273,655.46	$273,655.46
PROJECT TOTAL					**$2,098,000.00**

NOTES: QUANTITY OF INSTALLATION OF REINFORCED CONCRETE BOX INCLUDES LENGTHS FOR MULTIPLE BARRELS

Table 3 - EPA SWMM node depth output

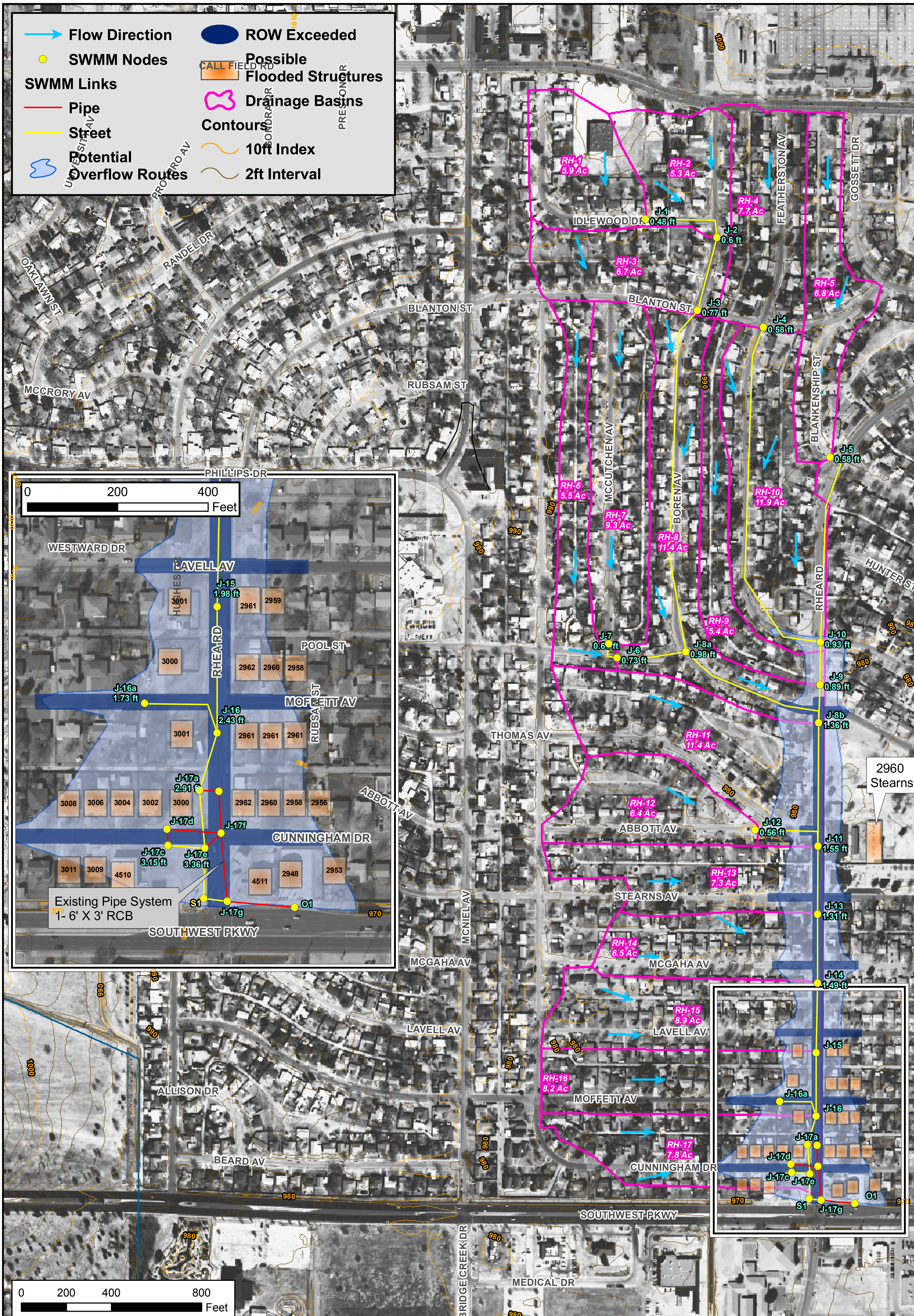
Node	Type	Maximum WSEL (feet)					
		2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
J-1	JUNCTION	999.32	999.37	999.39	999.43	999.46	999.48
J-2	JUNCTION	996.38	996.44	996.47	996.52	996.57	996.60
J-3	JUNCTION	992.51	992.59	992.63	992.68	992.73	992.77
J-4	JUNCTION	990.88	990.94	990.97	991.01	991.05	991.08
J-5	JUNCTION	984.37	984.43	984.46	984.51	984.55	984.58
J-6	JUNCTION	984.97	985.05	985.10	985.15	985.19	985.23
J-7	JUNCTION	985.39	985.45	985.49	985.54	985.58	985.61
J-8a	JUNCTION	983.64	983.73	983.79	983.87	983.93	983.98
J-8b	JUNCTION	980.67	980.81	980.87	980.98	981.08	981.16
J-9	JUNCTION	981.10	981.18	981.22	981.29	981.35	981.39
J-10	JUNCTION	981.62	981.71	981.75	981.83	981.88	981.93
J-11	JUNCTION	978.98	979.14	979.22	979.35	979.46	979.55
J-12	JUNCTION	979.86	979.91	979.94	979.99	980.03	980.06
J-13	JUNCTION	978.03	978.16	978.23	978.34	978.43	978.51
J-14	JUNCTION	976.12	976.28	976.36	976.48	976.59	976.69
J-15	JUNCTION	975.00	975.19	975.29	975.44	975.58	975.88
J-16a	JUNCTION	974.39	974.47	974.55	974.69	974.99	975.73
J-16	JUNCTION	974.29	974.47	974.55	974.68	974.99	975.73
J-17a	JUNCTION	973.64	973.80	973.87	974.00	974.88	975.71
J-17b	JUNCTION	970.97	972.86	971.39	972.95	972.95	972.95
J-17c	JUNCTION	973.04	973.20	973.27	973.46	974.88	975.71
J-17e	JUNCTION	973.04	973.20	973.27	973.46	974.88	975.71
J-17d	JUNCTION	971.29	971.66	971.81	973.03	973.31	973.31
J-17f	JUNCTION	970.87	972.33	971.20	972.17	973.03	973.03
J-17g	JUNCTION	968.68	969.73	971.28	973.22	974.46	974.94
O1	OUTFALL	968.60	968.88	969.49	971.12	972.75	973.50
S1	STORAGE	972.56	973.01	973.24	973.58	974.89	975.71

Table 4 – Rhea inundation summary comparison

		Summary of Inundation Depth by Frequency Event (ft)					
		2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
No. structures	Existing	1	1	1	1	4	27
	Proposed	0	0	0	0	0	0
Max depth	Existing	0.03	0.16	0.23	0.34	0.43	0.51
	Proposed	0.00	0.00	0.00	0.00	0.00	0.00
Min depth	Existing	0.03	0.16	0.23	0.34	0.08	0.21
	Proposed	0.00	0.00	0.00	0.00	0.00	0.00
Average depth	Existing	0.00	0.00	0.00	0.00	0.17	0.26
	Proposed	0.00	0.00	0.00	0.00	0.00	0.00

Table 5 – Rhea Road inundation depth comparison

Address	FFE	Existing InundationDepth	Proposed InundationDepth
2948 Southwest Pkwy	975.3	**0.41**	-
4510 Rhea Rd	975.5	**0.21**	-
4511 Rhea Rd	975.5	**0.21**	-
3011 Cunningham	975.5	**0.21**	-
3009 Cunningham	975.5	**0.21**	-
3008 Cunningham	975.5	**0.21**	-
3006 Cunningham	975.5	**0.21**	-
3004 Cunningham	975.5	**0.21**	-
3002 Cunningham	975.5	**0.21**	-
3000 Cunningham	975.5	**0.21**	-
2962 Cunningham	975.5	**0.21**	-
2960 Cunningham	975.5	**0.21**	-
2958 Cunningham	975.5	**0.21**	-
2956 Cunningham	975.5	**0.21**	-
2953 Cunningham	975.3	**0.41**	-
3001 Moffett Ave	975.5	**0.23**	-
3000 Moffett Ave	975.5	**0.23**	-
2962 Moffett Ave	975.5	**0.23**	-
2961 Moffett Ave	975.5	**0.23**	-
2960 Moffett Ave	975.5	**0.23**	-
2959 Moffett Ave	975.5	**0.23**	-
2958 Moffett Ave	975.5	**0.23**	-
2957 Moffett Ave	975.5	**0.23**	-
3001 Lavell Ave	975.5	**0.38**	-
2961 Lavell Ave	975.5	**0.38**	-
2959 Lavell Ave	975.5	**0.38**	-
2960 Stearns Ave	978.0	**0.51**	-
Number of Homes Flooded		**27**	**0**



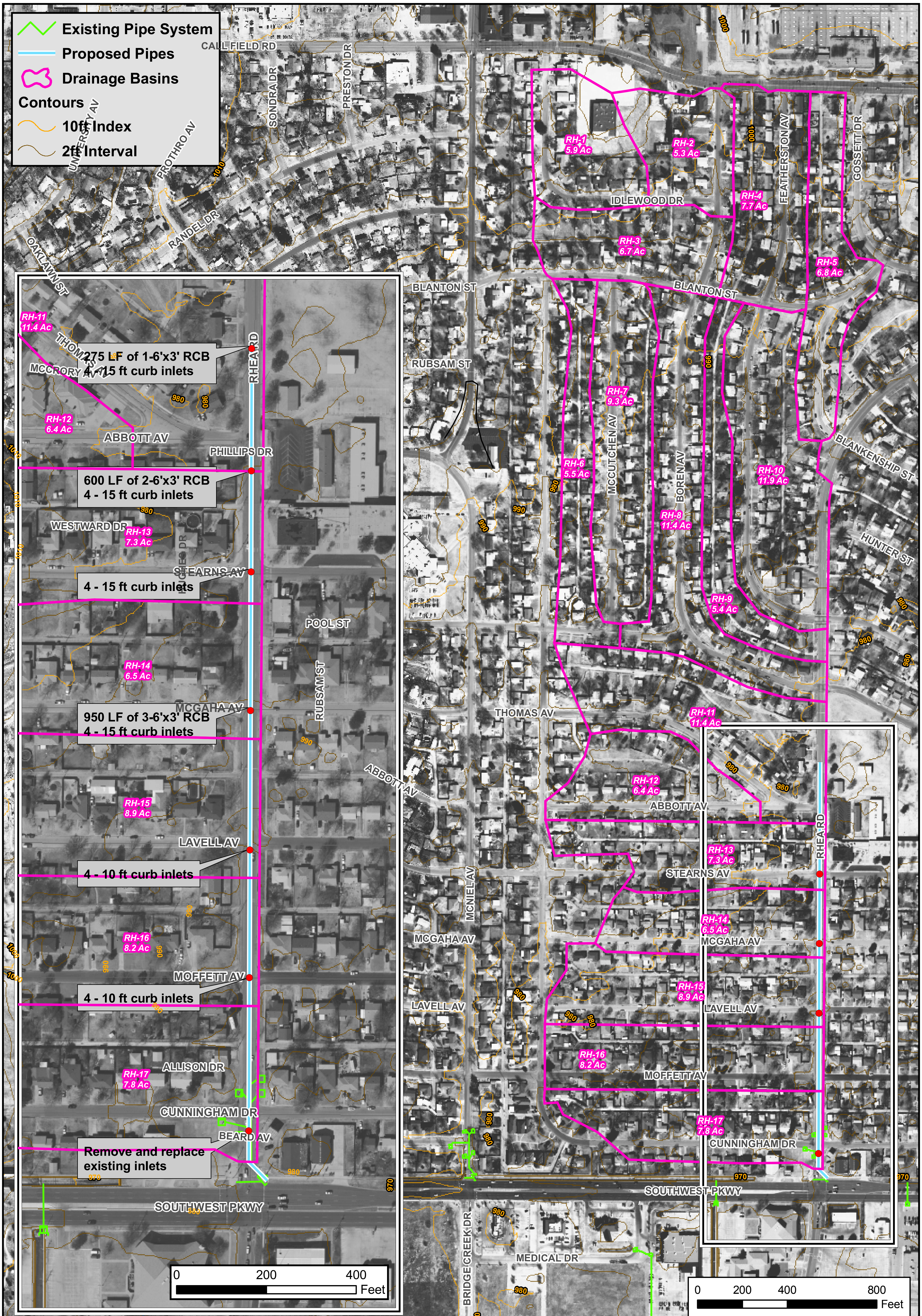
FREESE AND NICHOLS
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
P: 817-735-7300 F: 817-735-7491

AREA 38B - RHEA ROAD

EXISTING CONDITIONS: 100-YEAR RESULTS

FN JOB NO	WCH09429
FILE	H:\STORMWATER\GEODATABASE\StudyAreas
DATE	March, 2011
SCALE	1:4,800
DRAFTED	BAM

Exhibit 1



FREESE AND NICHOLS

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N W E S

AREA 38B - RHEA ROAD

PROPOSED IMPROVEMENTS

FN JOB NO	WCH09429
FILE	H:\STORMWATER\GEODATABASE\StudyAreas
DATE	March, 2011
SCALE	1:4,800
DRAFTED	BAM

Exhibit 2

Memorandum

Date:	Thursday, June 16, 2022
Project:	Canadian – Upper Red Regional Flood Plan
To:	Scott Hubley, PE, Freese and Nichols, Inc.
From:	David Dunn, PE (Texas PE No. 82630) Toby Li, EIT
Subject:	Spanish Trace Drainage Project FMP

The initial evaluation for this project was conducted in 2011 as a part of the Wichita Falls Drainage Master Plan Update by Freese and Nichols, Inc. (FNI)[1]. Excerpts from that study are included as Exhibit 1.

Multiple residents on the eastern side of Sierra Madre Drive have complained of flooding and filed a civil suit against the City claiming that drainage from Johnson Road to the north of these properties overflows the abandoned irrigation canal that runs behind these homes on the east. The homes have a finished floor elevation lower than the irrigation canal and therefore any overtopping of the canal results in flooding. At the southern end of the irrigation canal there is a headwall that intercepts flow and conveys it through a pipe system that continues east. The FNI analysis indicates that this pipe system has insufficient capacity to convey flows from the canal, causing the canal to overtop and flood eight adjacent properties with finished floor elevations below the top of bank of the canal.

Model Analysis

FNI created an EPA SWMM model composed of 43 junction nodes, 61 conduit links and 7 outfalls. The model helps determine inundated structures and exceeded right-of-way from flows at critical areas. The irregular canal and street flow were modeled with irregular conduits reflecting the geometry of the street. The storm drain outfalls into Lake Wichita Tributary with a 9'x4' RCB south of the Pyrenees Drive and Barnett Road intersection.

Summary of Improvements

FNI proposed a re-graded irrigation canal to convey additional flow north towards Johnson Road in the opposite direction from current flow, connecting to the existing storm sewer system. The renovated channel begins as a 30-foot wide, 1-foot deep triangular channel, transitioning to a 30 foot wide rectangular channel with a depth ranging from 2 to 7 feet. The new system would have the capability to remove all 8 structures from the floodplain for the 100-year storm event[2]. The following is an excerpt of the detailed proposed improvements.

[1] Wichita Falls, Texas, *Drainage Master Plan Update, Project: SPANISH TRACE DRAINAGE PROJECT,* Freese and Nichols, Inc., 2011.
[2] Note that the precipitation depths of these storm events were determined prior to the Atlas 14 update. The 100-year 24-hour storm depth has not changed significantly in Wichita Falls, TX. [NOAA Atlas 14 (weather.gov)](), figure 7.4

The proposed canal improvements will encompass the entire 1,500-foot length of the canal from the 48" RCP headwall to Johnson Road. In order to re-grade the channel to convey runoff north fill will be placed in the southern portion of the channel and the 48" RCP will be plugged.

On top of the fill a triangular channel will be constructed with 30-foot width and 1 foot depth with a concrete pilot channel. The channel will convey runoff toward Johnson Road with a slope of 0.003 ft/ft. At approximately 1,000 feet south of Johnson Road the channel will transition to a rectangular channel that will have a 30-foot bottom width and a depth ranging from 2 to 7 feet, getting deeper as it gets closer to Johnson Road. Approximately 30 feet of proposed 36" RCP will intercept the channel flow at a headwall on the south side of Johnson Road and will be connected to the existing 42" RCP of the Johnson Road storm sewer system. Exhibit 2 shows the location and features of the proposed pipe system for the Cherokee project area.

In addition to the proposed improvements described above, FNI also investigated the possibility of adding a parallel system to the existing 48" RCP or installing a new pipe at the south end of the canal to convey flow south on Catskills and then discharge into Lake Wichita Tributary. Both were determined to be not financially feasible. The first option would involve tunneling under the existing school gymnasium that sits on top of the existing pipe system alignment. Due to the large cost of tunneling, FNI determined that this option was not a feasible solution. The second option investigated the feasibility of installing a new pipe system that would convey runoff from the south end of the canal southwest along Catskills Drive and then discharge into Lake Wichita Tributary. To accomplish the proposed 1,700-foot pipe system two homes would need to be bought out, a home on the corner of Catskills Drive and Sierra Madre Drive and a home on the corner of Catskills Drive and Pyrenees Drive. Due to the cost of the home buyouts and the new pipe installation, FNI determined that this was also not a feasible solution.

Modeling Results

In the original 2011 analysis, the hydraulic modeling results from EPA SWMM 5.0 show that the proposed Spanish Trace Drainage Project would eliminate flooding for all 8 structures during the 1 percent annual chance (100-year) storm event (and all smaller events). Table 1 is from the 2011 report and summarizes results for the existing and proposed conditions.

Table 1. Spanish Trace Drainage Project FMP inundation summary comparison

		Summary of Inundation Depth by Frequency Event (ft)					
		2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
No. structures	Existing	0	8	8	8	8	8
	Proposed	0	0	0	0	0	0
Max depth	Existing	0	0.30	0.39	0.51	0.60	0.65
	Proposed	0	0	0	0	0	0
Min depth	Existing	0	0.28	0.36	0.46	0.53	0.57
	Proposed	0	0	0	0	0	0
Average depth	Existing	0	0.29	0.38	0.49	0.57	0.62
	Proposed	0	0	0	0	0	0

Benefit-Cost Analysis

TWDB requires each project included as an FMP in a regional flood plan to have a benefit/cost analysis (BCA) performed. Many flood mitigation studies document a computed benefit/cost ratio (BCR) and those can be incorporated into the regional flood plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool[3] to facilitate calculations of costs and benefits. It estimates flood damages for residential buildings before and after construction of the flood mitigation project for up to three recurrence interval flood events. Because the TWDB BCA Workbook calculates costs and benefits for only three recurrence intervals, a combination of two workbooks were used to complete calculations for six recurrence interval events (2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0[4], which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then entered back into the TWDB BCA Input Tool which then computes the resulting BCR for the project.

Project Costs

FNI estimated the total project cost to be $730,300 in the 2011 Drainage Master Plan[5]. A Construction Cost Index (CCI) factor of 1.27 was applied to convert the costs from 2011 to 2020 dollars, resulting in a project cost of $927,481. The construction was set to begin and end in 2020 to simplify the calculation of the BCR.

Flood Damages Before and After Implementation of the FMP

Based on Table 1, average depths of flooding at 8 residential structures were entered into the TWDB BCA Input Workbook for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events for both the existing and the proposed conditions.

The TWDB BCA Input Workbook includes flood damage-by-depth values for residential homes and commercial buildings in Texas. With each flood depth, there is a corresponding flood damage associated with the type of structure. The workbook sums damages for all structures to

[3] https://www.twdb.texas.gov/flood/planning/planningdocu/2023/doc/BCA%20Workbook.zip
[4] https://www.fema.gov/grants/guidance-tools/benefit-cost-analysis
[5] *Drainage Master Plan Update Project: SPANISH TRACE*, page 7

provide a comparison of damages before and after implementation of the FMP for each flood event. The damages were then entered into the FEMA BCA Toolkit 6.0. By calculating the annualized difference between the baseline and project damages for various return periods, The FEMA BCA Tool produces the total annualized benefits of the project's lifetime.

The total cost was entered into the TWDB BCA Input Workbook with estimated annual operation and maintenance costs of 1% of the construction costs for the assumed 30-year lifetime of the project. The tool then was used to compute total costs for the project over the 30-year assumed lifespan. The total annualized benefits as determined by the FEMA BCA Toolkit 6.0 were also entered. The data are summarized in Figure 2, which is a screen capture of the Results tab from the TWDB BCA Input Tool.

Note that the green shaded value of $1,237,219 represents the sum of the estimated total benefits computed over the 30-year useful life at a discount rate of 7 percent, per FEMA standards. **The final BCR computed by the TWDB BCA Input Tool for the Spanish Trace Drainage Project FMP is 1.2**, using the damages and benefits referenced to the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events. Even though there are only 8 residential structures removed from flooding by the FMP, the relatively low cost of the project has helped keep the BCR greater than 1.0.

Input Into BCA Toolkit		
Project Useful Life	**30**	
Event Damages	**Baseline**	**Project**
25 - year storm	**$523,638**	**$0**
50 - year storm	**$542,951**	**$0**
100 - year storm	**$555,027**	**$0**
Total Benefits from BCA Toolkit	$1,237,219	
Other Benefits (Not Recreation)	$0	
Recreation Benefits	-	
Total Costs	$1,042,572	
Net Benefits	$194,647	
Net Benefits with Recreation	$194,647	
Final BCR	**1.2**	
Final BCR with Recreation	**1.2**	

Figure 2. BCA Workbook Results – Spanish Trace Drainage Project FMP

No Negative Impact Analysis

No Negative Impact of Flood Risk

An FMP must have no negative impacts on its neighboring area due to its implementation. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 1 percent annual chance (100-year) event water surface elevation and peak discharge, using the best available data. It is recommended that no rise in water surface elevation or discharge should be permissible, and that the analysis extent must be vast enough to prove proposed project conditions are equal to or less than the existing conditions.

For the purposes of regional flood planning efforts, a determination of no negative impact can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial buildings and structures. Additionally, all of the following requirements, per TWDB Technical Guidelines, should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 ft) measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

For the Spanish Trace Drainage Improvements FMP, the EPA SWMM 5.0 model developed by FNI was used to assess and develop the project. Since no 2D model is available, only requirements #1, #2, #3, and #5 apply. However, computed depths at all nodes in the SWMM model decrease from existing to proposed conditions (with one exception explained below), meeting the intent of criteria #4.

In Table 1, the existing conditions were compared to conditions with the proposed improvements. In addition, in the Drainage Master Plan, flood depths at all 8 structures during a 100-year flood are compared for existing and proposed conditions.[6] The comparison shows that the project does not increase flooding at any location, meeting criteria #1. In the existing conditions, 8 structures are flooded by overflows. However, in the proposed conditions, overtopping depths decrease at all structures, and this meets criteria #2. Although the original

[6] *Drainage Master Plan Update Project: SPANISH TRACE*, Table 4.

report notes there is an increase of 0.46 ft at one node at the upstream end of Barnett Road[7], there are no homes in that area, and the effects are dissipated before the Barnett Road and Johnson Road intersection. Therefore, criteria #2 and #3 are still met.

A comparison of flows at the outlet between the existing and proposed conditions in the SWMM model shows that the peak discharge at the system outlet would increase from 1106 cfs to 1138 cfs during a 100-year flood, which is an increase of 2.9 percent. While this is an increase greater than the 0.5 percent allowed under criteria #5, during final design of the project a full hydrologic and hydraulic study would be completed with the possibility of including some detention in the project to decrease peak discharges. The final project would be designed and constructed to conform to the City's drainage/floodplain management criteria and flood planning requirements. Therefore, no negative impacts are anticipated and criteria #5 is met.

No Environmental Impacts

TWDB requires that environmental impacts be assessed for all eligible FMPs. Environmental impact categories include

a. water quality;
b. cultural heritage;
c. habitat, biodiversity and ecology;
d. air quality;
e. natural resources; and
f. agricultural resources/properties.[8]

With the nature of the urban drainage improvement project, none of the above is applicable for the Spanish Trace Drainage Improvements FMP.

Populating the RFPG required Tables 13 and 16

TWDB requires that Tables 13[9] and 16[10] to be populated along with the submission of the report and geodatabase. The required attributes are populated as follows. First, basic project information (name, description, etc.) are extracted from the 2011 FNI study[11]. Second, the project extents are drawn into GIS, and after doing so, spatial attributes are obtained by overlapping spatial layers (HUC12s, watersheds, etc.). Third, floodplain inundation information is extracted from the modeling results of the 2011 study (area in 100-yr floodplain, number of structures at 100-yr flood risk, etc.) for both pre-project and post-project conditions. Finally, benefit-and-cost related attributes are derived from the BCA performed in this study (cost, benefit-cost ratio, etc.).

Table 2 is a summary of key information in Tables 13 and 16 for the Spanish Trace Drainage Project. The estimated number of structures at 100-year risk equals the number of structures in

[7] *Drainage Master Plan Update Project: SPANISH TRACE*, Page 4
[8] Exhibit C Technical Guidelines for Regional Flood Planning, page 127.
[9] Exhibit C Technical Guidelines for Regional Flood Planning, page 63.
[10] Exhibit C Technical Guidelines for Regional Flood Planning, page 75.
[11] Wichita Falls, Texas, *Drainage Master Plan Update, Project: SPANISH TRACE DRAINAGE PROJECT,* Freese and Nichols, Inc., 2011.

the 100-year floodplain. Population is estimated based on three persons per structure. The estimated length of roads at 100-year flood risk is measured from the length of roads inundated within the 100-year floodplain. The post-project level-of-service is determined by the recurrence interval of the flood event in which no structures would be flooded. Finally, the cost/structure removed equals the total cost divided by the total number of structures.

Table 2. Project highlights from Tables 13 and 16

FMP Name	Spanish Trace Drainage Project
Associated Goals	2001, 2002
Watershed Name	Holliday Creek
Project Area (sq mi)	0.0461
Area in 100-yr (1% annual chance) Floodplain (sq mi)	0.0040
Estimated number of structures at 100yr flood risk	8
Estimated Population at 100-year flood risk	24
Estimated length of roads at 100-year flood risk (miles)	0.00
Number of Structures removed from 100-yr (1% annual chance) flood risk	8
Pre-Project Level-of-Service	Unknown
Post-Project Level-of-Service	1% annual
Cost/Structure removed	$130,322
Social Vulnerability Index (SVI)	0.508
Benefit-Cost Ratio	1.2

Exhibit 1: Excerpts from Wichita Falls Drainage Master Plan, Project: Spanish Trace

Project Information

Project ID:	Area_58	**Status:**	Studied
Project Name:	SPANISH TRACE DRAINAGE PROJECT	**Council District:**	3
Project Type:	Pipe System	**Panel #:**	89B, 89D, 88A
Date Identified:	1994	**# Structures Impacted:**	10

Problem Description:

Multiple residents on the eastern side of Sierra Madre Drive have complained of flooding and filed a civil suit against the City claiming that drainage from Johnson Road to the north of these properties overflows the irrigation ditch that runs behind these homes on the east. The homes have a finished floor elevation lower than the irrigation ditch and therefore any overtopping of the canal results in flooding. At the southern end of the irrigation ditch there is a headwall that intercepts flow and conveys it through a pipe system that continues east. This project was studied in 2011 FNI Master Plan Update.

Proposed Improvements:

Although this project is partially complete with the addition of a drainage system along Johnson Road, the proposed improvements to this area call for the irrigation canal to be re-graded to convey flow north towards Johnson Road, connecting to the existing torm sewer system. The 48" RCP at the southern end of the canal will be plugged and fill will be placed in the canal so that it flows to the north. The renovated channel begins as a 30 foot wide, 1 foot deep triangular channel, transitioning to a 30 foot wide rectangular channel with a depth ranging from 2 to 7 feet. These proposed

CIP Ranking Criteria

Weight		Score
11.83	**Life Safety/Road Flooding:**	0
8.84	**Property Damage:**	2
8.66	**Frequency of Flooding:**	4
5.34	**Project Cost:**	3
5.33	**Maintenance Cost/Work Orders:**	3
	Total Weighted Point Score:	84.3
	CIP Rank:	21

Project Costs

Conceptual Cost Range:	$500,000 to $1,000,000
Est. Construction Cost:	$730,300.00

Project Photos

Looking northwest along the irrigation canal east of Sierra Madre Dr.

Looking east at the inlet headwall on the south end of the irrigation ditch.

SPANISH TRACE

Background

The Spanish Trace project area is located south of Johnson Road and west of Cypress Avenue. The project area is comprised of single family residential development. Runoff in the area is conveyed through surface drainage, storm sewer systems and an abandoned irrigation canal. The abandoned irrigation canal is located behind the homes on Sierra Madre Drive and Spanish Trace. Runoff in the canal south of Johnson Road is conveyed to the south where it is intercepted by a 48” RCP. The irrigation canal north of Johnson Road used to be conveyed south across Johnson Road through a 48” RCP culvert but was plugged on the south end and redirected to an extended storm sewer system constructed on Johnson Road based on as-built plans from Corlett, Probst and Boyd, LLP dated February 2004. The Johnson Road storm sewer system conveys runoff west on Johnson Road and then south on Barnett Road until it discharges into Lake Wichita Tributary.

Problem Description

Flooding complaints were received from residents on the west side of the irrigation canal on Sierra Madre between 1996 and 2000. Houses on the west side of the irrigation canal have a finished floor elevation below the top bank of the canal which makes them susceptible to flooding in the event that the canal is overtopped. Photo 1 is looking north from the south end of the irrigation canal.

Photo 1 - Looking north at the irrigation canal.

Existing Conditions Analysis

FNI performed an analysis of the irrigation canal capacity, the 48" RCP discharge pipe, and flumes in the area. EPA SWMM 5.0 was used for the hydrologic and hydraulic analyses of this area.

Hydrology

The drainage areas that discharge into the canal and Lake Wichita Tributary are approximately 21.6 acres and 189.2 acres, respectively, and both consist of medium residential development. The drainage area is bordered on the north by Johnson Road and on the east and west by Sierra Madre Drive and Cypress Avenue. For the hydrologic study, the canal drainage area was broken up into six (6) subcatchments ranging in size from 1.84 to 5.44 acres. The Johnson Road pipe drainage area was broken up into fifteen (15) subcatchments ranging in size from 1.17 to 58.1 acres Curve numbers for each sub basin were calculated based on soil type and future land use provided by the City.

Runoff from the canal area drains towards the canal by surface runoff or through flumes located at the west ends of the Capistrano Court and Court de Casitas cul-de-sacs. Flow is then directed south to 48" RCP and conveyed north east for approximately 3,070 feet and under a school gymnasium before outfalling into an open channel north of Johnson Road and west of Fairway Boulevard. A small portion of runoff is conveyed in the alley north of Catskills Drive and discharges through a flume between 5112 and 5110 Catskills Drive onto Catskills Drive where it is then conveyed through curb and gutter.

The trapezoidal irrigation canal has approximately a 10 foot bottom width with a maximum depth of 4 feet and 1:1 side slopes. The canal is approximately 1,500 feet in length. The capacity of the canal is 167 cfs. The capacity of the intercepting 48"RCP at the south end of the canal is 38 cfs and the 100-year flow is 119 cfs, which means the pipe is insufficient and causes a high headwater that floods the houses on Sierra Madre Drive. The concrete flume between the 5112 and 5110 Catskills Drive is rectangular and approximately 2 feet wide and 1 foot deep. The flume is approximately 140 feet in length and has a capacity of 17 cfs and the 100-year flow is 17.81 cfs, which means the flume is adequately sized.

Runoff from the Johnson Road storm drain area drains towards Johnson Road or Barnett Road and is intercepted in curb inlets and conveyed south through a storm drain system. The storm drain outfalls into Lake Wichita Tributary with a 9'x4' RCB south of the Pyrenees Drive and Barnett Road intersection. The storm drain system has a capacity of approximately the 5-year storm event with depths in the road reaching approximately 1.6 inches during the 100-year storm event.

Hydraulics

Along with the hydrologic model, FNI also constructed a hydraulic model using SWMM for the Spanish Trace study area. The system was modeled to determine the depths of flow at critical areas in order to identify locations of inundated structures as well as exceeded right-of-way. A hydraulic model made up of 43 junctions, 61 links, and 7 outfalls was developed to represent storm water runoff through this area. The irrigation canal and roadway drainage were modeled as irregular channels with appropriate Manning's n-values to show the geometry of the feature and any overbank flow that might occur. Data for the existing pipe system located on Johnson Road and Barnett Road was taken from as builts and storm drain CAD files acquired from the City of Wichita Falls.

Existing Conditions Results

Existing analysis shows that south end of the canal has a maximum depth of 4.38 feet for the 100-year storm event and starts spilling over to the west at a depth of 4 feet. Weirs were modeled from the irrigation canal to account for any spillover onto the properties west of the canal. The weirs show approximately 90 cfs will spillover starting approximately 385 feet north of the 48" RCP headwall. Properties to the west of the canal are below the top banks of the canal it is possible that these flows could cause flooding.

Based on the existing analysis and the node depths in Table 2 there are eight (8) structures that have the potential to be flooded during the 100-year storm event for the Spanish Trace project area. Table 3 shows the properties flooding during the 100-year storm event and that are shown on Exhibit 1. All flooded structures are located on Sierra Madre Drive, west of the irrigation canal. A summary of flooded structures by storm event is shown in Table 4. Finished floors were estimated at 0.5 feet above the lowest adjacent grade based on site visit observation and two-foot topography.

Proposed Improvements

After the existing conditions study of the Spanish Trace project area was completed, FNI presented the results to the City along with proposed alternatives for discussion. It was recommended that the proposed solution would be to re-grade the irrigation canal to convey flow north towards Johnson Road and connect to the existing storm sewer system to eliminate structure flooding for the 100-year storm event.

Proposed Canal Improvements

The proposed canal improvements will encompass the entire 1,500 foot length of the canal from the 48" RCP headwall to Johnson Road. In order to re-grade the channel to convey runoff north fill will be placed in the southern portion of the channel and the 48" RCP will be plugged.

On top of the fill a triangular channel will be constructed with 30 foot width and 1 foot depth with a concrete pilot channel. The channel will convey runoff toward Johnson Road with a slope of 0.003 ft/ft. At approximately 1,000 feet south of Johnson Road the channel will transition to a rectangular channel that will have a 30 foot bottom width and a depth ranging from 2 to 7 feet, getting deeper as it gets closer to Johnson Road. Approximately 30 feet of proposed 36" RCP will intercept the channel flow at a headwall on the south side of Johnson Road and will be connected to the existing 42" RCP of the Johnson Road storm sewer system. Exhibit 2 shows the location and features of the proposed pipe system for the Cherokee project area.

In addition to the proposed improvements described above, FNI also investigated the possibility of adding a parallel system to the existing 48" RCP or installing a new pipe at the south end of the canal to convey flow south on Catskills and then discharge into Lake Wichita Tributary. Both were determined to be not financially feasible. The first option would involve tunneling under the existing school gymnasium that sits on top of the existing pipe system alignment. Due to the large cost of tunneling, FNI determined that this option was not a feasible solution. The second option investigated the feasibility of installing a new pipe system that would convey runoff from the south end of the canal southwest along Catskills Drive and then discharge into Lake Wichita Tributary. To accomplish the proposed 1,700 foot pipe system two homes would need to be bought out, a home on the corner of Catskills Drive and Sierra Madre Drive and a home on the corner of Catskills Drive and Pyrenees Drive. Due to the cost of the home buy-outs and the new pipe installation, FNI determined that this was also not a feasible solution.

Results

An analysis of the proposed improvements described above was performed to determine the amount of flooding that would be eliminated after implementation. Tables 3 and 4 provide a summary of the difference in flooding from existing to proposed conditions. The results show that the proposed canal improvements for the Spanish Trace project area would eliminate all potential structure flooding for the area in the 100-year storm event.

Since flow is being added to the Johnson Road storm sewer system a comparison was performed on node and street depths for the system between existing and proposed conditions. One node registered an increase in depth of 0.46 feet at the upstream end of Barnett Road. The proposed depth in the street at this location is increased to 1.56 feet. There are no homes in the area that would experience flooding from this increase and the effects are dissipated before the Barnett Road and Johnson Road intersection.

An opinion of probable construction cost was developed for the proposed improvements to the Spanish Trace study area. The estimated construction cost for the improvements described in this section is approximately $730,300. A detailed breakdown of the cost analysis for the

Spanish Trace project area is shown in Table 1. FNI suggests that the City implement the proposed solutions as described above to resolve flooding problems in the area.

AREA 58 - SPANISH TRACE

OPINION OF PROBABLE CONSTRUCTION COST

PROPOSED CHANNEL REGRADE AND PIPE

CITY OF WICHITA FALLS - DRAINAGE MASTERPLAN UPDATE

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
WCH09429	BAM		April 6, 2011

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
General					
	Traffic Control	3.0	MO	$5,000.00	$15,000.00
	Site Preparation	0.5	AC	$25,000.00	$12,500.00
	Erosion Control and SWPPP Implementation	1.0	LS	$5,000.00	$5,000.00
			General Item Subtotal		**$32,500.00**
Storm Drain					
	Trench Safety	30.0	LF	$2.00	$60.00
	Install 36" RCP	30.0	LF	$68.00	$2,040.00
	Pressure Grouting	1,430.0	CY	$150.00	$214,500.00
			Storm Drain Subtotal		**$216,600.00**
Utility Adjustments					
	Remove and Replace 8" PVC Sewer Line	1,500.0	LF	$48.00	$72,000.00
	Trench Safety for Sewer Line	1,500.0	LF	$1.00	$1,500.00
	Connections to Existing Sewer Line	2.0	EA	$1,000.00	$2,000.00
			Utility Adj. Subtotal		**$75,500.00**
Channel Improvements					
	Unclassified Excavation (Channel)	3,333.0	CY	$15.00	$49,995.00
	6" Reinforced Concrete Lining	3,833.0	SY	$25.00	$95,825.00
			Paving Subtotal		**$145,820.00**
		SUBTOTAL:			**$470,420.00**
	MOBILIZATION	5	%	$23,521.00	$23,521.00
	CONTINGENCY	30	%	$141,126.00	$141,126.00
		SUBTOTAL:			**$635,070.00**
	ENGINEERING FEES	15	%	$95,260.50	$95,260.50
PROJECT TOTAL					**$730,300.00**

NOTES: AVERAGE HEIGHT OF 4.5 FEET ASSUMED FOR RECTANGULAR CONCRETE CHANNEL SECTION.

Table 2- Spanish Trace existing conditions maximum WSEL output by node

Node	Type	Maximum Depth (feet)					
		2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
J-B1	JUNCTION	0.64	0.74	0.79	0.87	0.95	1.02
J-B10	JUNCTION	0.56	0.85	1.01	1.25	1.45	1.61
J-B1A	JUNCTION	1.70	3.37	3.37	3.37	3.37	3.37
J-B2	JUNCTION	0.87	1.01	1.09	1.21	1.30	1.38
J-B3	JUNCTION	0.66	0.78	0.85	0.95	1.02	1.09
J-B4	JUNCTION	0.53	0.67	0.77	0.93	1.05	1.15
J-B5	JUNCTION	0.55	0.69	0.80	0.97	1.10	1.20
J-B6	JUNCTION	0.67	0.85	0.99	1.20	1.36	1.49
J-B7	JUNCTION	0.55	0.71	0.83	1.01	1.17	1.28
J-B8	JUNCTION	0.59	0.81	0.96	1.18	1.37	1.51
J-B9	JUNCTION	0.57	0.84	1.01	1.26	1.47	1.63
J-C1	JUNCTION	2.36	3.04	3.13	3.27	3.37	3.45
J-C2	JUNCTION	2.78	3.45	3.55	3.68	3.78	3.85
J-C3	JUNCTION	3.09	3.76	3.85	3.97	4.06	4.11
J-C4	JUNCTION	0.49	0.63	0.72	0.83	0.93	0.96
J-J1	JUNCTION	0.73	1.02	1.13	1.26	1.37	1.46
J-J2	JUNCTION	0.26	0.48	0.64	0.82	0.96	1.06
J-L1	JUNCTION	0.29	0.34	0.36	0.40	0.42	0.44
J-P1	JUNCTION	3.43	4.10	4.18	4.28	4.35	4.39
J-P-B1	JUNCTION	2.62	5.95	5.48	5.42	5.36	5.51
J-P-B10	JUNCTION	5.22	5.63	5.76	5.94	6.07	6.17
J-P-B11	JUNCTION	3.74	4.07	4.13	4.22	4.29	4.34
J-P-B1A	JUNCTION	6.67	6.97	7.08	7.21	7.32	7.41
J-P-B2	JUNCTION	4.54	6.07	6.20	6.37	6.44	6.53
J-P-B2A	JUNCTION	4.68	6.75	7.01	7.07	7.12	7.17
J-P-B3	JUNCTION	6.20	7.86	8.34	8.33	8.49	8.61
J-P-B3A	JUNCTION	7.41	9.88	10.06	10.25	10.39	10.51
J-P-B4	JUNCTION	6.64	8.71	9.00	9.32	9.51	9.66
J-P-B5	JUNCTION	6.86	8.71	9.00	9.32	9.51	9.65
J-P-B6	JUNCTION	6.63	8.10	8.39	8.70	8.88	9.02
J-P-B7	JUNCTION	6.26	7.61	7.81	7.99	8.17	8.31
J-P-B8	JUNCTION	6.96	8.18	8.37	8.24	8.41	8.54
J-P-B9	JUNCTION	7.14	7.54	7.71	7.94	8.11	8.24
J-P-IC1	JUNCTION	2.73	4.82	5.00	5.00	5.00	5.00
J-P-IC2	JUNCTION	2.80	4.89	5.13	5.16	5.18	5.23
J-P-IC3	JUNCTION	3.98	6.06	6.30	6.34	6.38	6.42
J-P-L1	JUNCTION	0.47	2.08	2.58	3.35	3.38	3.03
Node	**Type**	**Maximum Depth (feet)**					

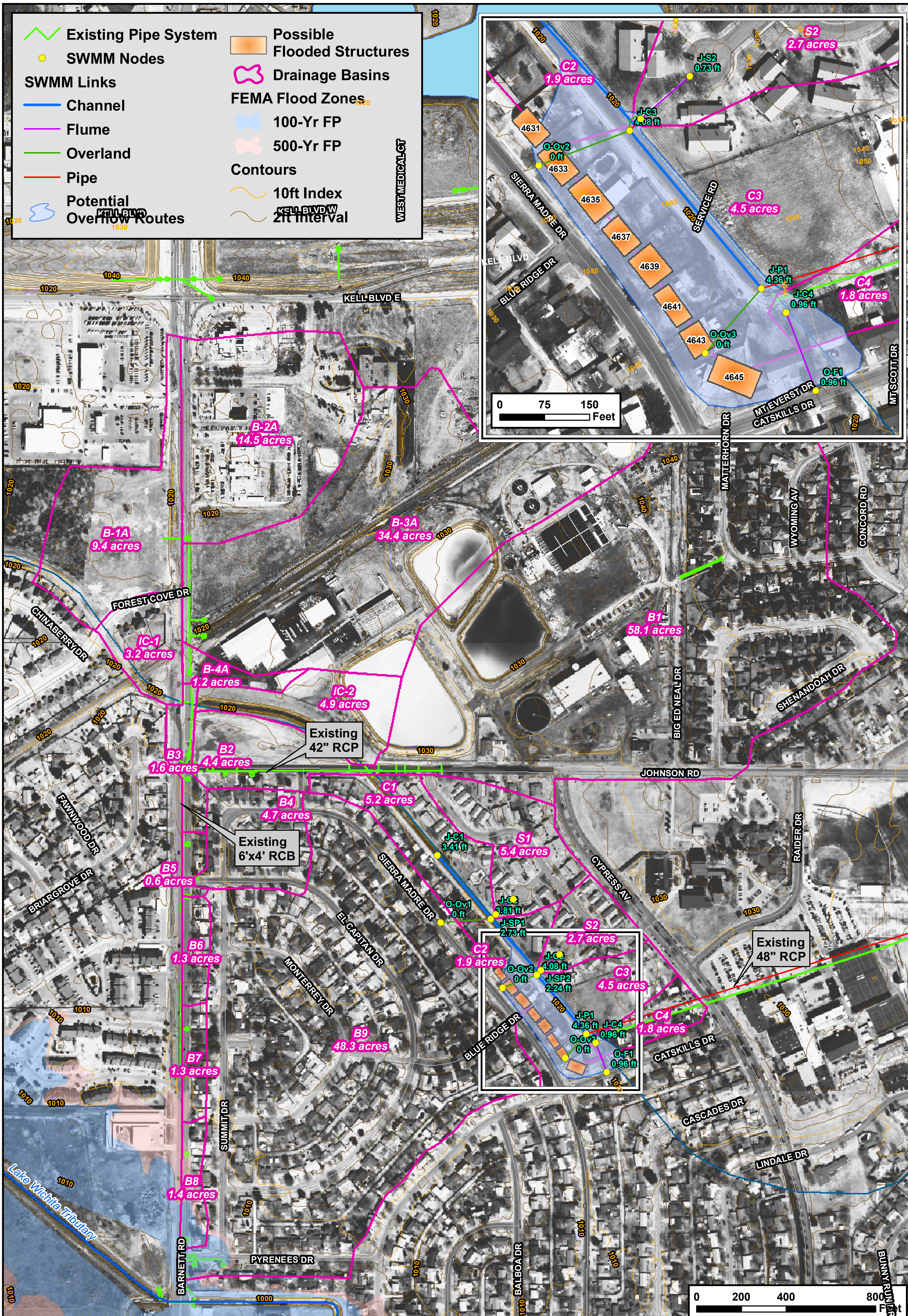
		2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
J-P-L2	JUNCTION	6.64	6.91	7.04	7.19	7.35	7.50
J-Py1	JUNCTION	0.63	0.92	1.04	1.20	1.36	1.52
J-S1	JUNCTION	0.57	0.76	1.00	1.21	1.30	1.35
J-S2	JUNCTION	0.52	0.57	0.60	0.65	0.81	0.96
J-SP1	JUNCTION	1.69	2.20	2.43	2.65	2.74	2.79
J-SP2	JUNCTION	1.29	1.62	1.82	2.12	2.33	2.49
O-1	OUTFALL	4.07	4.07	4.07	4.07	4.07	4.07
O-F1	OUTFALL	0.49	0.63	0.72	0.83	0.93	0.96
O-Ov2	OUTFALL	0.00	0.00	0.00	0.00	0.00	0.00
O-Ov1	OUTFALL	0.00	0.00	0.00	0.00	0.00	0.00
O-Ov3	OUTFALL	0.00	0.00	0.00	0.00	0.00	0.00
O-B1	OUTFALL	0.55	0.85	1.01	1.23	1.42	1.57
O-P1	OUTFALL	2.43	2.51	2.54	2.58	2.61	2.63

Table 3 – Spanish Trace inundation summary comparison

		Summary of Inundation Depth by Frequency Event (ft)					
		2 yr	**5 yr**	**10 yr**	**25 yr**	**50 yr**	**100 yr**
No. structures	**Existing**	0	8	8	8	8	8
	Proposed	0	0	0	0	0	0
Max depth	**Existing**	0	0.30	0.39	0.51	0.60	0.65
	Proposed	0	0	0	0	0	0
Min depth	**Existing**	0	0.28	0.36	0.46	0.53	0.57
	Proposed	0	0	0	0	0	0
Average depth	**Existing**	0	0.29	0.38	0.49	0.57	0.62
	Proposed	0	0	0	0	0	0

Table 4 – Spanish Trace inundation depth comparison

Address		100-yr Existing Inundation Depth	100-yr Proposed Inundation Depth
4631	SIERRA MADRE	**0.65**	
4633	SIERRA MADRE	**0.65**	
4635	SIERRA MADRE	**0.65**	
4637	SIERRA MADRE	**0.65**	
4639	SIERRA MADRE	**0.65**	
4641	SIERRA MADRE	**0.57**	
4643	SIERRA MADRE	**0.57**	
4645	SIERRA MADRE	**0.57**	
Number of Homes Flooded		**8**	**0**



FREESE AND NICHOLS
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
P: 817-735-7300 F: 817-735-7491

N W E S

AREA 58 - SPANISH TRACE

EXISTING CONDITIONS: 100-YEAR RESULTS

FN JOB NO	WCH09429
FILE	H:\STORMWATER\GEODATABASE\StudyAreas
DATE	March, 2011
SCALE	1:4,800
DRAFTED	BAM

Exhibit 1

FREESE AND NICHOLS
4055 International Plaza Suite 200
Fort Worth, Texas 76109-4895
P: 817-735-7300 F: 817-735-7491

N W E S

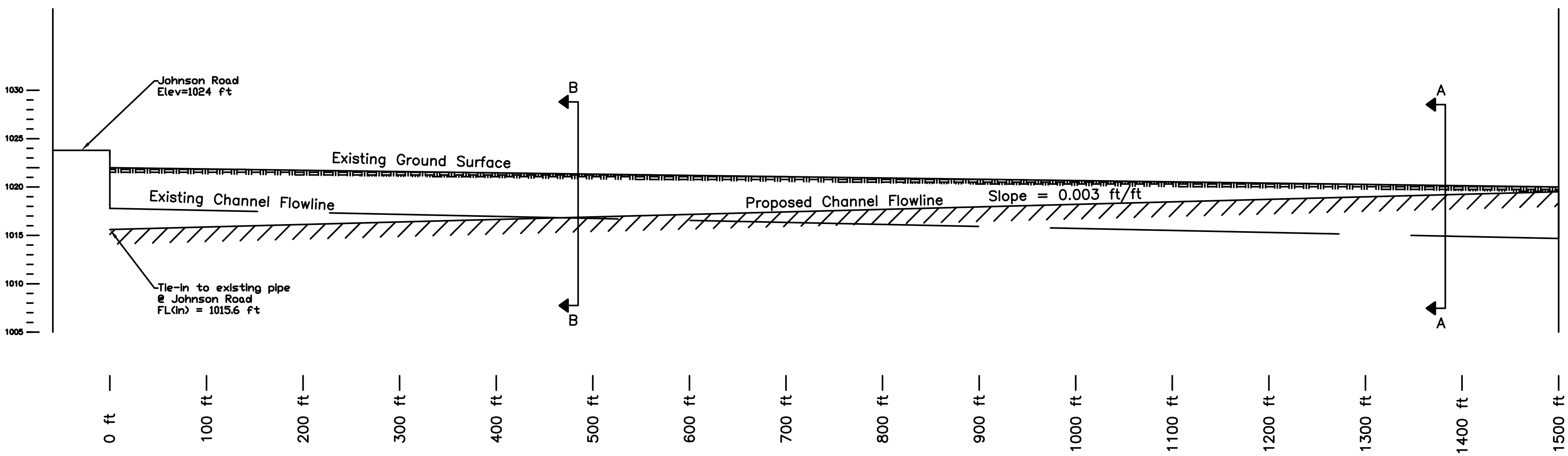
AREA 58 - SPANISH TRACE

PROPOSED IMPROVEMENTS

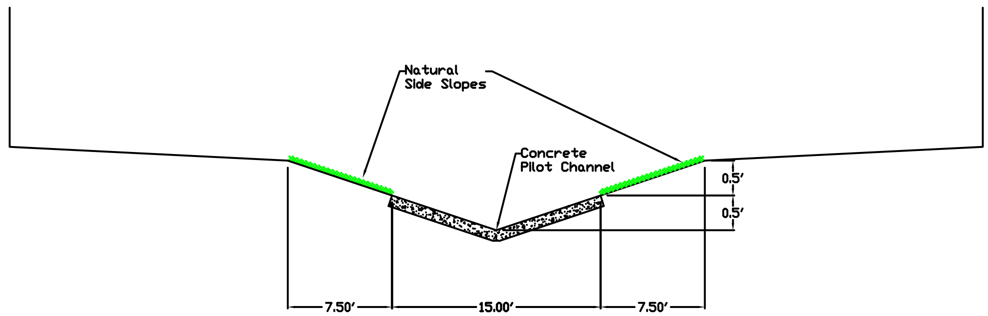
FN JOB NO	WCH09429
FILE	H:\STORMWATER\GEODATABASE\StudyAreas
DATE	March, 2011
SCALE	1:2,400
DRAFTED	BAM

Exhibit 2

Spanish Trace Channel Profile
Existing vs. Proposed

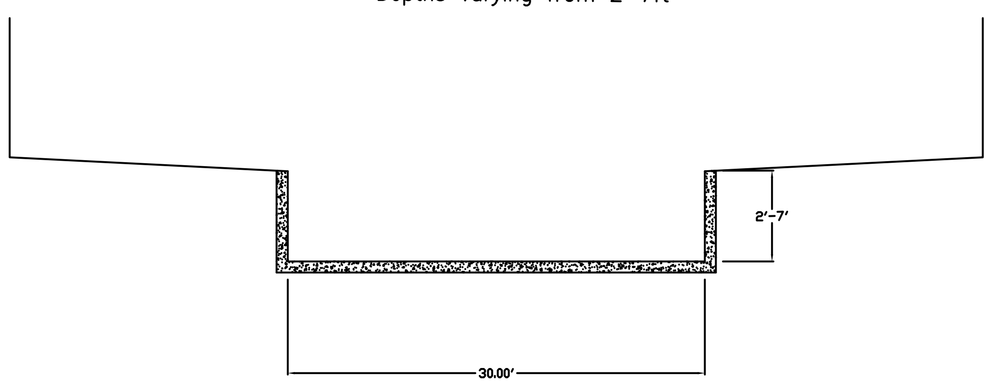


Section A–A
Pilot Channel



Section B–B

Proposed concrete–lined
rectangular channel.
Depths varying from 2–7ft



Memorandum

Date:	Thursday, June 16, 2022
Project:	Canadian – Upper Red Regional Flood Plan
To:	Scott Hubley, PE, Freese and Nichols, Inc.
From:	David Dunn, PE (Texas PE No. 82630) Toby Li, EIT
Subject:	Wichita Gardens Drainage Upgrades

The initial evaluation for this project was conducted in 2011 as a part of the Wichita Falls Drainage Master Plan Update by Freese and Nichols, Inc. (FNI)[1]. Excerpts from that study are included as Exhibit 1.

The Wichita Gardens Neighborhood is located in Wichita Falls, Wichita County, TX. The area was initially developed with limited ability to positively convey runoff to an adequate outfall. The slope of the area is flat, and even with the presence of roadside drainage ditches, the lack of grade throughout the area prevents runoff from adequately draining from the area. Most homes are single-family units built at or below the grade of the street, subject to flooding when the roadside ditches overflow.

Model Analysis

The flooding in the neighborhood originates from the network of roadside drainage ditches, so for the 2011 study FNI created an EPA SWMM hydraulic model for the study area, which consists of 23 junctions, 26 links, 3 storage nodes, and 4 outfalls. FNI applied the SWMM model to determine existing conditions, and to evaluate proposed solutions to the flooding problems.

Summary of Improvements

FNI proposed an upgraded storm drain system combined with the installation of concrete curbs and gutters throughout the entire development. The system has curb inlets and a trunk line that runs from north to south underneath N. Beverly Drive, to an outfall at the Wichita River. The proposed pipe system was designed to eliminate structure flooding from a 25-year storm event. The following is an excerpt of the detailed proposed improvements.

> *The main trunk line of this storm drain system begins at the intersection of Southwest Drive and Beverly Drive. This trunk line is an 8'X4' RCB that reaches 2,450 LF to the south down Beverly where it outfalls at the Wichita River. The system picks up flow from the west side of Beverly from a 36" RCP that reaches approximately 850 LF to the west on Southwest Drive with inlets at Ozmun Street and Skelly Drive. Runoff from the east*

[1] Wichita Falls, Texas, *Drainage Master Plan Update, Project: WICHITA GARDENS,* Freese and Nichols, Inc., 2011.

side of Beverly Drive by a 24" RCP that reaches 1125 LF to the east on Southeast Drive and north on Willow Drive with inlets at Frauline St and on Southeast Drive.

There are two low crossings on Beverly Drive between Southwest Drive and the Wichita River where curb inlets will be placed allowing runoff to drain to the proposed trunk line. In addition, the proposed system includes a 24" RCP line that reaches west on Beverly Drive and north on Wyneth Drive to Calloway Street, collecting runoff from the southwest portion of the development. The 8'X4' RCB trunk line then runs south from Beverly Drive where it outfalls at the Wichita River.

In addition to this trunk line system down Beverly, the proposed improvements also include a total of 2215 LF of 36" RCP along Northeast Drive and Southeast Drive that outfalls at the existing channel located at the northeast corner of the development.

To supplement the proposed storm drain system, all of the streets in the area will be reconstructed to have a crowned center with a six-inch curb and gutter on each side to convey runoff to the inlets throughout the system. In addition to installing the new storm drain system, many existing water and sewer lines that serve the Wichita Gardens project area will be removed and replaced.

Modeling Results

In the original 2011 analysis, model cross sections were "truncated", resulting in small cross-sectional areas and modeled water surface elevations that are greater than what would be expected. Given this model limitation, a flood-depth reduction of 6" is applied to the modeled WSEL to determine flood damages. Results show that the proposed storm drain system for the Wichita Gardens project area would eliminate flooding for all 100 structures during the 1 percent annual chance (100-year) storm event (and all smaller events). Table 1 is derived from Table 3 of the 2011 report with the 6" flood reduction applied and summarizes results for the existing and proposed conditions.

Table 1. Wichita Gardens inundation summary comparison

		Summary of Inundation Depth by Frequency Event (ft)					
		2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
No. structures	Existing	92	94	95	99	100	100
	Proposed	0	0	0	0	0	0
Max depth	Existing	0.62	0.73	0.85	1.01	1.07	1.67
	Proposed	0	0	0	0	0	0
Min depth	Existing	0	0	0	0	0	0
	Proposed	0	0	0	0	0	0
Average depth	Existing	0.15	0.27	0.81	0.87	0.91	0.96
	Proposed	0	0	0	0	0	0

Benefit-Cost Analysis

TWDB requires each project included as an FMP in a regional flood plan to have a benefit/cost analysis (BCA) performed. Many flood mitigation studies document a computed benefit/cost ratio (BCR) and those can be incorporated into the regional flood plan. For situations where a BCR is not available for a project, TWDB has developed the BCA Input Tool[2] to facilitate calculations of costs and benefits. It estimates flood damages for residential buildings before and after construction of the flood mitigation project for up to three recurrence interval flood events. Because the TWDB BCA Workbook calculates costs and benefits for only three recurrence intervals, a combination of two workbooks were used to complete calculations for six recurrence interval events (2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). The BCA Input Tool is intended to be used in conjunction with the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0[3], which calculates annual benefits from the information compiled in the TWDB BCA Input Tool. The annual benefits data are then entered back into the TWDB BCA Input Tool which then computes the resulting BCR for the project.

Project Costs

FNI estimated the total project cost to be $6,167,800 in the 2011 Drainage Master Plan[4] (see Exhibit 1, page 8). A Construction Cost Index (CCI) factor of 1.27 was applied to convert the costs from 2011 to 2020 dollars, resulting in a project cost of $7,833,106. The construction was set to begin and end in 2020 to simplify the calculation of the BCR.

Flood Damages Before and After Implementation of the FMP

Based on Table 1, average depths of flooding at 100 structures were entered into the TWDB BCA Input Workbook for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events for both the existing and the proposed conditions.

The TWDB BCA Input Workbook includes flood damage-by-depth values for residential homes and commercial buildings in Texas. With each flood depth, there is a corresponding flood damage associated with the type of structure. The workbook sums damages for all structures to provide a comparison of damages before and after implementation of the FMP for each flood event.

The total cost was entered into the TWDB BCA Input Tool with estimated annual operation and maintenance costs of 1% of the total construction cost for the assumed 30-year lifetime of the project. The tool then was used to compute total costs for the project over the 30-year assumed lifespan. The total annualized benefits as determined by the FEMA BCA Toolkit 6.0 were also entered. The data are summarized in Figure 2, which is a screen capture of the Results tab from the TWDB BCA Input Tool.

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[2] https://www.twdb.texas.gov/flood/planning/planningdocu/2023/doc/BCA%20Workbook.zip
[3] https://www.fema.gov/grants/guidance-tools/benefit-cost-analysis
[4] *Drainage Master Plan Update Project: WICHITA GARDENS*, pages 7 & 8

Note that the green shaded value of $31,522,414 represents the sum of the estimated total benefits computed over the 30-year useful life at a discount rate of 7 percent, per FEMA standards. **The final BCR computed by the TWDB BCA Input Tool for the Wichita Gardens Drainage Improvements FMP is 3.1**, using the damages and benefits referenced to the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events. This large BCR can be attributed to the large number of structures removed from flooding by the FMP.

Input Into BCA Toolkit		
Project Useful Life	**30**	
Event Damages	**Baseline**	**Project**
25 - year storm	**$5,704,834**	**$0**
50 - year storm	**$6,137,362**	**$0**
100 - year storm	**$6,545,476**	**$0**
Total Benefits from BCA Toolkit	$31,522,414	
Other Benefits (Not Recreation)	$0	
Recreation Benefits	-	
Total Costs	$10,008,177	
Net Benefits	$21,514,237	
Net Benefits with Recreation	$21,514,237	
Final BCR	**3.1**	
Final BCR with Recreation	**3.1**	

Figure 2. BCA Workbook Results

No Negative Impact Analysis

No Negative Impact of Flood Risk

An FMP must have no negative impacts on its neighboring area due to its implementation. No negative impact means that a project will not increase flood risk of surrounding properties. The increase in flood risk must be measured by the 1 percent annual chance (100-year) event water surface elevation and peak discharge, using the best available data. It is recommended that no rise in water surface elevation or discharge should be permissible, and that the analysis extent must be vast enough to prove proposed project conditions are equal to or less than the existing conditions.

For the purposes of regional flood planning efforts, a determination of no negative impact can be established if stormwater runoff does not increase inundation of infrastructure such as residential and commercial buildings and structures. Additionally, all of the following requirements, per TWDB Technical Guidelines, should be met to establish no negative impact, as applicable:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (<0.05 ft) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (<0.35 ft) measured at each computation cell.

5. Maximum increase in hydrologic peak discharge must be <0.5 percent measured at computation nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to a 2D overland analysis.

For the Wichita Gardens Drainage Improvements FMP, the EPA SWMM 5.0 model developed by FNI was used to assess and develop the project. Since 2D model is available, only requirements #1, #2, #3, and #5 apply. However, computed depths at all nodes in the SWMM model decrease from existing to proposed conditions, meeting the intent of criteria #4.

In Table 1, the existing conditions were compared to conditions with the proposed improvements. In addition, in the Drainage Master Plan, flood depths at all 100 residential structures during a 100-year flood are compared for existing and proposed conditions.[5] The comparison shows that the project does not increase flooding at any location, meeting criteria #1. In the existing conditions, 100 houses are flooded by overflows. However, in the proposed conditions, overtopping depths decrease at all houses, and this meets criteria #2. Within the project limits, there is no location where water surface elevations for the 100-year flood rises, meeting criteria #3.

A comparison of flows at the outlet between the existing and proposed conditions in the SWMM model shows that the peak discharge at the system outlet would increase by 400 cfs during a 100-year flood. The 100-year peak flow of the Wichita river is 17,500 cfs ~ 24,800 cfs[6], and therefore the increase represents 1.6%~2.3% of the peak flow. However, given the total area of the Wichita River watershed and the location of the study area within the watershed, it is unlikely that the peak discharge from the Wichita Gardens storm drain system is coincidental with the peak discharge of the Wichita River. Therefore, no negative impacts are anticipated and criteria #5 is met. During final design of the project, a full hydrologic and hydraulic study

[5] *Drainage Master Plan Update Project: WICHITA GARDENS*, Table 4.
[6] *Wichita County Flood Insurance Study*, page 15

would be completed to determine conformance with the City's drainage/floodplain management criteria and flood planning requirements.

No Environmental Impacts

TWDB requires that environmental impacts be assessed for all eligible FMPs. Environmental impact categories include

a. water quality;
b. cultural heritage;
c. habitat, biodiversity and ecology;
d. air quality;
e. natural resources; and
f. agricultural resources/properties.[7]

With the nature of the urban drainage improvement project, none of the above is applicable for the Wichita Gardens Drainage Improvements FMP.

Populating the RFPG required Tables 13 and 16

TWDB requires that Tables 13[8] and 16[9] to be populated along with the submission of the report and geodatabase. The required attributes are populated as follows. First, basic project information (name, description, etc.) are extracted from the 2011 FNI study[10]. Second, the project extents are drawn into GIS, and after doing so, spatial attributes are obtained by overlapping spatial layers (HUC12s, watersheds, etc.). Third, floodplain inundation information is extracted from the modeling results of the 2011 study (area in 100-yr floodplain, number of structures at 100-year flood risk, etc.) for both pre-project and post-project conditions. Finally, benefit-and-cost related attributes are derived from the BCA performed in this study (cost, benefit-cost ratio, etc.).

Table 2 is a summary of key information in Tables 13 and 16 for Wichita Gardens. The estimated number of structures at 100-year risk equals the number of structures in the 100-year floodplain. Population is estimated based on three persons per structure. The estimated length of roads at 100-year flood risk is measured from the length of roads inundated within the 100-year floodplain. The post-project level-of-service is determined by the recurrence interval of the flood event in which no structures would be flooded. Finally, the cost/structure removed equals the total cost divided by the total number of structures.

[7] Exhibit C Technical Guidelines for Regional Flood Planning, page 127.
[8] Exhibit C Technical Guidelines for Regional Flood Planning, page 63.
[9] Exhibit C Technical Guidelines for Regional Flood Planning, page 75.
[10] Wichita Falls, Texas, *Drainage Master Plan Update, Project: WICHITA GARDENS,* Freese and Nichols, Inc., 2011.

Table 2. Project highlights from Tables 13 and 16

FMP Name	Wichita Gardens Drainage Improvements
Associated Goals	2001, 2002
Watershed Name	Buffalo Creek-Wichita River
Project Area (sqmi)	0.2192
Area in 100-year (1% annual chance) Floodplain (sq mi)	0.0010
Area in 500-year (0.2% annual chance) Floodplain (sq mi)	0.0547
Estimated number of structures at 100-year flood risk	100
Estimated Population at 100-year flood risk	300
Estimated length of roads at 100-year flood risk (miles)	2.43
Number of Structures removed from 100-year (1% annual chance) flood risk	100
Pre-Project Level-of-Service	Unknown
Post-Project Level-of-Service	0.2% annual
Cost/Structure removed	$100,082
Social Vulnerability Index (SVI)	0.632
Benefit-Cost Ratio	3.1

Exhibit 1: Excerpts from Wichita Falls Drainage Master Plan, Project: Wichita Gardens

Drainage Master Plan Update
Project: WICHITA GARDENS

Project Information

Project ID:	Area_60	**Status:**	Studied
Project Name:	WICHITA GARDENS	**Council District:**	1
Project Type:	Pipe System	**Panel #:**	1A, 4B
Date Identified:	1994	**# Structures Impacted:**	100

Problem Description:

This area was developed with limited ability to positively convey runoff to an adequate outfall. The area is very flat and although there are ditches along most of the streets, the lack of grade throughout the area prohibits runoff from adequately draining through this ditch system. Most of the homes in this single-family development were built at or below the grade of the street, leaving them subject to flooding from overflow of the ditches. This project was studied in 2011 FNI Master Plan Update.

Proposed Improvements:

The proposed improvements call for the installation of concrete curb and gutter throughout entire development in order to install a storm drain system with curb inlets and a trunk line that runs from north to south underneath N Beverly Drive to an outfall at the Wichita River. The proposed pipe system was designed to eliminate structure flooding in a 25-year storm event.

CIP Ranking Criteria

Weight		Score
11.83	**Life Safety/Road Flooding:**	2
8.84	**Property Damage:**	5
8.66	**Frequency of Flooding:**	5
5.34	**Project Cost:**	0
5.33	**Maintenance Cost/Work Orders:**	3
	Total Weighted Point Score:	127.1
	CIP Rank:	8

Project Costs

Conceptual Cost Range:	> $3,000,000
Est. Construction Cost:	$6,167,800.00

Project Photos

Wichita Gardens typical street section with no curb and gutter and very shallow road side swales.

Homes at street level with no road drainage.

WICHITA GARDENS

Background

The Wichita Gardens project area is located just north of the Wichita River and just east of Valley View Road. The existing conditions of this project area were studied in two phases, east and west. The Wichita Gardens development is divided by Beverly Drive which runs north and south through the development. Both the east and west sides of the development have similar characteristics and drainage issues. The entire drainage area is made up of single family residential development with surface drainage as the primary source of conveying runoff. Ditches and driveway culverts are present throughout the area but in many cases the ditches are ill-defined and/or overgrown. A portion of the study area is located within the AO Zone of East Plum Creek which represents shallow flooding from one (1) to three (3) feet. In addition, there is a low area that circles through the western portion of this drainage area that is part of the 500-year floodplain of the Wichita River.

Problem Description

This area was developed with limited ability to positively convey runoff to an adequate outfall. The area is very flat and although there are ditches along most of the streets, the lack of grade throughout the area prohibits runoff from adequately draining through this ditch system. Most of the homes in this single-family development were built at or below the grade of the street, leaving them subject to flooding from overflow of the ditches. Photo 1 shows a typical of the ditch and driveway culvert in the area.

Photo 1 – A typical ditch and driveway culvert in the Wichita Gardens project area.

The ditches in the southwest portion of the drainage area drain to a culvert on Wyneth Drive between Galloway Street and Glenn Drive. This culvert falls northeast where it outfalls into a very ill-defined channel that is intended to direct flow to the low area that circles through the neighborhood. Since this channel is not well defined, the homes on either side are subject to flooding. Photo 2 shows this culvert and channel.

Photo 2 – Culvert outfall and channel on Wyneth Drive.

Existing Conditions Analysis

FNI performed an existing conditions analysis of the Wichita Gardens drainage area to determine the extents of flooding in the area. EPA SWMM 5.0 was used for the hydrologic and hydraulic analyses of this area.

Hydrology

The Wichita Gardens drainage area is a total of 193.6 acres. The existing analysis of this area was performed in two phases, with Beverly Drive dividing the drainage area in two. The eastern drainage area is a total of 73.7 acres broken up into seven (7) subcatchments while the western drainage area is divided into 19 subcatchments totaling 119.9 acres. The development is made mostly of single-family residential (1/2 acre to 1 acre lots), with a few scattered lots of undeveloped land.

Runoff on the west side of Beverly generally drains to the center towards the low area shown in Exhibit 1. Although this low area provides some storage for runoff from the area, the extremely flat terrain throughout the neighborhood limits the amount of runoff that can actually flow to this area. In addition, in order for stored runoff to exit this low area, it must flow across the fence line between Beverly Drive and Wyneth Drive to a culvert at Beverly Drive, then to an open area just east of Beverly Drive. This culvert crossing on Beverly Drive is at a low point on the road that has a very high potential to flood.

Runoff on the east side of Beverly is much like that of the west side. The drainage in the area consists of bar ditches and driveway culverts. Most of the ditches eventually flow to the northeast where there is a small channel that conveys flow out towards the Wichita River. There is also a small culvert running from east to west across Beverly Drive at Northeast Drive that conveys a small drainage area of runoff from Northeast Drive to a ditch on the west side of Beverly Drive.

Hydraulics

Along with the hydrologic model, FNI also constructed a hydraulic model using SWMM for the Wichita Gardens study area. The system was modeled to determine the depths of flow at critical areas in order to identify locations of inundated structures as well as exceeded right-of-way. An existing conditions hydraulic model made up of 23 junctions, 26 links, 3 storage nodes, and 4 outfalls was developed to represent storm water runoff through this area. Since this area was designed so that streets and ditches are the primary source of conveying storm water runoff, each street in the area was modeled as an irregular shaped link with cross sections (refer to Figure 1 in Volume 1 – Documentation and Methodology). Storage nodes were used to represent the low areas in the development where runoff is typically stored, and were given storage curves based on two-foot topography relating the depth of storage (ft) to the surface area of water (ft^2).

Existing Conditions Results

The nature of the flooding in this area would be best represented by a two-dimensional (2D) model due to the shallow flooding and flat grades throughout the study area. However, the development of a 2D model was beyond the scope of this project. EPA SWMM attempts to represent this type of shallow flooding but there is limited accuracy with this approach. Very wide cross sections have numerical instability problems within the model so they are typically truncated at the front of the house for each street cross section. Because the cross sections must be truncated and the flow is not allowed to spread out in the model (like it physically does in this area), the flow depths tend to be overestimated compared to a 2D model. Consequently, even though most of the homes are constructed either at grade or with a minimal slab, the actual number of homes could be overestimated from realistic physical flooding conditions. The existing conditions results of the one-dimensional model are described in the following text.

Analysis of existing conditions shows that 100 homes have the potential to flood in the 100-year storm. However, this analysis also shows that 92 homes are at risk of flooding in just the 2-year storm event. Tables 3 and 4 provide detailed data on the structure flooding in the area. It is apparent that due to the lack of drainage infrastructure and the extremely flat grades in this development, rainfall accumulates throughout the neighborhood without any means of being conveyed to an outfall. Therefore, streets and homes throughout the development are subject to flooding in minor storm events. Exhibit 1 shows the homes that FNI determined to be at risk of flooding as well as the extents of ROW flooding during the 100-year storm event.

Proposed Improvements

After the existing conditions study of the Wichita Gardens project area was completed, FNI presented the results to the City along with proposed alternatives for discussion. It was recommended that the proposed solution would be to install a storm drain system throughout the area and construct curb and gutter on all streets throughout the neighborhood, including Beverly Street.

Proposed Storm Drain System

The proposed storm drain system for the Wichita Gardens project area has several lines that run through both the east and west portions of the development. The purpose of this system is to remove runoff from the streets and ditches where it currently causes flooding and provide an efficient method to convey the runoff to a main outfall at the Wichita River.

The main trunk line of this storm drain system begins at the intersection of Southwest Drive and Beverly Drive. This trunk line is an 8'X4' RCB that reaches 2,450 LF to the south down Beverly where it outfalls at the Wichita River. The system picks up flow from the west side of Beverly from a 36" RCP that reaches approximately 850 LF to the west on Southwest Drive with inlets at Ozmun Street and Skelly Drive. Runoff from the east side of Beverly Drive by a 24" RCP that reaches 1125 LF to the east on Southeast Drive and north on Willow Drive with inlets at Frauline St and on Southeast Drive.

There are two low crossings on Beverly Drive between Southwest Drive and the Wichita River where curb inlets will be placed allowing runoff to drain to the proposed trunk line. In addition, the proposed system includes a 24" RCP line that reaches west on Beverly Drive and north on Wyneth Drive to Calloway Street, collecting runoff from the southwest portion of the development. The 8'X4' RCB trunk line then runs south from Beverly Drive where it outfalls at the Wichita River.

In addition to this trunk line system down Beverly, the proposed improvements also include a total of 2215 LF of 36” RCP along Northeast Drive and Southeast Drive that outfalls at the existing channel located at the northeast corner of the development.

To supplement the proposed storm drain system, all of the streets in the area will be reconstructed to have a crowned center with a six-inch curb and gutter on each side to convey runoff to the inlets throughout the system. In addition to installing the new storm drain system, many existing water and sewer lines that serve the Wichita Gardens project area will be removed and replaced.

Results

An analysis of the proposed improvements described above was performed to determine the amount of flooding that would be eliminated after implementation. The results show that the proposed storm drain system for the Wichita Gardens project areas would eliminate flooding in 81 out of 100 structures in the 100 year storm event, and lowers the average depth in the 100 year storm event by over 50 percent. Tables 3 and 4 provide a summary of the difference in flooding from existing to proposed conditions.

An opinion of probable construction cost was developed for the proposed improvements to the Wichita Gardens study area. The estimated construction cost for the improvements described in this section is approximately $6,167,800.00. Because the City budget provides approximately $2.2 million annually, the project was divided into three (3) phases. The improvements provided in each phase are shown in Exhibit 2. A detailed breakdown of the cost analysis for the Wichita Gardens project area is shown in Table 1. FNI suggests that the City implement the proposed solutions as described above to resolve flooding problems in the area.

AREA 60 - WICHITA GARDENS

OPINION OF PROBABLE CONSTRUCTION COST

PROPOSED STORM DRAIN SYSTEM

CITY OF WICHITA FALLS - DRAINAGE MASTERPLAN UPDATE

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
WCH09429	BAM		April 9, 2011

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	PHASE I - TRUNK LINE ON BEVERLY				
General					
	Traffic Control	3.0	MO	$5,000.00	$15,000.00
	Site Preparation	0.5	AC	$25,000.00	$12,500.00
	Erosion Control and SWPPP Implementation	1.0	LS	$5,000.00	$5,000.00
		Phase I - General Item Subtotal			**$32,500.00**
Storm Drain					
	Trench Safety	2,450.0	LF	$2.00	$4,900.00
	Install 8'X4' RCB	2,450.0	LF	$280.00	$686,000.00
	Install 18" RCP Lateral	60.0	LF	$35.00	$2,100.00
	Install 15' Curb Inlet	6.0	EA	$4,000.00	$24,000.00
	Install Headwall	3.0	EA	$5,000.00	$15,000.00
		Phase I - Storm Drain Subtotal			**$732,000.00**
Utility Adjustments					
	Remove and Replace 4" PVC Water Line	2,600.0	LF	$24.00	$62,400.00
	Remove and Replace 24" PVC Water Line	2,700.0	LF	$140.00	$378,000.00
	Trench Safety for Water Line	5,300.0	LF	$1.00	$5,300.00
	Connections to Existing Water and Sewer Lines	2.0	EA	$1,000.00	$2,000.00
		Phase I - Utility Adj. Subtotal			**$447,700.00**
Paving					
	Asphalt Pavement Saw, Remove and Dispose	8,166.7	SY	$6.00	$49,000.00
	6" Stabilized Subgrade Install	8,166.7	SY	$2.50	$20,416.67
	6" Asphalt Pavement	8,166.7	SY	$33.00	$269,500.00
	Install Concrete Curb and Gutter	4,900.0	LF	$3.00	$14,700.00
		Phase I - Paving Subtotal			**$353,616.67**
		PHASE I SUBTOTAL:			**$1,565,816.67**
	MOBILIZATION	5	%	$78,290.83	$78,290.83
	CONTINGENCY	30	%	$469,745.00	$469,745.00
		PHASE I TOTAL:			**$2,113,850.00**
	PHASE II - EXTEND TRUNK LINE TO REACH DEVELOPMENT				
General					
	Traffic Control	3.0	MO	$5,000.00	$15,000.00
	Site Preparation	0.5	AC	$25,000.00	$12,500.00
	Erosion Control and SWPPP Implementation	1.0	LS	$5,000.00	$5,000.00
		Phase II - General Item Subtotal			**$32,500.00**
Storm Drain					
	Trench Safety	3,925.0	LF	$2.00	$7,850.00
	Install 24" RCP	3,075.0	LF	$40.00	$123,000.00
	Install 36" RCP	850.0	LF	$68.00	$57,800.00
	Install 18" RCP Lateral	100.0	LF	$35.00	$3,500.00
	Install 15' Curb Inlet	10.0	EA	$4,000.00	$40,000.00
		Phase II - Storm Drain Subtotal			**$232,150.00**
Utility Adjustments					
	Remove and Replace 2" PVC Water Line	1,330.0	LF	$12.00	$15,960.00
	Remove and Replace 6" PVC Water Line	1,000.0	LF	$36.00	$36,000.00
	Remove and Replace 8" PVC Water Line	2,200.0	LF	$48.00	$105,600.00
	Trench Safety for Water line	4,530.0	LF	$1.00	$4,530.00
	Remove and Replace 6" PVC Sewer Line	2,600.0	LF	$36.00	$93,600.00
	Remove and Replace 8" PVC Sewer Line	850.00	LF	$48.00	$40,800.00
	Trench Safety for Sewer line	3,450.0	LF	$1.00	$3,450.00
	Connections to Existing Water and Sewer Lines	10.0	EA	$1,000.00	$10,000.00
		Phase II - Utility Adj. Subtotal			**$309,940.00**

Paving					
	Asphalt Pavement Saw, Remove and Dispose	24,100.0	SY	$6.00	$144,600.00
	6" Stabilized Subgrade Install	24,100.0	SY	$2.50	$60,250.00
	6" Asphalt Pavement	24,100.0	SY	$33.00	$795,300.00
	Install Concrete Curb and Gutter	17,810.0	LF	$3.00	$53,430.00
		Phase II - Paving Subtotal			**$1,053,580.00**
		PHASE II SUBTOTAL:			**$1,600,670.00**
	MOBILIZATION	5	%	$80,033.50	$80,033.50
	CONTINGENCY	30	%	$480,201.00	$480,201.00
		PHASE II TOTAL:			**$2,160,900.00**
PHASE III - SD LINE CONNECTING TO EXISTING CHANNEL ON NORTHEAST					
General					
	Traffic Control	3.0	MO	$5,000.00	$15,000.00
	Site Preparation	0.5	AC	$25,000.00	$12,500.00
	Erosion Control and SWPPP Implementation	1.0	LS	$5,000.00	$5,000.00
		Phase III - General Item Subtotal			**$32,500.00**
Storm Drain					
	Trench Safety	2,215.0	LF	$2.00	$4,430.00
	Install 36" RCP	2,215.0	LF	$68.00	$150,620.00
	Install 18" RCP Lateral	40.0	LF	$35.00	$1,400.00
	Install 15' Curb Inlet	4.0	EA	$4,000.00	$16,000.00
	Install Headwall	1.0	EA	$5,000.00	$5,000.00
		Phase III - Storm Drain Subtotal			**$177,450.00**
Utility Adjustments					
	Remove and Replace 8" PVC Water Line	3,450.0	LF	$48.00	$165,600.00
	Trench Safety for Water line	3,450.0	LF	$1.00	$3,450.00
	Remove and Replace 6" PVC Sewer Line	2,815.0	LF	$36.00	$101,340.00
	Trench Safety for Sewer line	2,815.0	LF	$1.00	$2,815.00
	Connections to Existing Water and Sewer Lines	4.0	EA	$1,000.00	$4,000.00
		Phase III - Utility Adj Subtotal			**$277,205.00**
Paving					
	Asphalt Pavement Saw, Remove and Dispose	7,700.0	SY	$6.00	$46,200.00
	6" Stabilized Subgrade Install	7,700.0	SY	$2.50	$19,250.00
	6" Asphalt Pavement	7,700.0	SY	$33.00	$254,100.00
	Install Concrete Curb and Gutter	6,900.0	LF	$3.00	$20,700.00
		Phase III - Paving Subtotal			**$340,250.00**
		PHASE III SUBTOTAL:			**$799,905.00**
	MOBILIZATION	5	%	$39,995.25	$39,995.25
	CONTINGENCY	30	%	$239,971.50	$239,971.50
		PHASE III TOTAL:			**$1,079,870.00**
		PROJECT SUBTOTAL			**$5,354,620.00**
	ENVIRONMENTAL PERMITTING	1	LS	$10,000.00	$10,000.00
	ENGINEERING FEES	15	%	$803,193.00	$803,193.00
PROJECT TOTAL					**$6,167,800.00**

Table 2- Wichita Gardens existing conditions maximum WSEL output by node

Node	Type	Invert (feet)	Maximum WSEL (feet)					
			2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
J-NE1	JUNCTION	953.50	954.53	954.60	954.64	954.69	954.73	954.76
J-SE3	JUNCTION	952.25	953.42	953.72	953.85	954.01	954.06	954.16
J-B1	JUNCTION	952.92	954.14	954.29	954.32	954.37	954.41	954.43
J-W1	JUNCTION	954.00	955.07	955.21	955.24	955.29	955.32	955.34
J-SW1	JUNCTION	954.00	955.05	955.12	955.15	955.21	955.26	955.29
J-SW2	JUNCTION	952.80	953.74	953.81	953.85	954.00	954.06	954.16
J-SW3	JUNCTION	951.50	953.38	953.72	953.85	954.00	954.05	954.16
J-SE1	JUNCTION	953.10	954.00	954.08	954.13	954.23	954.26	954.29
J-SE2	JUNCTION	952.39	953.62	953.73	953.85	954.01	954.07	954.17
J-2a	JUNCTION	954.00	954.99	955.21	955.25	955.30	955.35	955.38
J-1b	JUNCTION	947.14	950.23	950.42	950.50	950.63	950.73	950.87
J-1a	JUNCTION	952.00	952.58	952.66	952.71	952.78	952.83	952.87
J-3a	JUNCTION	954.80	955.81	955.94	956.01	956.12	956.22	956.32
J-3b	JUNCTION	954.00	954.07	954.09	954.09	954.11	954.12	954.14
J-7	JUNCTION	955.00	956.02	956.17	956.24	956.37	956.47	956.57
J-5a	JUNCTION	954.80	956.00	956.16	956.24	956.37	956.47	956.57
J-5b	JUNCTION	954.00	954.10	954.13	954.14	954.16	954.19	954.21
J-11b	JUNCTION	951.80	951.91	951.94	951.95	951.98	952.05	952.05
J-13	JUNCTION	954.00	954.58	954.69	954.73	954.81	954.87	954.93
J-11a	JUNCTION	951.90	953.24	953.50	953.62	953.81	953.87	953.95
J-1c	JUNCTION	947.00	950.23	950.41	950.48	950.59	950.68	950.78
J-12	JUNCTION	948.00	950.23	950.43	950.51	950.63	950.74	950.88
J-2b	JUNCTION	951.23	951.30	951.31	951.32	951.34	951.35	951.36
O1	OUTFALL	944.00	944.22	944.40	944.47	944.57	944.66	944.73
O-1	OUTFALL	948.00	949.05	949.22	949.27	949.61	950.42	950.43
O-2	OUTFALL	952.00	952.00	952.00	952.00	952.00	952.00	952.00
Storage1	STORAGE	946.00	950.09	950.22	950.28	950.41	950.49	950.61
StorageEast1	STORAGE	946.00	949.55	950.21	950.42	950.90	951.16	951.29
StorageEast2	STORAGE	950.00	950.23	950.41	950.48	950.58	950.66	950.74

Table 3 – Wichita Gardens inundation summary comparison

		Summary of Inundation Depth by Frequency Event (ft)					
		2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
No. structures	Existing	92	94	95	99	100	100
	Proposed	0	0	0	0	15	16
Max depth	Existing	1.12	1.23	1.35	1.51	1.57	1.67
	Proposed	0.00	0	0	0	0.29	0.68
Min depth	Existing	0.11	0.11	0.14	0.13	0.12	0.22
	Proposed	0.00	0	0	0	0.13	0.18
Average depth	Existing	0.65	0.77	0.81	0.87	0.91	0.96
	Proposed	0.00	0.00	0.00	0.00	0.19	0.31

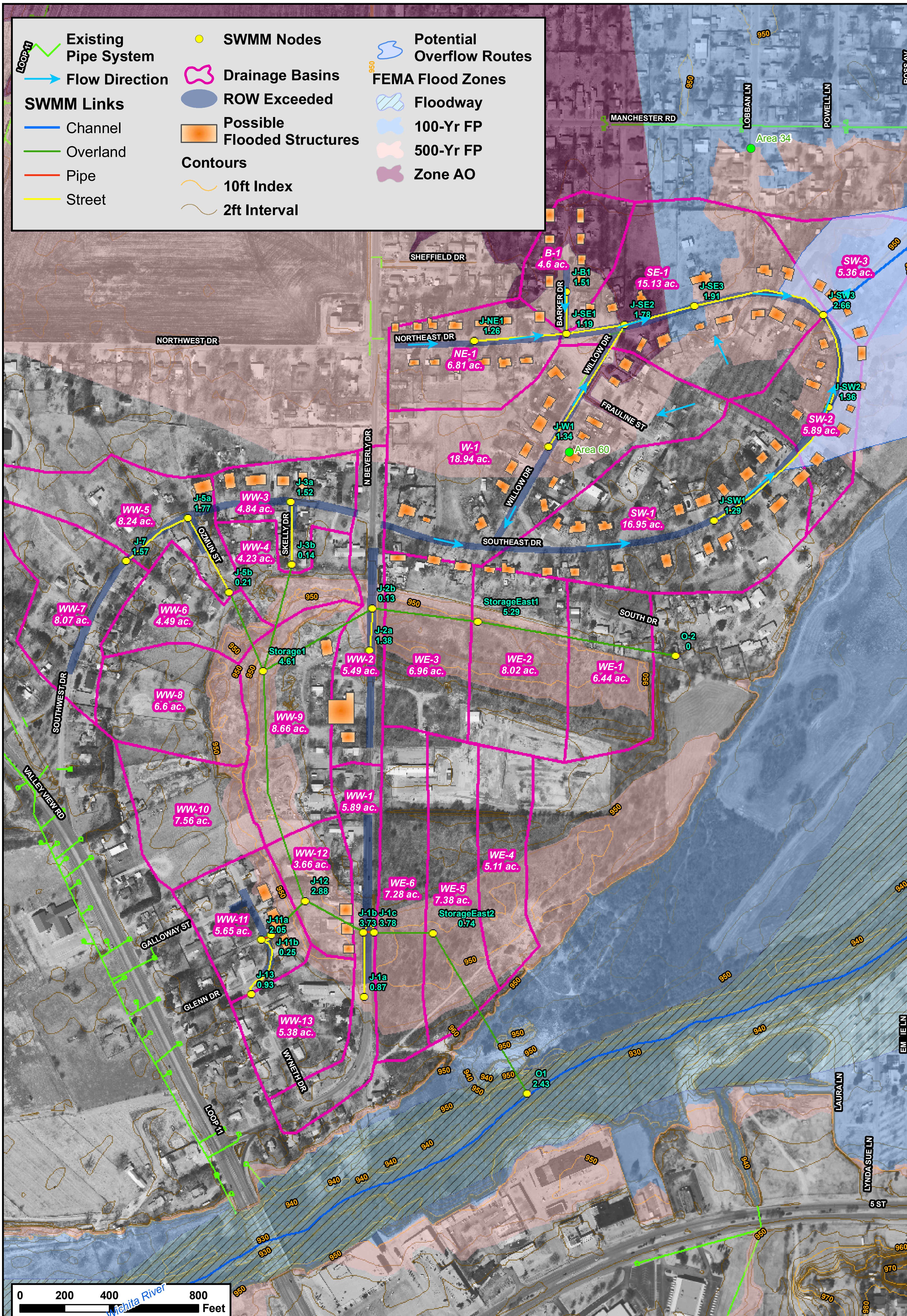
Table 4 - Cherokee inundation depth comparison

Address		Existing 100-yr Inundation Depth	Proposed 100-yr Inundation Depth
506	BARKER	**1.01**	**0.18**
507	BARKER	**1.01**	**0.18**
508	BARKER	**1.01**	**0.18**
509	BARKER	**1.01**	**0.18**
510	BARKER	**1.01**	**0.18**
511	BARKER	**1.01**	**0.18**
512	BARKER	**1.01**	**0.18**
513	BARKER	**1.01**	**0.18**
307	BEVERLY	**0.79**	
3100	NORTHEAST	**0.86**	
3101	NORTHEAST	**0.86**	
3102	NORTHEAST	**0.86**	
3103	NORTHEAST	**0.86**	
3104	NORTHEAST	**1.66**	
3105	NORTHEAST	**1.66**	
3106	NORTHEAST	**1.66**	
3108	NORTHEAST	**1.66**	
3109	NORTHEAST	**1.66**	
3110	NORTHEAST	**1.66**	
3111	NORTHEAST	**1.66**	
3112	NORTHEAST	**1.66**	
3113	NORTHEAST	**1.66**	**0.38**

Address		Existing 100-yr Inundation Depth	Proposed 100-yr Inundation Depth
3113	SOUTHEAST	**0.79**	
3115	SOUTHEAST	**0.79**	
3116	SOUTHEAST	**0.79**	
3119	SOUTHEAST	**0.79**	
3120	SOUTHEAST	**0.79**	
3121	SOUTHEAST	**0.79**	
3122	SOUTHEAST	**0.79**	
3123	SOUTHEAST	**0.79**	
3126	SOUTHEAST	**0.79**	
3129	SOUTHEAST	**0.79**	
3130	SOUTHEAST	**0.79**	
3131	SOUTHEAST	**0.79**	
3133	SOUTHEAST	**0.79**	
3139	SOUTHEAST	**0.79**	
3140	SOUTHEAST	**0.79**	
3141	SOUTHEAST	**0.79**	
3143	SOUTHEAST	**0.79**	
3146	SOUTHEAST	**0.79**	
3147	SOUTHEAST	**0.79**	
3148	SOUTHEAST	**0.79**	
401	WILLOW	**0.84**	
402	WILLOW	**0.84**	

Address		Existing 100-yr Inundation Depth	Proposed 100-yr Inundation Depth
3114	NORTHEAST	**1.66**	**0.38**
3115	NORTHEAST	**1.66**	**0.38**
3118	NORTHEAST	**1.66**	**0.38**
3119	NORTHEAST	**1.66**	**0.38**
3123	NORTHEAST	**1.67**	
3126	NORTHEAST	**1.67**	
3128	NORTHEAST	**1.67**	
3130	NORTHEAST	**0.69**	
3136	NORTHEAST	**0.69**	
3137	NORTHEAST	**0.69**	
3139	NORTHEAST	**1.16**	
3140	NORTHEAST	**1.16**	
3142	NORTHEAST	**1.16**	
3143	NORTHEAST	**1.16**	
3144	NORTHEAST	**1.26**	
3147	NORTHEAST	**1.26**	
3148	NORTHEAST	**1.26**	
3149	NORTHEAST	**0.26**	
3152	NORTHEAST	**1.26**	
3154	NORTHEAST	**1.26**	
3100	SOUTHEAST	**0.66**	
3101	SOUTHEAST	**0.86**	
3103	SOUTHEAST	**0.86**	
3104	SOUTHEAST	**0.66**	
3106	SOUTHEAST	**0.66**	
3107	SOUTHEAST	**0.66**	
3109	SOUTHEAST	**0.79**	
3110	SOUTHEAST	**0.79**	
3112	SOUTHEAST	**0.79**	

Address		Existing 100-yr Inundation Depth	Proposed 100-yr Inundation Depth
405	WILLOW	**0.84**	
406	WILLOW	**0.84**	
407	WILLOW	**0.84**	
410	WILLOW	**0.84**	
411	WILLOW	**0.84**	
412	WILLOW	**0.84**	
413	WILLOW	**0.84**	
414	WILLOW	**0.84**	
415	WILLOW	**0.84**	
416	WILLOW	**0.84**	
417	WILLOW	**0.84**	
421	WILLOW	**1.67**	**0.68**
425	WILLOW	**1.67**	**0.68**
210	BEVERLY	**0.37**	
212	BEVERLY	**0.37**	
214	BEVERLY	**0.37**	
232	BEVERLY	**0.28**	
236	BEVERLY	**0.88**	
300	BEVERLY	**0.88**	
3206	SOUTHWEST	**0.52**	
3208	SOUTHWEST	**0.22**	
3212	SOUTHWEST	**0.72**	
3214	SOUTHWEST	**0.82**	
3216	SOUTHWEST	**0.37**	
213	WYNETH	**0.75**	**0.27**
215	WYNETH	**0.55**	
217	WYNETH	**0.25**	
Number of Homes Flooded		**100**	**16**



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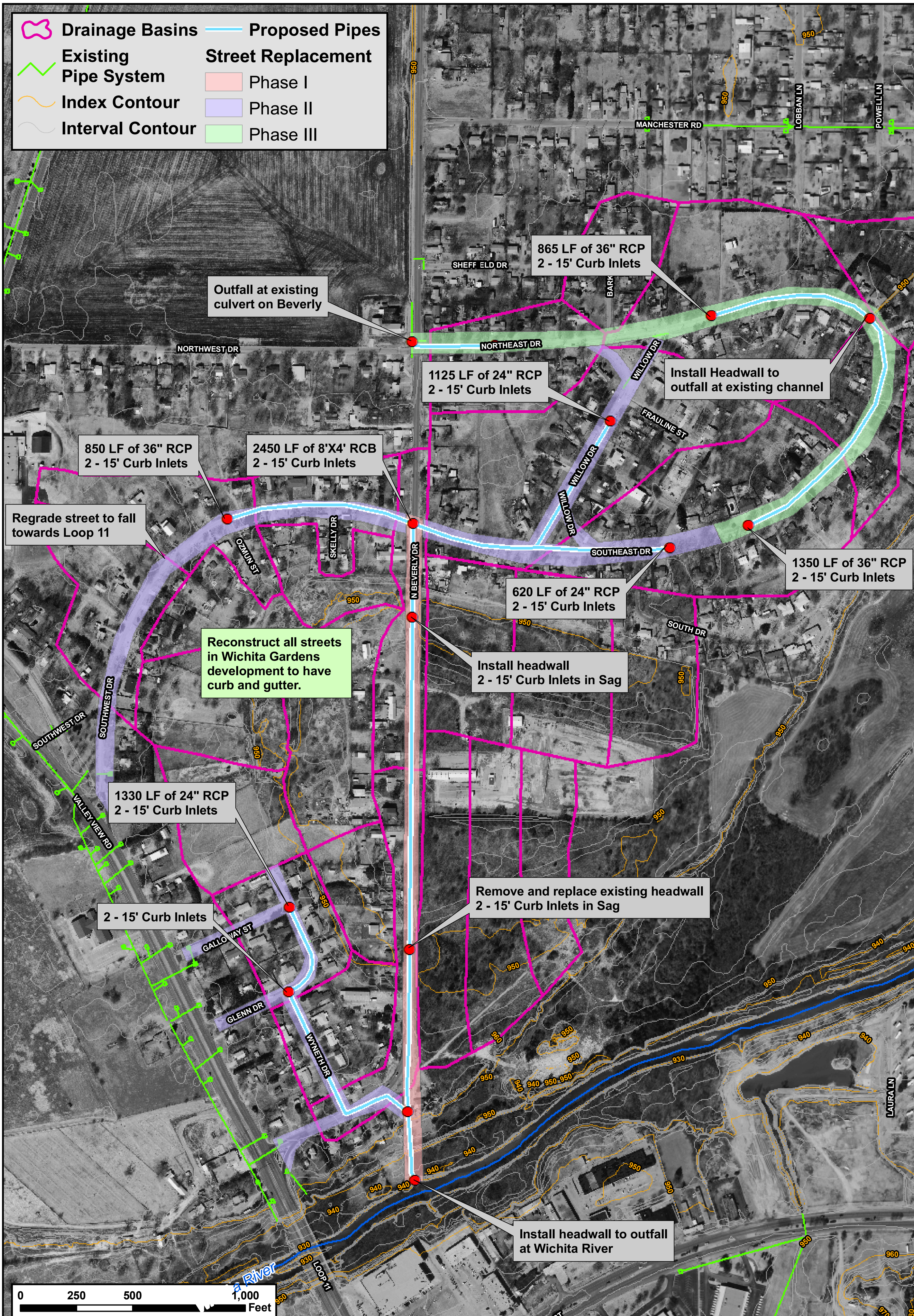
N W E S

AREA 60 - WICHITA GARDENS

EXISTING CONDITIONS: 100-YEAR RESULTS

FN JOB NO	WCH09429
FILE	H:\STORMWATER\GEODATABASE\StudyAreas
DATE	March, 2011
SCALE	1:4,800
DRAFTED	BAM

Exhibit 1



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Fort Worth, Texas 76109-4895
817-735-7300

N W E S

AREA 60 - WICHITA GARDENS

PROPOSED IMPROVEMENTS

FN JOB NO	WCH09429
FILE	H:\STORMWATER\GEODATABASE\StudyAreas
DATE	February 23, 2011
SCALE	1:4,800
DESIGNED	LMB
DRAFTED	BAM

Exhibit 2

TECHNICAL MEMORANDUM

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TO:	Canadian – Upper Red Regional Flood Planning Group
FROM:	Chris Johnson, PE, CFM; Scott Hubley, PE, CFM
SUBJECT:	Buffalo Creek FMP - 013000021
PROJECT:	PPC21323
DATE:	June 9, 2023
CC:	Jarian E. Fred; Alex Guerrero

1. BACKGROUND

As part of the 2023 Amended Plan for the Canadian – Upper Red Regional Flood Plan, Buffalo Creek was identified as a Flood Mitigation Project (FMP) due to adjacent neighborhood flooding from the creek. Buffalo Creek is located in Iowa Park, Texas, and the project area is shown in **Figure 1**. This memo presents an analysis of existing conditions and conceptual alternatives for the Regional Flood Planning Group's (RFPG) consideration.

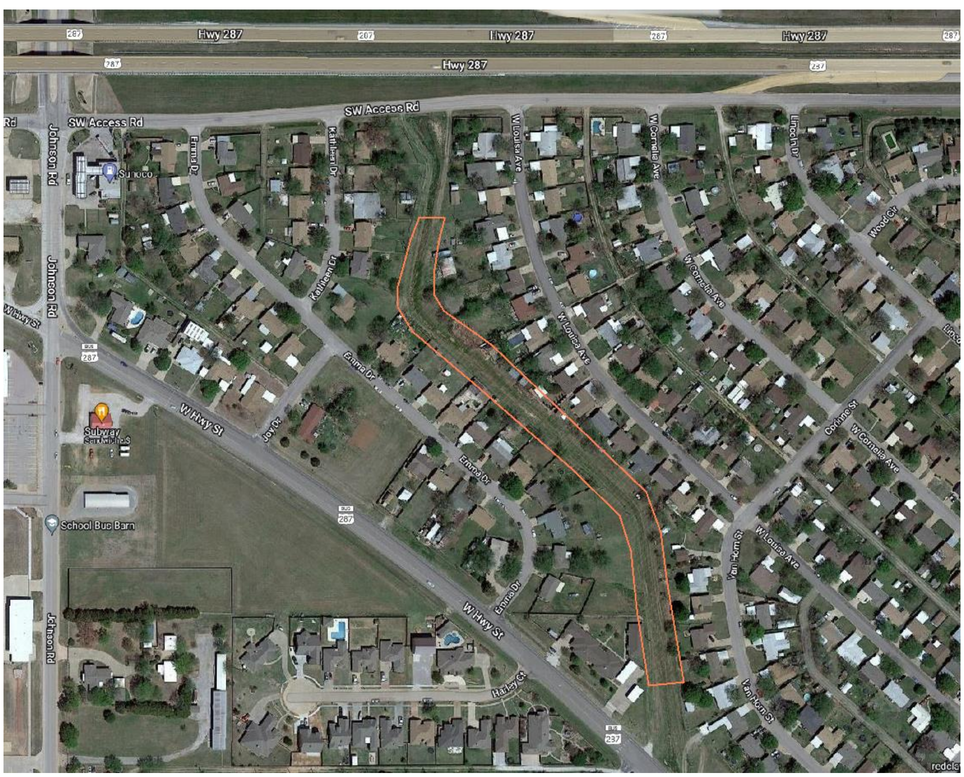

Figure 1: Project Area along Buffalo Creek

2. DATA GATHERING

During the data gathering process, the Technical Consultant team met with the City of Iowa Park, who expressed Buffalo Creek as their greatest need due to the adjacent West Iowa Park Neighborhood flooding during storm events. 2023 survey was conducted by Biggs and Matthews Survey on the structures included in the hydraulic model. 2018 LiDAR was obtained from TNRIS datasets.

3. EXISTING CONDITIONS

HEC-HMS version 4.10 was used to create a hydrologic model for Buffalo Creek. SCS Curve Number and Unit Hydrograph methods were used with Lag & K Routing for hydrologic analysis. Rainfall data was taken from NOAA Atlas 14. The flows for the 50%, 20%, 10%, 4%, 2%, and 1% Annual Chance Events (ACE) generated in HEC-HMS were used as input in the hydraulic analysis. HEC-RAS version 6.3 was used to create a 1D steady state hydraulic model of the creek. The model extends from immediately downstream of Johnson Road to approximately 1400 ft downstream of W Smith Avenue. 2018 TNRIS LiDAR was used to create the existing conditions terrain. Cross sections were placed every 100 to 200 ft and bounding cross sections were placed around structures. The model contains seven structures, located at US 287, W Hwy St, W Magnolia Ave (two crossings), an industrial crossing, BNSF RR, and W Smith Avenue. Manning's n values were applied as a land cover layer using the National Land Cover Database (NLCD) dataset, with n values adjusted in accordance with the ranges set in the HEC-RAS User's Manual. Flow change locations were set to cross sections in corresponding locations to HEC-HMS Junctions. The existing conditions analysis revealed that in the 1% ACE, Buffalo Creek causes 37 homes to flood in the West Iowa Park Neighborhood.

4. CONCEPTUAL ALTERNATIVE

For the portion of Buffalo Creek running through the neighborhood, the identified alternative was to add channel grading throughout the channel. A proposed model was created using channel modifications to cross sections 8079 through 6820, spanning a length of approximately 1500 ft. These modifications consist of widening the channel bottom to 20 to 30 ft with 3:1 side slopes to increase the conveyance area of the channel. This identified alternative removes 3 homes from the floodplain in the 1% ACE. The water surface elevation (WSE) comparison in the proposed channel section is shown in Table 1. Further, the storage loss from the cumulative volume difference in the channel was analyzed during the 100-yr storm event, and the decrease was determined to be approximately 4.87%. This is below the precision of the planning level analysis, at 5%.

Table 1 - 100-yr (1%) WSE Comparison Through Modified Channel Section

Cross Section	Existing 100yr WSE (ft)	Proposed 100yr WSE (ft)	Δ
8400 US 287	Culvert		
8295	1049.24	1049.21	-0.03
8229	1048.77	1048.7	-0.07
8079	*1047.13*	*1046.93*	*-0.2*
7734	*1045.03*	*1044.96*	*-0.07*
7411	*1043.24*	*1043.09*	*-0.15*
7080	*1042.08*	*1041.79*	*-0.29*
6965	*1041.82*	*1041.5*	*-0.32*
6924	*1041.65*	*1041.22*	*-0.43*
6868	*1040.44*	*1040.33*	*-0.11*
6820	*1040.33*	*1040.32*	*-0.01*
6723	1040.05	1040.05	0
6634	1040.03	1040.03	0
6500 W Hwy St / BU 287	Culvert		

4.01 OPINION OF PROBABLE CONSTRUCTION COST

The proposed project as defined in this planning level analysis has a total cost of $687,000. An opinion of probable construction cost (OPCC) has been included in **Table 2**.

Table 2 - Opinion of Probable Construction Cost

1	Site Preparation	20	STA	$ 3,000.00	$ 60,000
2	Traffic Control	1	LS	$ 30,000.00	$ 30,000
3	Develop and Implement SWPPP	1	LS	$ 25,000.00	$ 25,000
4	Remove Existing Asphalt Pavement	0	SY	$ 15.00	$ -
5	Remove Existing Culvert	0	LF	$ 50.00	$ -
6	Remove Existing Bridge	0	LS	$ -	$ -
7	Remove Trees	0	EA	$ -	$ -
8	Excavation and Haul	900	CY	$ 25.00	$ 22,500
9	Embankment (Fill)	0	CY	$ 30.00	$ -
10	Rock Rip Rap	0	SY	$ 150.00	$ -
11	Lime Treatment	0	SY	$ 15.00	$ -
12	Erosion Control Blankets, Hydromulch, and Topsoil	7000	SY	$ 15.00	$ 105,000
13	Temporary Irrigation	1	LS		$ 70,000
14	Concrete Pavement	0	SY	$ 95.00	$ -
15	Headwalls	0	LS		$ -
16	Concrete Approach Slab	0	CY	$ 800.00	$ -
17	Sidewalks	0	SY	$ 95.00	$ -
18	Combination Rail	0	LF	$ 175.00	$ -
		SUBTOTAL		(2023 COSTS)	$ 462,500
		SUBTOTAL		(2020 COSTS)	$ 398,523
		SUBTOTAL			$ 528,043

PROJECT TOTAL (2020 COSTS)	**$ 686,456**

Operations & Maintenance Total (*30-year project life*)	$	686

4.02 BENEFIT COST ANALYSIS

The benefit cost ratio (BCR) was determined utilizing the Benefit Cost Analysis (BCA) Input Workbook and is shown in **Table 3**. The BCR was determined to be 0.3.

Table 3 - Benefit Cost Analysis

Input Into BCA Toolkit		
Project Useful Life	**30**	
Event Damages	**Baseline**	**Project**
25 - year storm	**$1,183,665**	**$1,037,895**
50 - year storm	**$1,781,492**	**$1,638,065**
100 - year storm	**$4,201,447**	**$3,914,900**
Total Benefits from BCA Toolkit	$159,481	
Other Benefits (Not Recreation)	$0	
Recreation Benefits	-	
Total Costs	$530,563	
Net Benefits	-$371,082	
Net Benefits with Recreation	-$371,082	
Final BCR	**0.3**	
Final BCR with Recreation	**0.3**	

5. NO NEGATIVE IMPACTS CERTIFICATION

The Technical Guidelines for Regional Flood Planning [1] require a certification of no negative impacts from an engineer. The following requirements must be met for the no negative impact certification to be met:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (< 0.05ft) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (< 0.35ft) measured at each computational cell.

5. Maximum increase in hydrologic peak discharge must be < 0.5 percent measured at computational nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to 2D overland analysis.

The No Negative Impacts Certification is provided in **Table 4**.

Table 4 - No Negative Impacts Certification

FMP Name	Buffalo Creek
FMP Meets ALL No Negative Impacts Requirements from Exhibit C Section 3.6.A (Yes/ No)	Yes
Negative Impact Description	Not Applicable
Planning level Mitigation Plan (Yes/ No)	Not Applicable
Mitigation Plan Description	Not Applicable
No Negative Impact Determination (Yes/No)	Yes
Basis of No Negative Impact Determination (Model, Study, Engineering Judgement)	Model
Model ID	010000000013, 010000000020
Model Name	Buffalo Creek Hydrologic Model, Buffalo Creek Hydraulic Model
Model Submitted	Yes
Study Name and Location	Buffalo Creek, City of Iowa Park, TX
Engineer of Record (Optional)	Freese and Nichols
Engineering Judgement Description	Not Applicable

6. CONCLUSION

The Buffalo Creek FMP is intended to reduce flooding conditions in a residential neighborhood by performing channel grading along a portion of Buffalo Creek. This FMP reduces the 100-yr water surface elevation in the channel running through the neighborhood and removes three structures from the 100-yr floodplain. As demonstrated in this technical memorandum, this FMP meets all the TWDB requirements for inclusion in the Regional Flood Plans. Therefore, the Technical Consultant team considers this FMP a feasible project that the RFPG can recommend for inclusion in the Canadian – Upper Red Regional Flood Plan.

7. REFERENCES

1. Texas Water Development Board (TWDB). Exhibit C Technical Guidelines for Regional Flood Planning, Apr. 2021, www.twdb.texas.gov/flood/planning/planningdocu/2023/doc/04_Exhibit_C_TechnicalGuidelines_April2021.pdf.
2. Army Corps of Engineers HEC-RAS User's Manual, Creating Land Cover, Manning's n values, and % Impervious Layers, May 2021, Creating Land Cover, Manning's n values, and % Impervious Layers (army.mil)

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TO:	Canadian – Upper Red Regional Flood Planning Group
FROM:	Chris Johnson, PE, CFM; Scott Hubley, PE, CFM
SUBJECT:	China Creek FMP - 13000019
PROJECT:	PPC21323
DATE:	June 9, 2023
CC:	Jarian E. Fred; Alex Guerrero

1. BACKGROUND

As part of the 2023 Amended Plan for the Canadian – Upper Red Regional Flood Plan, SH-25 at China Creek was identified as a Flood Mitigation Project (FMP). China Creek is located in Wichita County, Texas, about 3 miles north of the City of Electra. The project area is shown in **Figure 1**. This memo presents an analysis of existing conditions and conceptual alternatives for the Regional Flood Planning Group's (RFPG) consideration.

Figure 1: Project Area along China Creek at SH-25

2. DATA GATHERING

During the data gathering process, the Technical Consultant team met with Wichita County, who expressed SH-25 at China Creek as their greatest need due to the low water crossing being inundated in multiple storm events. 2023 survey was conducted by Biggs and Matthews Survey on the structures included in the hydraulic model. 2018 LiDAR was obtained from TNRIS datasets. 2009 As-Builts were used for SH-25 specifically.

3. EXISTING CONDITIONS

HEC HMS version 4.10 was used to create a hydrologic model for China Creek. SCS Curve Number and Unit Hydrograph methods were used with Lag & K Routing for hydrologic analysis. Rainfall data was taken from NOAA Atlas 14. The flows for the 50%, 20%, 10%, 4%, 2%, and 1% Annual Chance Events (ACE) generated in HEC HMS were used as input in the hydraulic analysis. HEC RAS version 6.3 was used to create a 1D steady state hydraulic model of the creek. The model extends from 1500 ft upstream of SH-25 to 3000 ft downstream of SH-240. 2018 TNRIS LiDAR was used to create the existing conditions terrain. Cross sections were placed every 200 ft and bounding cross sections were placed around structures. The model contains three structures, located at SH-25, a golf course crossing, and SH-240. Manning's n values were applied as a land cover layer using the National Land Cover Database (NLCD) dataset, with n values adjusted in accordance with the ranges set in the HEC RAS User's Manual. Flow change locations were set to cross sections in corresponding locations to HEC-HMS Junctions.

SH-25 spans China Creek and a tributary south of China Creek, with a confluence downstream of SH-25. Since the two reaches are hydraulically connected surrounding the structure, the structure was represented as one structure with the multiple opening analysis applied. The existing conditions analysis revealed that SH-25 is inundated in all storm events included. It is overtopped by 7.3 ft in the 1% ACE, and by 4.9 ft in the 10% ACE.

4. CONCEPTUAL ALTERNATIVE

For this area, no feasible alternative to increase the level of service on SH-25 was identified, so safety improvements are recommended. The proposed safety improvements include installing staff gauges at both the China Creek and tributary SH-25 crossings for drivers to see the level of water overtopping the road. Additionally, flashers should be installed at either end of the 25-yr (4% ACE) floodplain to warn drivers of the hazard during frequent storm events. Streetlights are also recommended along this section of SH-25, at 200 ft intervals, so drivers can see the hazard while driving at night. At the nearest intersections north and south of this low water crossing, flood warning signs should be installed to warn drivers of upcoming hazards so they can adjust their route when necessary. Lastly, while guardrails are currently installed in the northern crossing of China Creek, the tributary crossing does not have guardrails. Adding approximately 250 ft of guardrail on the downstream side of the crossing is recommended to prevent cars from getting washed away off the road.

4.01 OPINION OF PROBABLE CONSTRUCTION COST

The proposed project as defined in this planning level analysis has a total cost of $455,000. An opinion of probable construction cost (OPCC) has been included in **Table 1**.

Table 1 - Opinion of Probable Construction Cost

1	Site Preparation	1	LS	$ 4,000.00	$ 4,000
2	Traffic Control	1	LS	$ 30,000.00	$ 30,000
3	Combination Rail (Object Marker End Treatment)	250	LF	$ 175.00	$ 43,750
4	Install Staff Gauge	2	EA	$ 2,000.00	$ 4,000
5	Install HWWS Flashers	2	EA	$ 17,500.00	$ 35,000
6	Install HWWS Master	1	EA	$ 22,500.00	$ 22,500
7	Install Flood Hazard Signs	2	EA	$ 1,000.00	$ 2,000
8	Install Lighting Fixture (every 200 ft)	11	EA	$ 5,000.00	$ 55,000
9	Install Lighting Pole Assembly	11	EA	$ 10,000.00	$ 110,000
		SUBTOTAL		(2023 COSTS)	$ 306,250
		SUBTOTAL		(2020 COSTS)	$ 263,887
		SUBTOTAL			$ 349,650

PROJECT TOTAL (2020 COSTS)	**$**	**454,545**

RECURRING COSTS		
Operations & Maintenance Total (*30-year project life*)	$	455
ANNUAL RECURRING TOTAL (ROUNDED 2020 COSTS)	**$**	**455,000**

4.02 BENEFIT COST ANALYSIS

Due to the safety improvements being a non-structural solution, a benefit cost ratio (BCR) cannot be calculated as there are no quantifiable flood reduction benefits. However, these improvements bring safety benefits to drivers traveling along SH-25 and could potentially save lives during a flood related disaster. This is consistent with the overarching goal of all regional flood plans which is to “protect against the loss of life and property”.

5. NO NEGATIVE IMPACTS CERTIFICATION

The Technical Guidelines for Regional Flood Planning [1] require a certification of no negative impacts from an engineer. The following requirements must be met for the no negative impact certification to be met:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (< 0.05ft) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (< 0.35ft) measured at each computational cell.

5. Maximum increase in hydrologic peak discharge must be < 0.5 percent measured at computational nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to 2D overland analysis.

The No Negative Impacts Certification is provided in **Table 2**.

Table 2 - No Negative Impacts Certification

FMP Name	China Creek
FMP Meets ALL No Negative Impacts Requirements from Exhibit C Section 3.6.A (Yes/ No)	Yes
Negative Impact Description	Not Applicable
Planning level Mitigation Plan (Yes/ No)	Not Applicable
Mitigation Plan Description	Not Applicable
No Negative Impact Determination (Yes/No)	Yes
Basis of No Negative Impact Determination (Model, Study, Engineering Judgement)	Model
Model ID	010000000013, 010000000019
Model Name	China Creek Hydrologic Model, China Creek Hydraulic Model
Model Submitted	Yes
Study Name and Location	China Creek, Wichita County, TX
Engineer of Record (Optional)	Freese and Nichols
Engineering Judgement Description	Not Applicable

6. CONCLUSION

The China Creek FMP is intended to adequately warn drivers of potential flooding and overtopping of SH-25, so they can find alternative routes and avoid potential harm. As demonstrated in this technical memorandum, this FMP meets all the TWDB requirements for inclusion in the Regional Flood Plans. Therefore, the Technical Consultant team considers this FMP a feasible project that the RFPG can recommend for inclusion in the Canadian – Upper Red Regional Flood Plan.

7. REFERENCES

1. Texas Water Development Board (TWDB). Exhibit C Technical Guidelines for Regional Flood Planning, Apr. 2021, www.twdb.texas.gov/flood/planning/planningdocu/2023/doc/04_Exhibit_C_TechnicalGuidelines_April2021.pdf.
2. Army Corps of Engineers HEC-RAS User's Manual, Creating Land Cover, Manning's n values, and % Impervious Layers, May 2021, Creating Land Cover, Manning's n values, and % Impervious Layers (army.mil)

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TO:	Canadian – Upper Red Regional Flood Planning Group
FROM:	Chris Johnson, PE, CFM; Scott Hubley, PE, CFM
SUBJECT:	Gilbert Creek FMP - 13000022
PROJECT:	PPC21323
DATE:	June 9, 2023
CC:	Jarian E. Fred; Alex Guerrero

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1. BACKGROUND

As part of the 2023 Amended Plan for the Canadian – Upper Red Regional Flood Plan, Cropper Road (also known as Daniels Rd or FM 3429) at Gilbert Creek was identified as a Flood Mitigation Project (FMP). Cropper Road at Gilbert Creek is located approximately 2 miles south of Burkburnett, and the project area is shown in **Figure 1**. This memo presents an analysis of existing conditions and conceptual alternatives for the Regional Flood Planning Group's (RFPG) consideration.

Figure 1: Project Area along Cropper Rd at Gilbert Creek

2. DATA GATHERING

During the data gathering process, the Technical Consultant team met with the City of Burkburnett, who expressed Cropper Road as their greatest need since this crossing experiences flooding conditions during relatively small storm events. Gilbert Creek was included in a 2010 FIS Study, and the effective flows were used as the basis for the existing and proposed hydraulic analyses. 2023 survey was conducted by Biggs and Matthews Survey on the structures included in the hydraulic model. 1983 as-builts were obtained and used for Cropper Road specifically. 2018 LiDAR was obtained from TNRIS datasets.

3. EXISTING CONDITIONS

As previously mentioned, effective flows from the FIS Study were used as input in the hydraulic analysis. Flows were obtained for the 10%, 2%, 1%, and 0.2% Annual Chance Events (ACE). HEC-RAS version 6.3 was used to create a 1D steady state hydraulic model of the creek. The model extends approximately 1600 ft upstream of Cropper Road to approximately 2400 ft upstream of Ashton Road. 2018 TNRIS LiDAR was used to create the existing conditions terrain. Cross sections were placed every 500 ft and bounding cross sections were placed around structures. The model contains six structures, located at Cropper Road, WT&J RR, an industrial crossing, I-44, Bishop Rd, and TX-240. Manning's n values were applied as a land cover layer using the NLCD land cover dataset, with n values adjusted in accordance with the ranges set in the HEC-RAS User's Manual. Flow change locations were set to the cross section closest to the location set in the FIS Report, at cross section XS 27744 and XS 13161.

Cropper Road spans Gilbert Creek and two smaller tributaries that connect to Gilbert Creek downstream. During the modeling analysis, it was seen that these two tributaries were hydraulically connected to Gilbert Creek upstream and downstream of Cropper Road. Therefore, all three structures are modeled as one structure with the multiple opening analysis applied. The existing conditions analysis revealed that Cropper Road is inundated during all storm events included. It is overtopped by 2.8 ft in the 1% ACE, and by 1.7 ft in the 10% ACE.

4. CONCEPTUAL ALTERNATIVE

Achieving a 1% level of service (LOS) for this area is not feasible as it requires extensive work with excessive project costs. Therefore a 10% LOS alternative was identified. All three existing culverts are severely undersized and are proposed to be upgraded in this alternative. The northern most culvert will be increased from two 8'x5' box culverts to three 10'x6' box culverts. The middle culvert will be increased from two 11'x2.7' box culverts to three 12'x6' box culverts. Lastly, the six 10'x6' box culverts at Gilbert Creek will be replaced with a 230 ft span bridge. Additionally, some channel grading is recommended to increase the size of the Gilbert Creek channel bottom upstream and downstream of Cropper Road to coincide with the increased opening and to increase the conveyance in the channel. This channel grading is shown in the proposed model as channel modifications from cross section 26634 to cross section 25948. Lastly, the alternative proposes to raise the road 1.7 ft for approximately 1940 ft of roadway. The storage loss from the cumulative volume difference in the channel was analyzed during the 10-yr storm event, and the decrease was determined to be approximately 0.5%. This is below the precision of the planning level analysis, at 5%.

It is important to note that this is a conceptual high-level design, and the exact size of the culverts, bridge, and channel grading may be modified during a future design phase.

4.01 OPINION OF PROBABLE CONSTRUCTION COST

The proposed project as defined in this planning level analysis has a total cost of $11,748,000. An opinion of probable construction cost (OPCC) has been included in **Table 1**.

Table 1 - Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION LINE ITEMS					
1	Site Preparation	50	STA	$ 3,000.00	$ 150,000
2	Traffic Control	1	LS	$ 30,000.00	$ 30,000
3	Develop and Implement SWPPP	1	LS	$ 25,000.00	$ 25,000
4	Remove Existing Asphalt Pavement	11400	SY	$ 15.00	$ 171,000
5	Remove Existing Culvert	630	LF	$ 50.00	$ 31,500
6	Remove Existing Bridge	0	LS	$ -	$ -
7	Remove Trees	0	EA	$ -	$ -
8	Excavation and Haul	39000	CY	$ 25.00	$ 975,000
9	Embankment (Fill)	1700	CY	$ 30.00	$ 51,000
10	Rock Rip Rap	7000	SY	$ 150.00	$ 1,050,000
11	Lime Treatment	10100	SY	$ 15.00	$ 151,500
12	Erosion Control Blankets, Hydromulch, and Topsoil	32000	SY	$ 15.00	$ 480,000
13	Temporary Irrigation	1	LS		$ 160,000
14	Concrete Pavement	10100	SY	$ 95.00	$ 959,500
15	10x6 Box Culvert	144	LF	$ 1,600.00	$ 230,400
16	12x6 Box Culvert	177	LF	$ 2,100.00	$ 371,700
17	Headwalls	1	LS		$ 197,000
18	Bridge Super Structure (50ft Width)	230	LF	$ 6,800.00	$ 1,564,000
19	Bridge Sub Structure (50ft Width)	230	LF	$ 4,600.00	$ 1,058,000
20	Concrete Approach Slab	75	CY	$ 800.00	$ 60,000
21	Sidewalks	0	SY	$ 95.00	$ -
22	Combination Rail	420	LF	$ 175.00	$ 73,500
23	*Mitigation*	*0*	*0*	*$ -*	*$ -*
24	*Utility Relocation*	*1*	*LS*	*$ 150,000.00*	*$ 150,000*
25	*Easement/Land Acquisition*	*0*	*SF*	*$ 1.10*	*$ -*
26	*Buyouts*	*0*	*0*	*$ -*	*$ -*
27	*Property Elevations*	*0*	*0*	*$ -*	*$ -*

SUBTOTAL	(2023 COSTS)	$	7,939,100
SUBTOTAL	(2020 COSTS)	$	6,840,893
SUBTOTAL		$	9,064,183

PROJECT TOTAL (2020 COSTS)	**$**	**11,783,437**

RECURRING COSTS		
Operations & Maintenance Total (*30-year project life*)	$	11,783
ANNUAL RECURRING TOTAL (ROUNDED 2020 COSTS)	**$**	**11,784,000**

4.02 BENEFIT COST ANALYSIS

The benefit cost ratio (BCR) was determined utilizing the Benefit Cost Analysis (BCA) Input Workbook and is shown in **Table 2**. The BCR was determined to be 2.3.

Table 2 - Benefit Cost Analysis

Input Into BCA Toolkit		
Project Useful Life	**30**	
Event Damages	**Baseline**	**Project**
10 - year storm	**$12,194,622**	**$0**
50 - year storm	**$28,291,523**	**$1,714,869**
100 - year storm	**$28,310,577**	**$13,337,868**
500 - year storm	**$17,987,067**	**$30,808,569**
Total Benefits from BCA Toolkit	$21,267,186	
Other Benefits (Not Recreation)	$0	
Recreation Benefits	-	
Total Costs	$9,107,500	

Net Benefits	$12,159,686
Net Benefits with Recreation	$12,159,686
Final BCR	**2.3**
Final BCR with Recreation	**2.3**

5. NO NEGATIVE IMPACTS CERTIFICATION

The Technical Guidelines for Regional Flood Planning [1] require a certification of no negative impacts from an engineer. The following requirements must be met for the no negative impact certification to be met:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (< 0.05ft) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (< 0.35ft) measured at each computational cell.

5. Maximum increase in hydrologic peak discharge must be < 0.5 percent measured at computational nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to 2D overland analysis.

The No Negative Impacts Certification is provided in **Table 3**.

Table 3 - No Negative Impacts Certification

FMP Name	Gilbert Creek
FMP Meets ALL No Negative Impacts Requirements from Exhibit C Section 3.6.A (Yes/ No)	Yes
Negative Impact Description	Not Applicable
Planning level Mitigation Plan (Yes/ No)	Not Applicable
Mitigation Plan Description	Not Applicable
No Negative Impact Determination (Yes/No)	Yes
Basis of No Negative Impact Determination (Model, Study, Engineering Judgement)	Model
Model ID	010000000017

Model Name	Gilbert Creek Hydraulic Model
Model Submitted	Yes
Study Name and Location	Gilbert Creek, City of Burkburnett, TX
Engineer of Record (Optional)	Freese and Nichols
Engineering Judgement Description	Not Applicable

6. CONCLUSION

The Gilbert Creek FMP is intended to reduce flooding conditions at a low water crossing by replacing undersized culverts with larger capacity culverts and a new bridge at Gilbert Creek. Channel grading and elevating a segment of the roadway are also proposed for this FMP. Once completed, this FMP will reduce flooding and provide better accessibility for the citizens of Burkburnett during flood events. As demonstrated in this technical memorandum, this FMP meets all the TWDB requirements for inclusion in the Regional Flood Plans. Therefore, the Technical Consultant team considers this FMP a feasible project that the RFPG can recommend for inclusion in the Canadian – Upper Red Regional Flood Plan.

7. REFERENCES

1. Texas Water Development Board (TWDB). Exhibit C Technical Guidelines for Regional Flood Planning, Apr. 2021, www.twdb.texas.gov/flood/planning/planningdocu/2023/doc/04_Exhibit_C_TechnicalGuidelines_April2021.pdf.
2. Army Corps of Engineers HEC-RAS User's Manual, Creating Land Cover, Manning's n values, and % Impervious Layers, May 2021, Creating Land Cover, Manning's n values, and % Impervious Layers (army.mil)

TECHNICAL MEMORANDUM

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TO:	Canadian – Upper Red Regional Flood Planning Group
FROM:	Chris Johnson, PE, CFM; Scott Hubley, PE, CFM
SUBJECT:	Wild Horse Creek FMP - 13000020
PROJECT:	PPC21323
DATE:	June 9, 2023
CC:	Jarian E. Fred; Alex Guerrero

1. BACKGROUND

As part of the 2023 Amended Plan for the Canadian – Upper Red Regional Flood Plan, SH-240 at Wild Horse Creek was identified as a Flood Mitigation Project (FMP). Wild Horse Creek is located in Burkburnett, Texas, and the project area is shown in **Figure 1**. This memo presents an analysis of existing conditions and conceptual alternatives for the Regional Flood Planning Group's (RFPG) consideration.

Figure 1: Project Area along Wild Horse Creek at SH-240

2. DATA GATHERING

During the data gathering process, the Technical Consultant team met with the City of Burkburnett, who expressed Wild Horse Creek as their greatest need due to the low water crossing being inundated in multiple storm events. 2023 survey was conducted by Biggs and Matthews Survey on the structures included in the hydraulic model. 2018 LiDAR was obtained from TNRIS datasets. 1950 As-Builts were used for SH-240 specifically.

3. EXISTING CONDITIONS

HEC-HMS version 4.10 was used to create a hydrologic model for Wild Horse Creek. SCS Curve Number and Unit Hydrograph methods were used with Lag & K Routing for hydrologic analysis. Rainfall data was taken from NOAA Atlas 14. The flows for the 50%, 20%, 10%, 4%, 2%, and 1% Annual Chance Events (ACE) generated in HEC-HMS were used as input in the hydraulic analysis. HEC-RAS version 6.3 was used to create a 1D steady state hydraulic model of the creek. The model extends from 1500 ft upstream of S FM 369 to immediately upstream of Holman Road. 2018 TNRIS LiDAR was used to create the existing conditions terrain. Cross sections were placed every 100 ft and bounding cross sections were placed around structures. The model contains four structures, located at an industrial crossing, SH-240, WT&J RR, and Gresham Road. Manning's n values were applied as a land cover layer using the National Land Cover Database (NLCD) dataset, with n values adjusted in accordance with the ranges set in the HEC-RAS User's Manual. Flow change locations were set to cross sections in corresponding locations to HEC-HMS Junctions. The existing conditions analysis revealed that SH-240 is inundated in all storm events included in the analysis. It is overtopped by 2.3 ft in the 1% ACE, and by 1.4 ft in the 10% ACE.

4. CONCEPTUAL ALTERNATIVE

The proposed alternative consists of replacing the existing one barrel 12'x5' culvert with an 82 ft span bridge. Additionally, some channel grading will be recommended to increase the size of the Wild Horse Creek channel bottom upstream and downstream of SH-240 to coincide with the increased opening and add increased conveyance in the channel. The proposed alternative is represented in the HEC-RAS model as channel modifications from cross section 7800 to cross section 6647. Lastly, the alternative proposes the road to be raised 0.5 ft for approximately 122 ft of roadway. This proposed alternative can provide a 1% ACE level of service (LOS) at this road crossing.

It is important to note that this is a conceptual high-level design, and the exact size of the bridge and channel grading may be modified during a future design phase.

4.01 OPINION OF PROBABLE CONSTRUCTION COST

The proposed project as defined in this planning level analysis has a total cost of $3,411,000. An opinion of probable construction cost (OPCC) has been included in **Table 1.**

Table 1 - Opinion of Probable Construction Cost

1	Site Preparation	20	STA	$ 3,000.00	$ 60,000
2	Traffic Control	1	LS	$ 30,000.00	$ 30,000
3	Develop and Implement SWPPP	1	LS	$ 25,000.00	$ 25,000
4	Remove Existing Asphalt Pavement	1300	SY	$ 15.00	$ 19,500
5	Remove Existing Culvert	60	LF	$ 50.00	$ 3,000
6	Remove Existing Bridge	0	LS	$ -	$ -
7	Remove Trees	0	EA	$ -	$ -
8	Excavation and Haul	8000	CY	$ 25.00	$ 200,000
9	Embankment (Fill)	10	CY	$ 30.00	$ 300
10	Rock Rip Rap	2000	SY	$ 150.00	$ 300,000
11	Lime Treatment	800	SY	$ 15.00	$ 12,000
12	Erosion Control Blankets, Hydromulch, and Topsoil	20000	SY	$ 15.00	$ 300,000
13	Temporary Irrigation	1	LS		$ 110,000
14	Concrete Pavement	800	SY	$ 95.00	$ 76,000
15	Headwalls	0	LS		$ -
16	Bridge Super Structure (50ft Width)	82	LF	$ 6,800.00	$ 557,600
17	Bridge Sub Structure (50ft Width)	82	LF	$ 4,600.00	$ 377,200
18	Concrete Approach Slab	75	CY	$ 800.00	$ 60,000
19	Sidewalks	0	SY	$ 95.00	$ -
20	Combination Rail	100	LF	$ 175.00	$ 17,500
	SUBTOTAL			(2023 COSTS)	$ 2,298,100
	SUBTOTAL			(2020 COSTS)	$ 1,980,206
	SUBTOTAL				$ 2,623,773

PROJECT TOTAL (2020 COSTS)	**$ 3,410,905**

RECURRING COSTS		
Operations & Maintenance Total (*30-year project life*)	$	3,411
ANNUAL RECURRING TOTAL (ROUNDED 2020 COSTS)	**$**	**3,411,000**

4.02 BENEFIT COST ANALYSIS

The benefit cost ratio (BCR) was determined utilizing the Benefit Cost Analysis (BCA) Input Workbook and is shown in **Table 2**. The BCR was determined to be 2.9.

Table 2 - Benefit Cost Analysis

Input Into BCA Toolkit		
Project Useful Life	**30**	
Event Damages	**Baseline**	**Project**
2 - year storm	**$6,577**	**$0**
5 - year storm	**$2,569,354**	**$0**
10 - year storm	**$2,203,429**	**$0**
25 - year storm	**$3,243,858**	**$65,381**
50 - year storm	**$3,776,128**	**$102,653**
100 - year storm	**$6,310,935**	**$109,229**
Total Benefits from BCA Toolkit	$7,660,933	
Other Benefits (Not Recreation)	$0	
Recreation Benefits	-	
Total Costs	$2,636,314	
Net Benefits	$5,024,619	
Net Benefits with Recreation	$5,024,619	
Final BCR	**2.9**	
Final BCR with Recreation	**2.9**	

5. NO NEGATIVE IMPACTS CERTIFICATION

The Technical Guidelines for Regional Flood Planning [1] require a certification of no negative impacts from an engineer. The following requirements must be met for the no negative impact certification to be met:

1. Stormwater does not increase inundation in areas beyond the public right-of-way, project property, or easement.

2. Stormwater does not increase inundation of storm drainage networks, channels, and roadways beyond design capacity.

3. Maximum increase of 1D Water Surface Elevation must round to 0.0 feet (< 0.05ft) measured along the hydraulic cross-section.

4. Maximum increase of 2D Water Surface Elevations must round to 0.3 feet (< 0.35ft) measured at each computational cell.

5. Maximum increase in hydrologic peak discharge must be < 0.5 percent measured at computational nodes (sub-basins, junctions, reaches, reservoirs, etc.). This discharge restriction does not apply to 2D overland analysis.

The No Negative Impacts Certification is provided in **Table 3**.

Table 3 - No Negative Impacts Certification

FMP Name	Wild Horse Creek
FMP Meets ALL No Negative Impacts Requirements from Exhibit C Section 3.6.A (Yes/ No)	Yes
Negative Impact Description	Not Applicable
Planning level Mitigation Plan (Yes/ No)	Not Applicable
Mitigation Plan Description	Not Applicable
No Negative Impact Determination (Yes/No)	Yes
Basis of No Negative Impact Determination (Model, Study, Engineering Judgement)	Model
Model ID	010000000014, 010000000018
Model Name	Wild Horse Creek Hydrologic Model, Wild Horse Creek Hydraulic Model
Model Submitted	Yes
Study Name and Location	Wild Horse Creek, City of Burkburnett, TX
Engineer of Record (Optional)	Freese and Nichols
Engineering Judgement Description	Not Applicable

6. CONCLUSION

The Wild Horse Creek FMP is intended to reduce flooding conditions at a low water crossing by replacing an undersized culvert with a new bridge, performing some channel grading, and elevating a segment of the roadway. Once completed, this FMP will provide a 1% ACE LOS to SH-240. As demonstrated in this technical memorandum, this FMP meets all the TWDB requirements for inclusion in the Regional Flood Plans. Therefore, the Technical Consultant team considers this FMP a feasible project that the RFPG can recommend for inclusion in the Canadian – Upper Red Regional Flood Plan.

7. REFERENCES

1. Texas Water Development Board (TWDB). Exhibit C Technical Guidelines for Regional Flood Planning, Apr. 2021, www.twdb.texas.gov/flood/planning/planningdocu/2023/doc/04_Exhibit_C_TechnicalGuidelines_April2021.pdf.
2. Army Corps of Engineers HEC-RAS User's Manual, Creating Land Cover, Manning's n values, and % Impervious Layers, May 2021, Creating Land Cover, Manning's n values, and % Impervious Layers (army.mil)

Memo

Date:	Wednesday, March 22, 2023
Project:	Region 1 (Canadian – Upper Red) Regional Flood Plan
To:	Scott Hubley, PE Wylie Minot, PE
From:	Emily Daniel, PE David Dunn, PE
Subject:	Technical Memo 1 – H&H Analysis and Modeling Approach for Randal County Culvert Analyses

Technical Memo 1

Randall County, population 140,700 as of the 2020 census, is located in the Canadian-Upper Red (Region 1) Flood Planning Area. Region 1 received additional funds in October of 2022 to evaluate additional Flood Mitigation Projects (FMPs) that could be added to the 2022 Region 1 Flood Plan adopted December of 2022.

Randall County provided the Region 1 consultant team with 12 culvert crossings to be evaluated for potential FMP status. An email was received November 16, 2022, that added two additional culverts to the scope and provided a priority order for the crossings. The culvert crossings in Table 1 are listed in order of priority according to Freese and Nichols, Inc. After consolidation, 15 sites were identified for evaluation by the county. Twelve sites were selected for evaluation to meet the scope of the contract; the remaining three sites have methodology proposed in this memo, but will not be studied in Technical Memorandum 2.

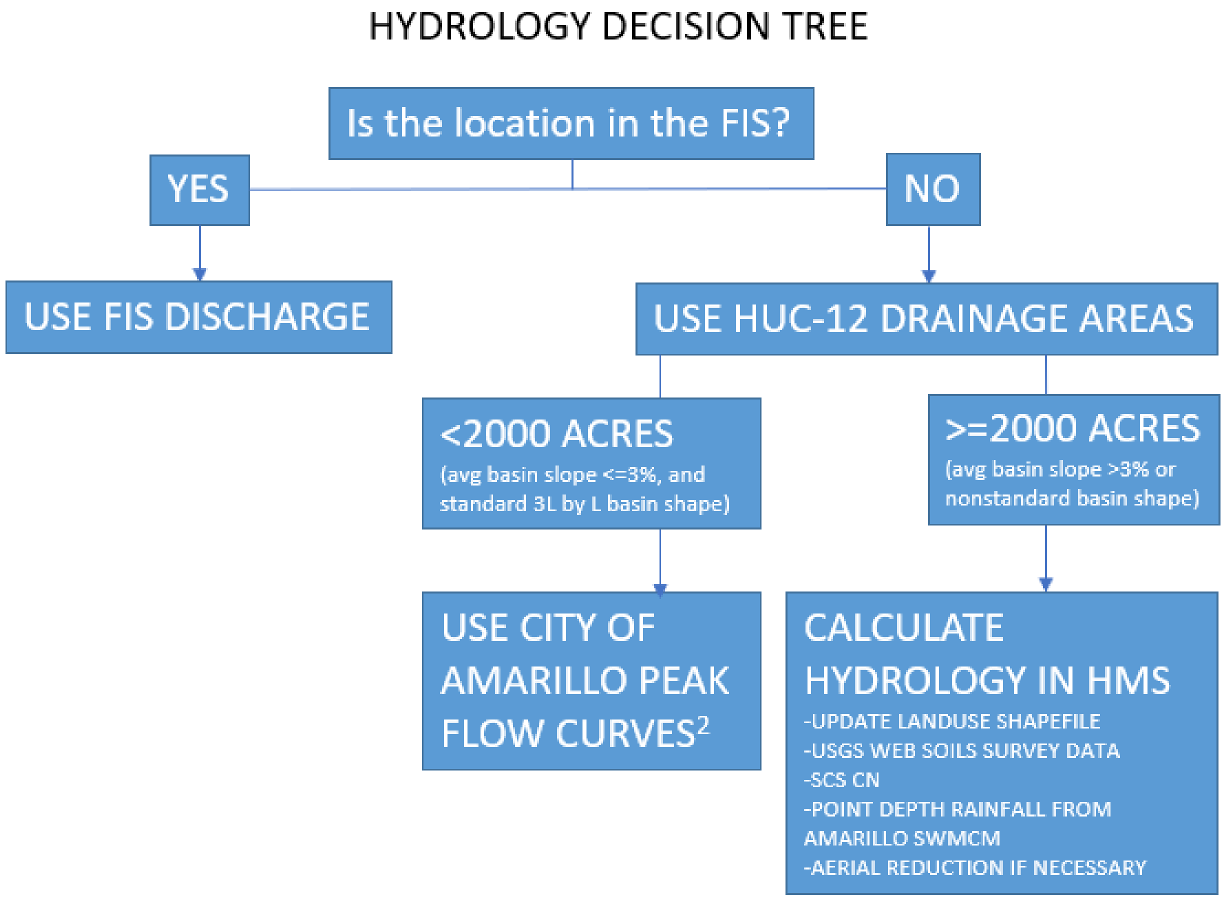
This memorandum presents the hydrologic and hydraulic analysis methodologies to be used to evaluate the culvert crossings and identify potential projects to mitigate roadway and ancillary flooding.

Hydrologic Methods

A Flood Insurance Study (FIS) was performed for Randall County and its unincorporated areas with an effective date of June 4, 2010[1]. If the crossing is located on a studied stream, the FIS discharges will be used. If the FIS doesn't include discharges at a culvert location, the following decision tree was used to determine the process for developing hydrology.

[1] FEMA, Flood Insurance Study, Randall County, Texas and Incorporated Areas, June 2010.

Figure 1. Hydrology Screening Decision Tree[2].



This analysis will evaluate the performance of the culverts under the peak discharges from the 50%, 20%, 10%, 4%, 2%, and 1% annual chance events. To determine the peak discharges for annual chance events not included in the FIS, the discharges from the FIS will be plotted on a log-probability chart, and additional annual chance events will be interpolated or extrapolated from the chart.

When FIS discharges are not available for a site, Hydrologic Unit Code (HUC)-12 drainage areas for each crossing will be used to determine drainage areas, then refined using Texas Natural Resources Information System (TNRIS) LiDAR data. The Texas Department of Transportation (TxDOT) 5' contour mapping will be used to determine average basin slope. Curve numbers will be determined using aerial imagery, a land use shapefile developed by HDR, and the US Geological Survey (USGS) web soil survey to determine hydrologic soil groups.

Watersheds Less than 2,000 Acres

Randall County does not maintain county-wide stormwater criteria. In lieu of county stormwater management guidelines, the City of Amarillo Storm Water Management Criteria Manual

[2] City of Amarillo. (2008). *Storm Water Management Criteria Manual.*

(SWMCM) will be consulted. The Amarillo SWMCM contains curves for estimating various annual chance event (ACE) peak discharges for basins with drainage areas less than 2,000 acres and average basin slopes less than 3 percent. The curves require the user to determine three parameters: drainage area (acres), average basin slope, and SCS Runoff Curve Number.

Watershed Greater than 2,000 Acres

The most current version of HEC-HMS (version 4.10) will be used to determine discharges for watersheds over 2,000 acres. TR-55 will be used for time of concentration calculations. The depth-duration-frequency data from the City of Amarillo SWMCM, as shown in Figure 2, will be used to determine rainfall depths for each storm event.

Several of the watersheds contain playa lakes that will impact flood hydrology. The playas will be modeled in series as appropriate in HMS or singularly with subdivided drainage areas for each playa and a lag routing reach to connect the playas. The TNRiS contours will be used to generate the elevation-storage curves for the playas, and outflow will be computed as a large overflow weir where the contours indicate that flow exits the playa and spills downstream. Should this approach in HEC-HMS prove insufficient at some sites, a simple ICPR[3] model may be developed.

When a crossing is located in an area that is determined to be inundated by a playa, inflows to the playa and water surface elevations will be evaluated using HEC-HMS or the FIS, as appropriate.

Figure 2. Depth-Duration-Frequency Table from the Amarillo SWMCM.

TABLE 2-6 Depth-Duration-Frequency Data for Amarillo, Texas

Duration (Min)	Rainfall Depth (inches) Frequency 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
5	0.45	0.54	0.60	0.69	0.77	0.84
10	0.69	0.86	0.97	1.14	1.28	1.41
15	0.85	1.08	1.23	1.46	1.64	1.81
30	1.18	1.53	1.77	2.12	2.38	2.65
60	1.52	2.00	2.33	2.80	3.16	3.52
120	1.65	2.15	2.48	3.00	3.37	3.80
180	1.80	2.30	2.65	3.20	3.63	4.01
360	2.15	2.75	3.15	3.65	4.20	4.70
720	2.40	3.10	3.55	4.05	4.70	5.20
1,440	2.72	3.45	3.96	4.49	5.23	5.79

[3] https://streamnologies.com/content/index.php/about-icpr-4/

Hydraulic Analyses

The hydraulic analysis approach will be determined by the location of each crossing.

Crossings Located in Playa Lakes

Crossings that are within a playa lake will be analyzed using HEC-HMS (version 4.10). The storage and routing will be modeled utilizing the playa lake elevation-area rating curves developed using 2018 TNRIS LiDAR data. The playa lakes will be modeled by assuming dry initial conditions and determining the peak pool elevation for each ACE.

Some of the playa lakes in Randall County are included in the FIS. Table 2 in the FIS, as shown below as Figure 3, summarizes the water surface elevations in the playa lakes studied within the limits of Randall County. Playa lakes that are associated with one or more of the culvert locations to be evaluated are noted in the figure.

Figure 3. Summary of Playa Lake Elevations Included in the FIS.

Table 2. Summary of Elevations

FLOODING SOURCE AND LOCATION	ELEVATION ABOVE NAVD (feet)				
	10% annual chance	2% annual chance	1% annual chance	0.2% annual chance	
PLAYA LAKES					
#3	3706.5	3708. 9	3710.0	3712.2	
#4	3697.1	3698.8	3699.5	3701.7	
#5 (McDonald Lake)	3681.1	3685.8	3687.0	3690.2	
#6 (Lawrence)	3609.2	3627.0	3628.4	3632.6	
#7	3673.7	3674.8	3675.2	3676.2	77th and Soncy
#8	3678.0	3679.7	3680.3	3681.6	
#9 (Spring Draw)	--*	--*	3682.7	--*	
#11	3643.9	3645.3	3645.8	3647.2	
#13	3624.1	3625.3	3625.8	3626.8	
#14 (Diamond Horseshoe Lake)	3655.1	3657.3	3658.2	3660.0	
#15 (McCarty Lake)	3624.4	3626.0	3626.7	3627.8	
#16 (Willow Grove Lake)	3631.0	3632.6	3633.1	3634.3	
#17 (Bennett Lake)	3638.2	3642.3	3642.9	3644.2	
#18	3580.4	3582.4	3583.0	3584.2	Tradewind and Farmers
#19 (Santa Fe Lake)	3634.3	3636.8	3637.6	3639.4	
#20 (Gooch Lake)	3576.3	3578.2	3578.9	3580.7	58th and Grand
#34	3550.0	3551.9	3552.6	3554.3	

--* Data not available

The additional ACE events (not provided by the FIS) will be computed by plotting known ACE elevations on an arithmetic-probability graph and interpolating/extrapolating additional ACE elevations.. The elevations for all events will be compared to the roadway elevation determined from the 2018 TNRIS LiDAR to determine if the crossing is inundated from runoff captured in a playa.

For playa lakes not in the FIS, the computed ACE hydrographs will be routed in HEC-HMS through an updated elevation-storage relationship utilizing the 2018 TNRIS LiDAR. The water surface results in HEC-HMS will determine if the crossing is inundated from runoff captured in a playa.

Riverine Systems

Crossings located on riverine systems will be modeled utilizing 1-D HEC-RAS (version 6.3) using seven cross sections – 3 upstream and 4 downstream with a culvert crossing. Cross section geometry will be extracted from the 2018 TNRIS LiDAR. Crossing sizes are provided by Freese and Nichols field investigation. The models will extend no further than 1,500 feet upstream and downstream of each crossing. Manning's n values will be determined from photos taken by Freese and Nichols during site visits, supplemented with aerial imagery when necessary. Downstream starting water surface profile slopes will be estimated using watershed slopes downstream of the crossing.

The culvert crossings will be evaluated for the degree of structural inundation and roadway overtopping, and the results of the hydraulic analyses will be described in Technical Memo #2.

A summary of the methodologies to be used is shown in Table 1.

Table 1. Culvert Crossings to be Analyzed.

Priority Number	Culvert Crossing name/Location	Drainage Area		Crossing Type	Hydrologic Method	Hydraulic Method
		acres	mi^2			
1	West Rockwell Road and Soncy Road	25,728	40.2	Riverine	FIS	HEC-RAS
2	Happy West Road and Bell Street	23,984	37.5	Riverine	HEC-HMS	HEC-RAS
3	Hix Drive and FM 217	2,186	3.4	Riverine	HEC-HMS	HEC-RAS
4	Country Club Road - East of i-27	34,013	53.1	Riverine	HEC-HMS	HEC-RAS
5	Arnot	697	0.8	Playa	HEC-HMS	HEC-HMS
6	Westline Road	523,955	818.7	Riverine	HEC-HMS	HEC-RAS
7	77th and Soncy	1,205	1.9	Playa	FIS	FIS elevations
8	Running Water Road and FM 1714	2,312	3.6	Riverine	HEC-HMS	HEC-RAS
9	Hill and 46th	3,270	5.1	Playa	HEC-HMS	HEC-HMS
10	Bushland, South of FM 2186	4,301	6.7	Playa	HEC-HMS	HEC-HMS
11	Gordon Cummings Road LWC	474,266	741.0	Riverine	FIS	HEC-RAS
12	Tradewinds and Farmers	5,156	8.1	Playa	FIS	FIS elevations
13	58th and Grand	564	0.9	Playa	HEC-HMS	HEC-RAS/HEC-HMS
14	Whitaker and FM 1151	916	1.4	Playa	HEC-HMS	HEC-HMS
15	Juet Atterbury and FM 1151	3,227	5.0	Playa	HEC-HMS	HEC-HMS

1. West Rockwell Road and Soncy Road

This crossing is located on Spring Draw approximately 3.0 miles upstream of the confluence with Palo Duro Creek and has been identified as 2-30'' pipes.

Hydrology

Discharge data for this crossing can be found in the FIS. Additional annual chance events will be interpolated/extrapolated from the log-probability curve developed from the FIS data.

Hydraulics

A HEC-RAS model will be created utilizing 2018 TNRIS LiDAR and the FIS discharges

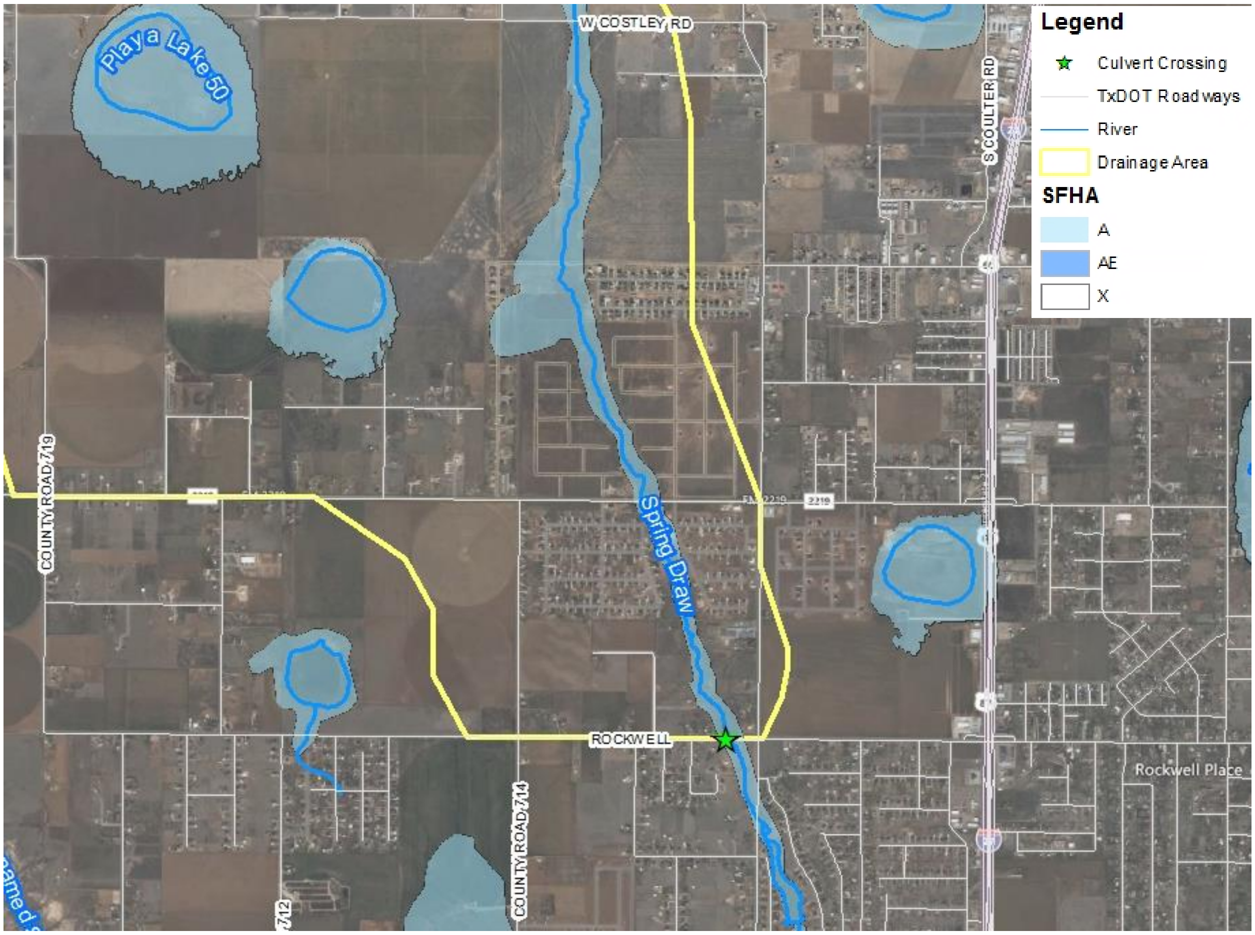


Figure 1: West Rockwell Rd & Soncy Rd Crossing
Source of Aerial Imagery: 2023 Bing Maps

2. Happy West Road and Bell Street

This crossing is located along Happy Draw approximately 3.5 miles upstream of IH-27 and has been characterized by Randal County as old failing boxes.

Hydrology

Happy Draw does not have FIS data. Its drainage area is greater than 2,000 acres and hydrology will be determined using HEC-HMS.

Hydraulics

A HEC-RAS model will be created utilizing 2018 TNRIS LiDAR and discharges determined by HEC-HMS. The culvert crossing will be modeled as outlined in the hydraulic section of this memo.

Figure 2: Happy West Road and Bell Street Crossing
Source of Aerial Imagery: 2023 Bing Maps

3. Hix Drive and FM 217

This crossing is located along an unnamed stream approximately 0.5 miles upstream of the confluence with Tierra Blanca Creek.

Hydrology

The unnamed stream does not have FIS data. Its drainage area is greater than 2,000 acres and hydrology will be determined using HEC-HMS. Note that Hix Drive is also referred to as County Road 634.

Hydraulics

A HEC-RAS model will be created utilizing 2018 TNRIS LiDAR and the computed discharges. The culvert crossing will be modeled as outlined in the hydraulic section of this memo.

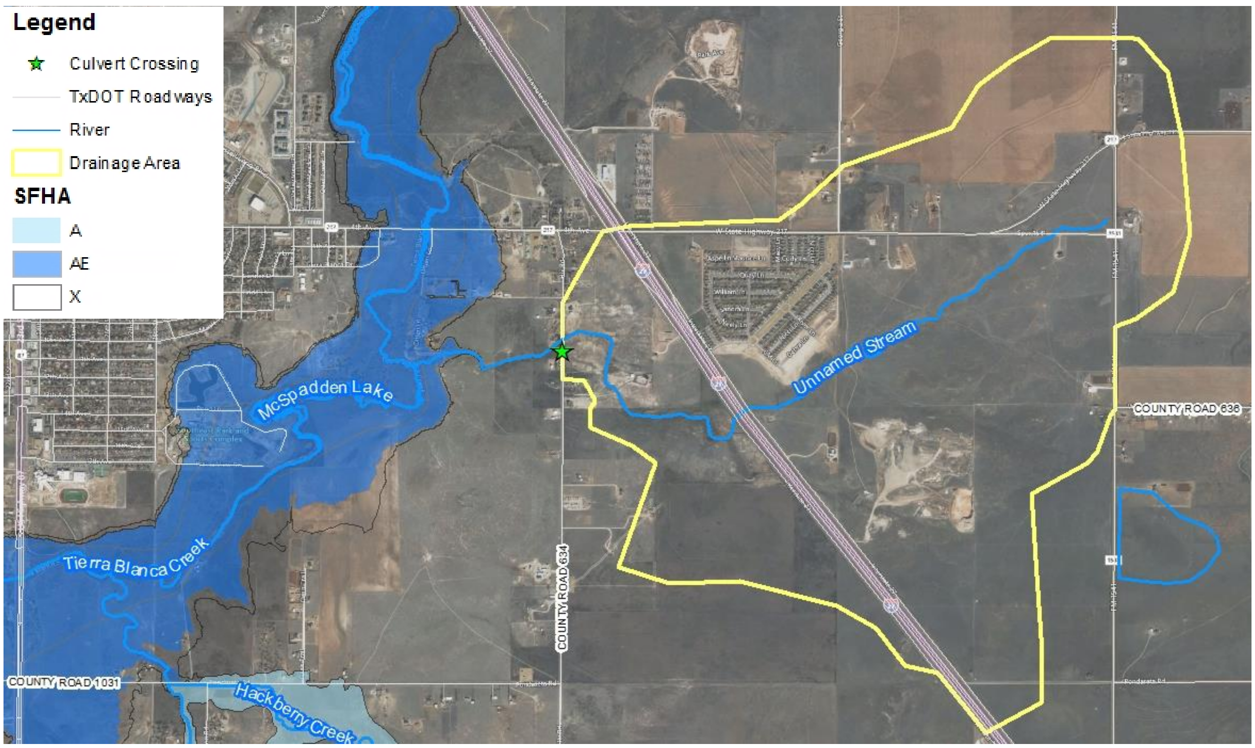


Figure 3: Hix Drive and FM 217 Crossing
Source of Aerial Imagery: 2023 Bing Maps

4. Country Club Road - East of I-27

This crossing is located along an unnamed stream approximately 1.0 mile upstream of the confluence with Prairie Dog Town Fork Red River.

Hydrology

The unnamed stream does not have FIS data. The drainage area is greater than 2,000 acres and hydrology will be determined using HEC-HMS.

Hydraulics

A HEC-RAS model will be created utilizing 2018 TNRIS LiDAR and the computed discharges. The culvert crossing will be modeled as detailed in the hydraulic section of this memo.

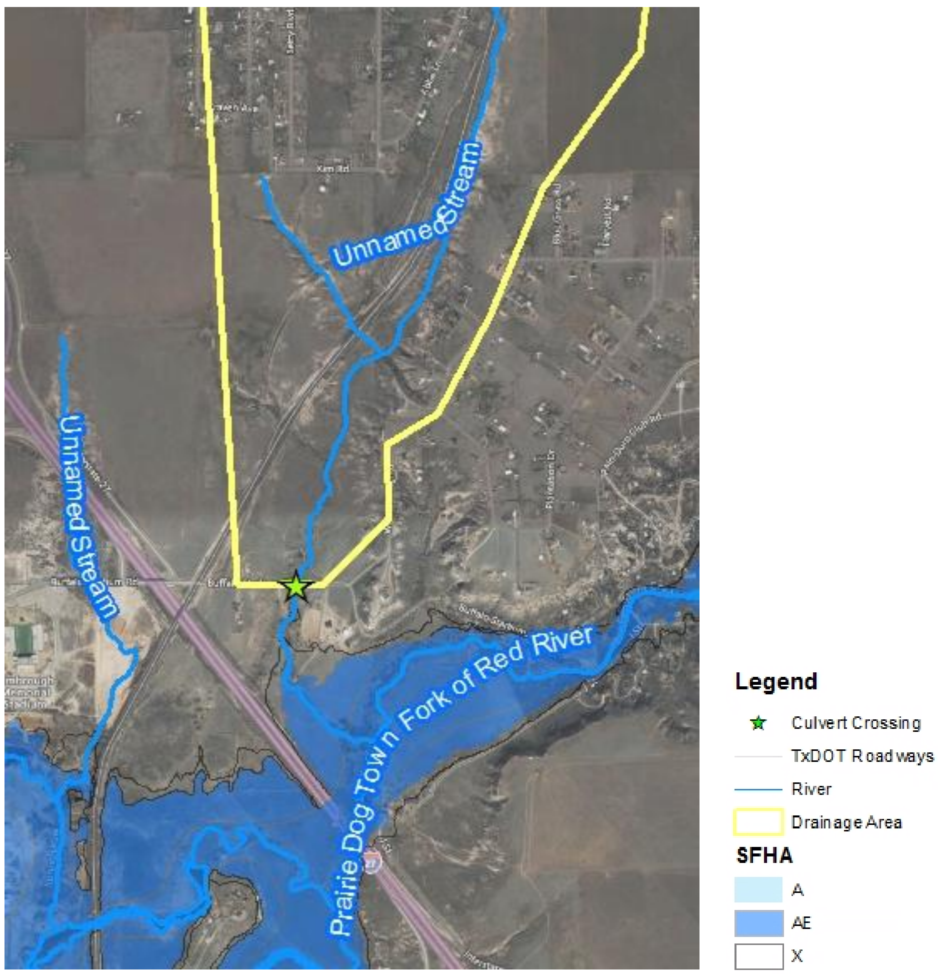


Figure 4: Country Club Road Crossing
Source of Aerial Imagery: 2023 Bing Maps

5. Arnot Rd

This crossing is located west of Playa Lake 54.

Hydrology

There is no available hydrology. The drainage area to this location is greater than 2,000 acres and hydrology will be determined using HEC-HMS.

Hydraulics

A HEC-HMS model will be utilized to model the crossing with a rating curve for Playa Lake 54. If the playa water surface elevations do not flood the Arnot Road crossing, a HEC-RAS model might be developed if appropriate for the hydraulic conditions.

Figure 5: Arnot Crossing
Source of Aerial Imagery: 2023 Bing Maps

6. Westline Road

Westline Road is on Palo Duro Creek near the border of Deaf Smith and Randall Counties.

Hydrology

Palo Duro Creek is included in the FIS, and the FIS discharges will be used for all ACEs. Additional ACEs will be interpolated/extrapolated from the log-probability curve developed from the FIS data.

Hydraulics

A HEC-RAS model will be created utilizing 2018 TNRIS LiDAR and the FIS discharges.

Figure 6: Westline Road Crossing
Source of Aerial Imagery: 2023 Bing Maps

7. 77th and Soncy

The crossing at 77th and Soncy is downstream of Playa Lake 7.

Hydrology

The FIS study does not provide flow data for Playa Lake 7 but does provide peak water surface elevations for the various ACEs.

Hydraulics

Playa Lake 7 is included in the FIS and the water surface elevations can be found in Figure 3 (Table 2 of the FIS) . The water surface elevations resulting from the ACEs in the FIS will be used to determine inundation levels of the culvert and roadway. Water surface elevations for ACEs not included in the FIS will be interpolated from the FIS data.

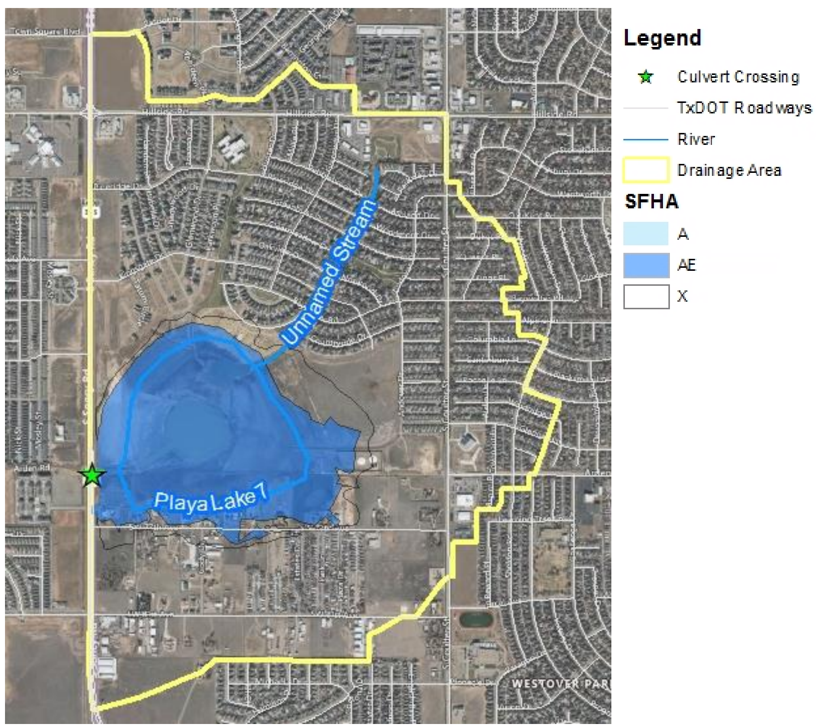


Figure 7: 77th and Soncy Crossing
Source of Aerial Imagery: 2023 Bing Maps

8. Running Water Road and FM 1714

Running Water Road (also known as County Road 603) and FM 1714 is on an unnamed tributary to Hackberry Creek 0.2 miles upstream of U.S 87.

Hydrology

The estimated drainage area to this location is greater than 2,000 acres and the hydrology will be determined using HEC-HMS.

Hydraulics

A HEC-RAS model will be created utilizing 2018 TNRIS LiDAR and computed discharges. The culvert crossing will be modeled as detailed in the hydraulic section of this memo.

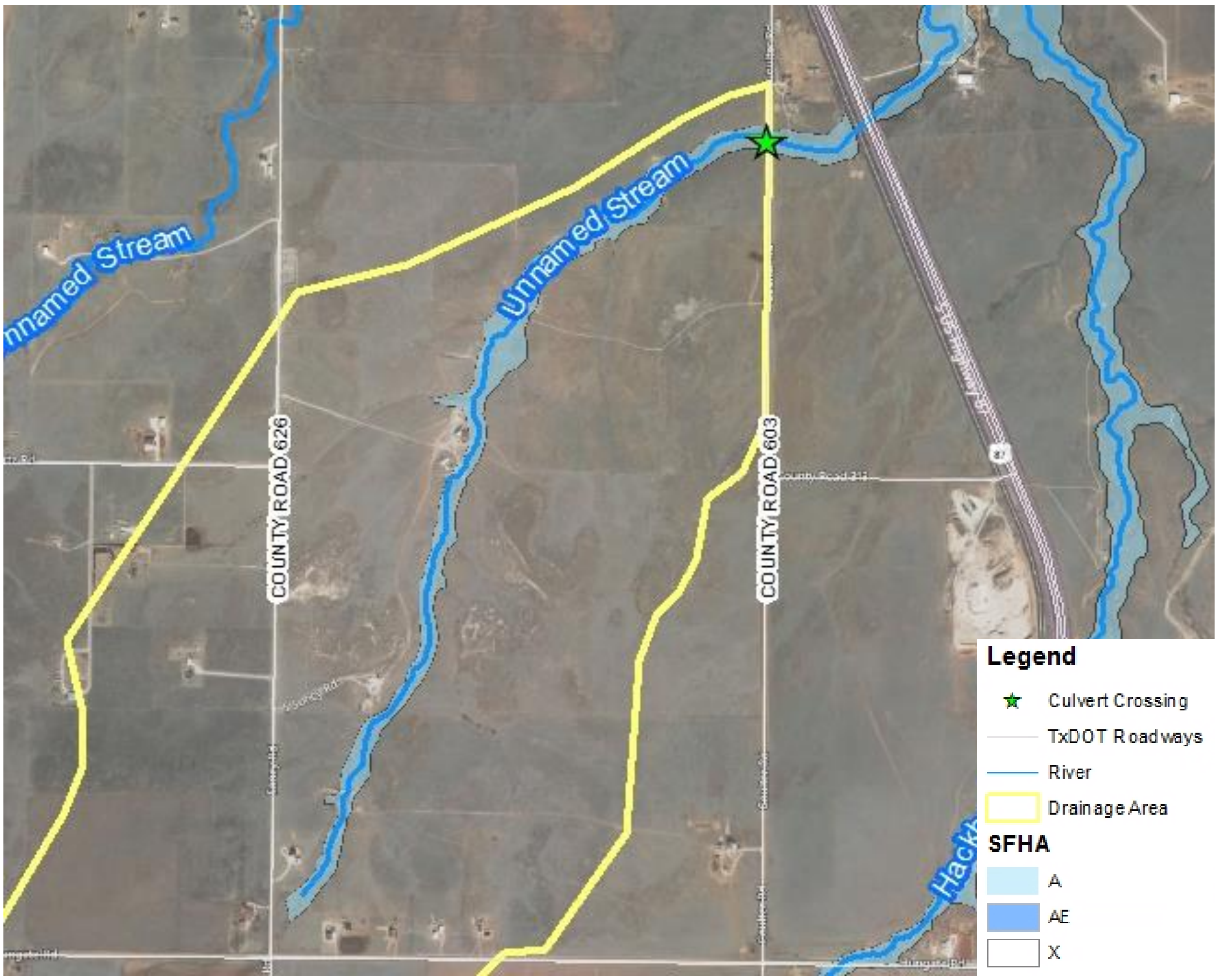


Figure 8: Running Water and FM 1714 Crossing
Source of Aerial Imagery: 2023 Bing Maps

9. Hill and 46th

This crossing is located on the edge of Playa Lake 53.

Hydrology

There is no available hydrology. The estimated drainage area to this location is greater than 2,000 acres and the hydrology will be determined using HEC-HMS.

Hydraulics

The HEC-HMS model will be utilized to model the crossing by updating the playa lake rating curves.

Figure 9: Hill and 46th Crossing
Source of Aerial Imagery: 2023 Bing Maps

10. Bushland, South of FM 2186

This crossing is located within an unnamed playa lake 2.0 miles west of the intersection between Sampson Rd and Black Arroyo.

Hydrology

The estimated drainage area to this location is greater than 2,000 acres and the hydrology will be determined using HEC-HMS.

Hydraulics

The HEC-HMS model will be utilized to model the crossing by updating the playa lake rating curves and defining the pond element outlet structure as described in the hydraulics section of this memo. If the water surface elevation of the playa lake floods the upstream neighborhood, a HEC-RAS model of the ditch along Bushland Road will be developed.

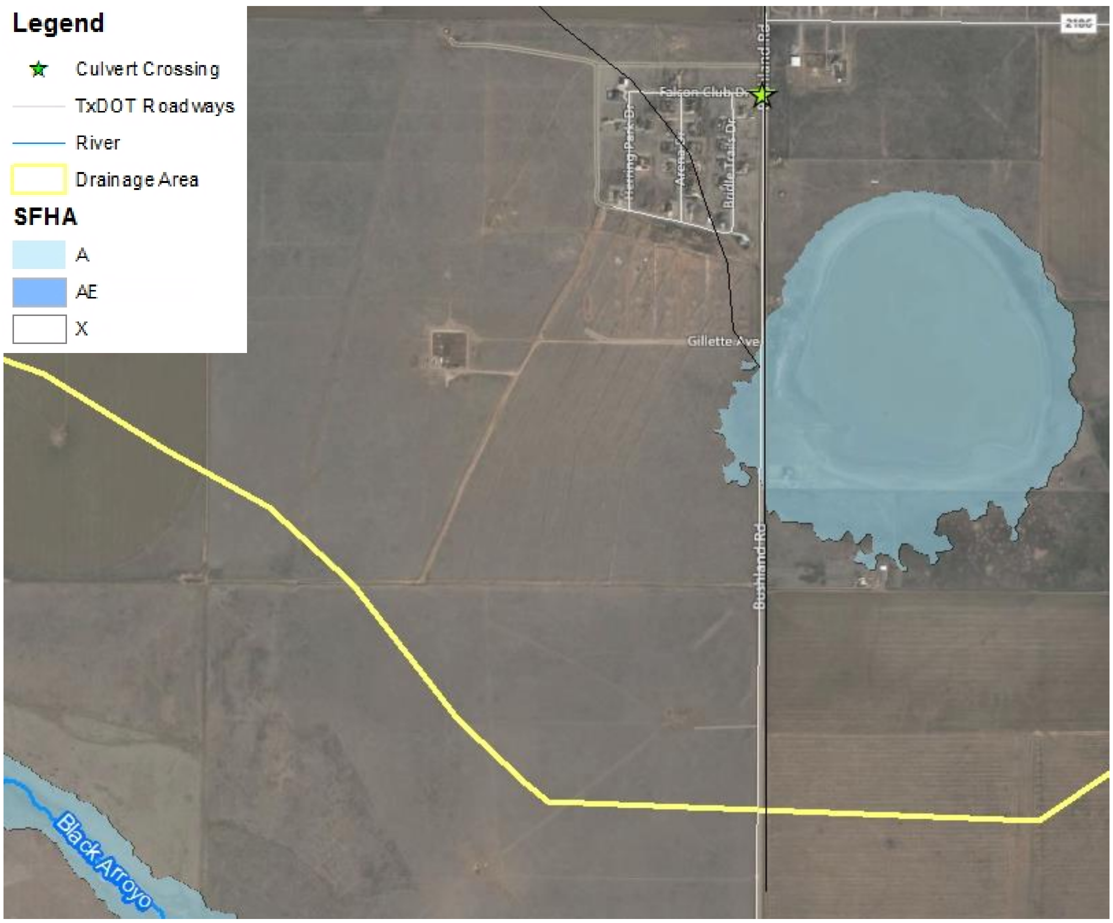


Figure 10: Bushland Crossing
Source of Aerial Imagery: 2023 Bing Maps

11. Gordon Cummings Road Low Water Crossing

This crossing is along Tierra Blanca Creek on County Rd 638.

Hydrology

Tierra Blanca Creek is included in the FIS, therefore the FIS discharges will be used for all ACEs. Additional ACEs will be interpolated/extrapolated from the log-probability curve developed from the FIS data.

Hydraulics

A HEC-RAS model with 7 cross-sections (as outlined previously) will be created utilizing 2018 TNRIS LiDAR and the FIS discharges.

Figure 10: Gordon Cummings LWC
Source of Aerial Imagery: 2023 Bing Maps

12. Tradewinds and Farmers

The Tradewinds crossing is located within Playa Lake 18 in the northeast quadrant of Loop 335 and S Washington St.

Hydrology

The FIS study does not provide hydrologic data for Play Lake 18 but does provide peak water surface elevations for the various ACEs.

Hydraulics

Playa Lake 18 is included in the FIS and the water surface elevations can be found in Table 2 of the FIS as shown in the hydraulics section of this memo. Those FIS elevations will be used to determine the inundation of the culvert and roadway. Water surface elevations for annual chance events not included in the FIS will be interpolated from the FIS elevations.

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Figure 12: Tradewinds Crossing
Source of Aerial Imagery: 2023 Bing Maps

13. 58th and Grand

58th street (aka County Road 740) and Grand Street is downstream of Playa Lake 20 in the northeast quadrant of S Osage St and 58th Street.

Hydrology

Playa Lake 20 is included in the FIS study. The FIS elevations will be used to determine if any of the ACEs inundate the crossing. If the ACEs don't inundate the crossing, a HEC-RAS model may be required.

Hydraulics

The HEC-HMS model will be utilized to model the crossing with playa lake rating curves developed using TNRIS LiDAR data, and a HEC-RAS model might be developed if necessary.

Figure 13: 58th and Grand Crossing
Source of Aerial Imagery: 2023 Bing Maps

14. Whitaker and FM 1151

This crossing is within Playa Lake 64 and is identified by Randall County as a clogged equalizer culvert.

Hydrology

Playa inflows will be determined using HEC-HMS.

Hydraulics

A HEC-HMS model will be utilized to model the crossing by developing playa lake rating curves from TNRIS LiDAR data.

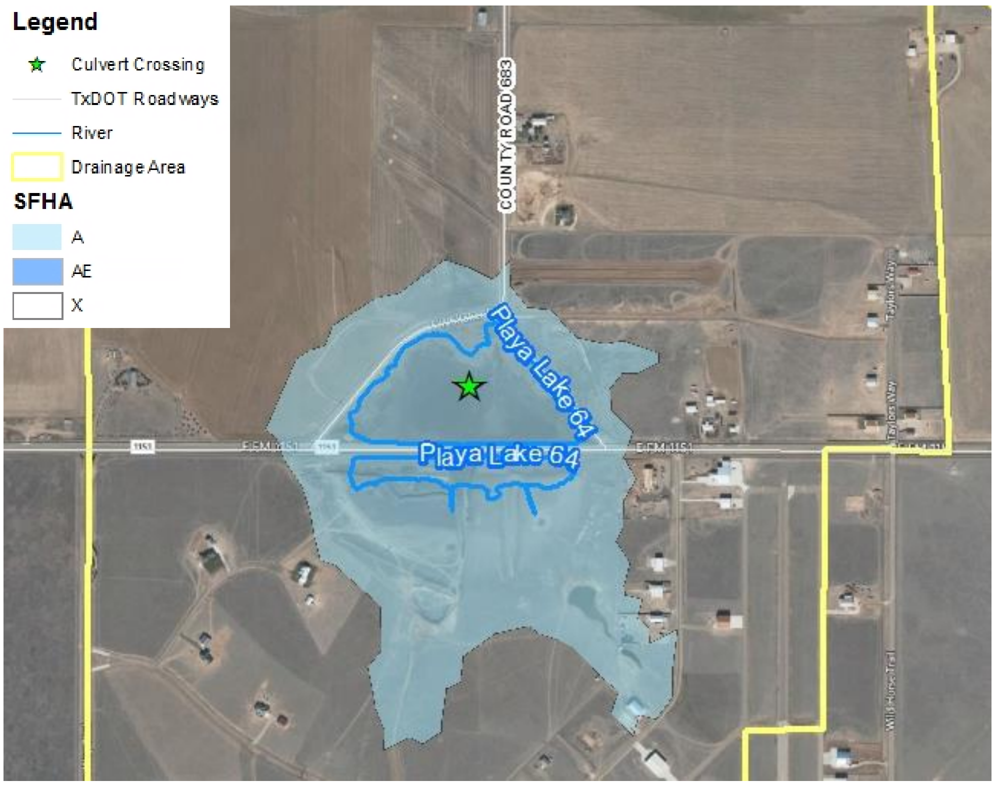

Figure 14: Whitaker and FM1151 Crossing
Source of Aerial Imagery: 2023 Bing Maps

15. Juet Attebury and FM 1511

The Juet Attebury and FM 1511 location is in the middle of an unnamed playa southeast of Amarillo.

Hydrology

The crossing appears to be on the downstream end of its HUC-12 drainage area and several cascading playas. HEC-HMS will be used to determine ACE hydrology.

Hydraulics

HEC-HMS will be utilized to model the crossing using playa lake rating curves developed from TNRIS LiDAR data.

The cascading playas could contribute flows to the unnamed playa. If acceptable to the flood planning group, an ICPR model would be used to model the playas in series if funds are available. Note that this is the lowest priority site and might not be evaluated.

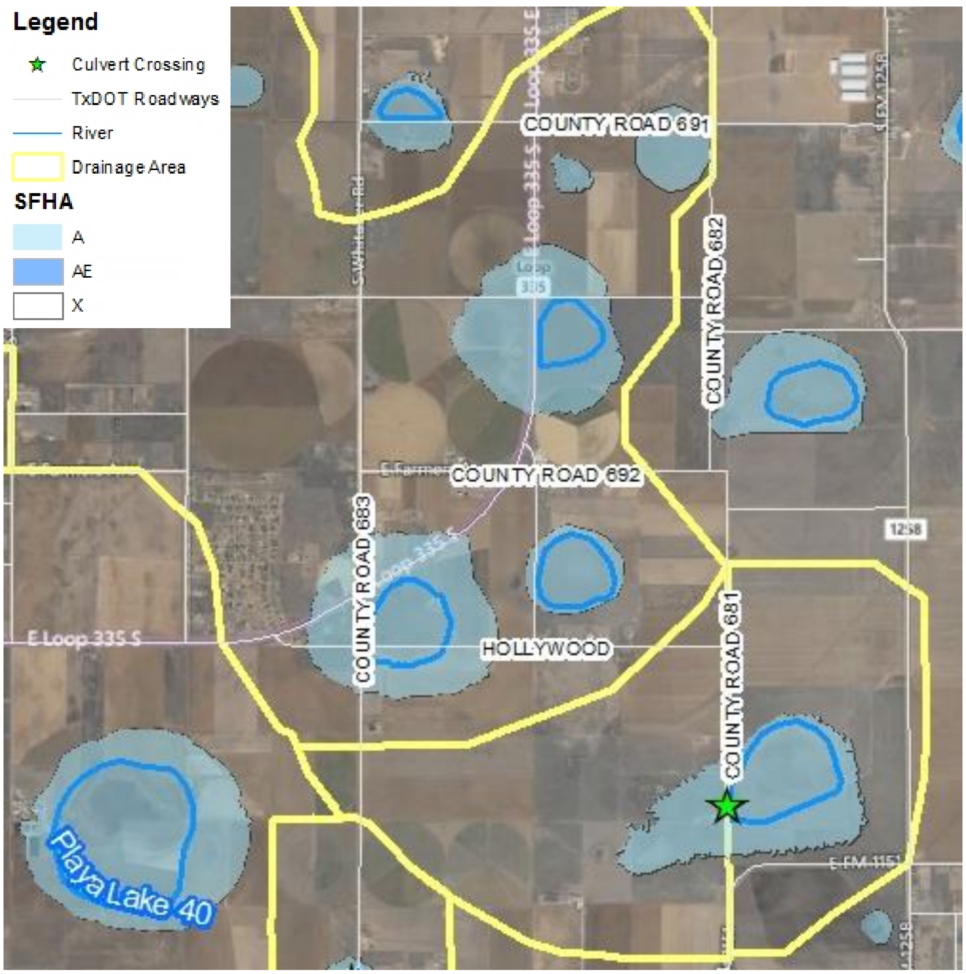

Figure 16: Juet Attebury and FM1511 Crossing
Source of Aerial Imagery: 2023 Bing Maps

Memo

Date:	Thursday, May 18, 2023
Project:	Region 1 (Canadian – Upper Red) Regional Flood Plan
To:	Scott Hubley, PE Wylie Minot, PE
From:	Emily Daniel, PE David Dunn, PE
Subject:	Technical Memo 2 – H&H Existing Conditions Analysis and Modeling Results for Randall County Culvert Analyses

Technical Memo 2

In Technical Memo 1 (TM1), dated March 22, 2023, Randall County provided the Region 1 consultant team with 15 culvert crossings to be evaluated for potential FMP status. In TM1, hydrologic and hydraulic analysis methodologies were determined to evaluate the culvert crossings and identify potential projects to mitigate roadway and ancillary flooding.

This memorandum presents the results of the existing conditions models of the various culvert crossings that were evaluated in Technical Memo 1. For more information regarding hydrologic and hydraulic methodologies for each culvert crossing, please refer to Technical Memo 1. Recommendations for proposed hydraulic improvements will be evaluated in the next memo.

Methodology 1: Flood Insurance Study Discharges for Studied Streams

Determination of Peak Discharges

Three of the culvert crossings are located on studied streams in the Flood Insurance Study (FIS) performed in Randall County. Figure 1 presents Table 1 of the FIS which provides a summary of the peak discharges for the 10%, 2%, 1%, and 0.2% annual chance events (ACE). Highlighted rows in the table indicate streams studied in the FIS that coincide with streams identified by Randall County for analysis.

Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet Per Second) 10-percent	2-percent	1-percent	0.2-percent
PALO DURO CREEK					
At Atchison, Topeka, and Santa Fe Railway	214	5,900	13,600	17,700	32,300
PRAIRIE DOG TOWN FORK OF RED RIVER					
Downstream of Palo Duro Club Dam	1,106	9,100	21,700	29,200	57,250
Upstream of Palo Duro Club Dam	1,088	9,400	22,350	30,200	58,200
SPRING DRAW					
At the confluence with Palo Duro Creek	20	2,400	4,700	6,000	9,950
TIERRA BLANCA CREEK					
Downstream of the confluence of Hackberry Creek	853	8,250	17,000	21,700	38,500
At U.S. Highway 87	825	5,600	11,750	17,150	38,500

Figure 1. Randall County FIS Table 1 - Summary of Discharges.

Technical Memo 1 states that each culverts' performance is to be evaluated for the peak discharges resulting from the 50%, 20%, 10%, 4%, 2%, and 1% ACEs. The FIS only provides the 10%, 2%, and 1% ACEs, thus the 50%, 20%, and 4% ACEs are interpolated and/or extrapolated from the ACEs provided in the FIS. To extrapolate the remaining ACEs, peak discharges (cfs) vs. exceedance probability (percent) were plotted on a 2-cycle log-probability graph of the four available ACEs in the FIS. The data points were used to create a linear "best-fit" line, where the remaining ACE peak discharges could be interpolated and/or extrapolated for the studied creek. An example of this process for Palo Duro Creek is shown below. The blue points are the discharges taken from the FIS summary table, and the red points are the extrapolated/interpolated discharges for the three other ACEs.

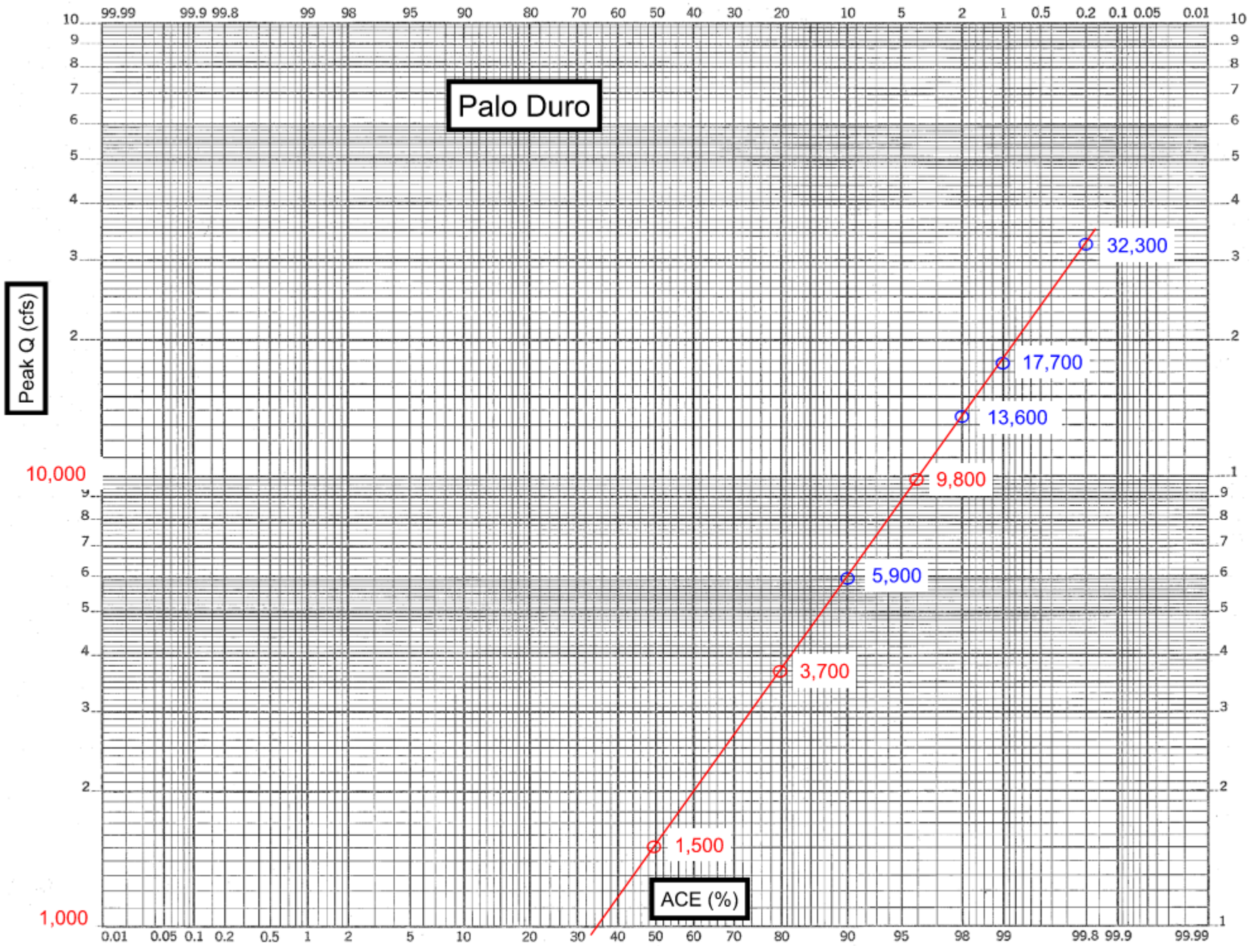

Figure 2. Example extrapolation/interpolation of FIS peak discharges.

Additionally, the summary table provided by the FIS provides location where the discharge was determined. In all cases, the location of the FIS discharges flows was downstream of the location selected by the County and have larger contributing drainage areas. To calculate the peak discharge at each culvert crossing, a transposition of peak flow was performed for each crossing using the drainage area ratio method suggested by the Texas Department of Transportation's (TxDOT) Hydraulic Design Manual (2019), as shown in Figure 3.

$$Q_1 = Q_2\sqrt{\frac{A_1}{A_2}}$$

Equation 4-10.

Where:

- Q_1 = Estimated AEP discharge at ungauged watershed 1 — Estimated Peak Discharge for Culvert
- Q_2 = Known AEP discharge at gauged watershed 2 — FIS Peak Discharge
- A_1 = Area of watershed 1 — Drainage Area to Culvert
- A_2 = Area of watershed 2 — Drainage Area to FIS Location

Figure 3. TxDOT procedure for drainage area ratio transposition of peak discharges.

Hydraulic Analysis

A one-dimensional steady state hydraulic model was created in HEC-RAS for each culvert crossing using 2018 TNRIS LiDAR data and stream crossing field data provided by Freese & Nichols, Inc. on February 22nd, 2023. The crossing flowline was estimated using the top of road elevation taken from LiDAR and the corresponding cover and culvert/bridge opening height from FNI field data. The channel slope from each end of the crossing was calculated and used to approximate the downstream flowline. Cross-sections were cut using LiDAR data and if applicable, were adjusted to match the crossing field data. The steady flow file contains the ratioed peak discharges for the six ACEs. The existing conditions hydraulic modeling results for the culvert crossings found on the studied streams are below.

Site 1. West Rockwell Road and Soncy Road at Spring Draw

This crossing is located on Spring Draw approximately 3.0 miles upstream of the confluence with Palo Duro Creek as shown in Figure 4 and has been identified as two 36’’ pipes. The transposition of the FIS peaks discharges to this crossing are shown in Table 1.

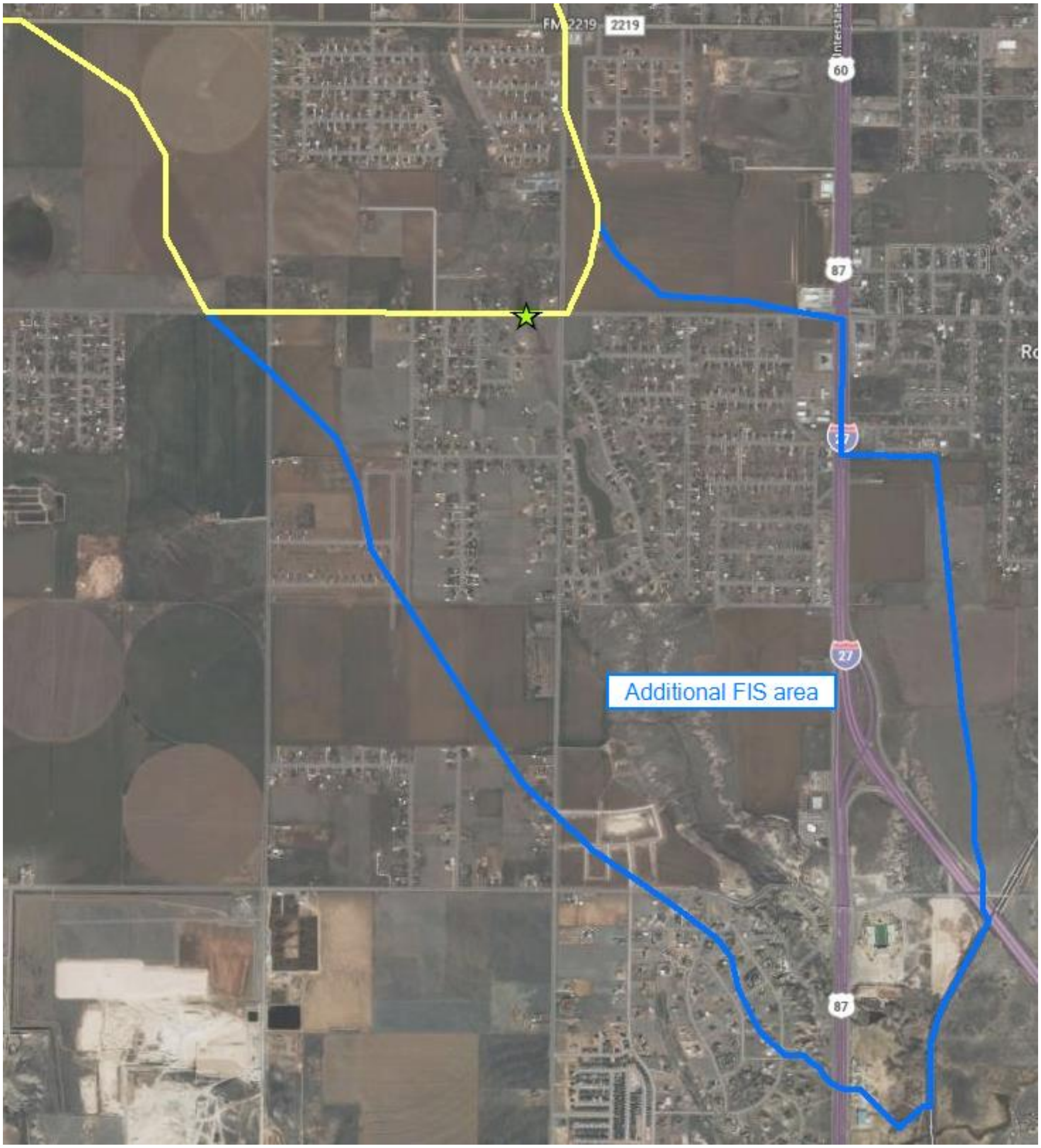

Figure 4. Locations of West Rockwell and Soncy Road culvert and corresponding FIS discharge location.

Table 1. Transposition of FIS discharges to West Rockwell Road crossing of Spring Draw.

West Rockwell Road & Soncy Road - Spring Draw							
Area (sq mi)	**To Culvert Crossing (A_1)**		40.20	**To FIS Location (A_2)**		44.39	
ACE	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**$\sqrt{(A_1/A_2)}$**
FIS Q_2 (cfs)	720	1,600	2,400	3,650	4,700	6,000	***0.952***
Ratio Q_1 (cfs)	***685***	***1,523***	***2,284***	***3,474***	***4,473***	***5,710***	

Based on the hydraulic model using the peak discharges in the table above, the culvert crossing is unable to convey the peak flow from all six ACEs and the West Rockwell Road is overtopped and flooded in each storm event modeled. The upstream cross-section of the culvert crossing is shown in Figure 5.

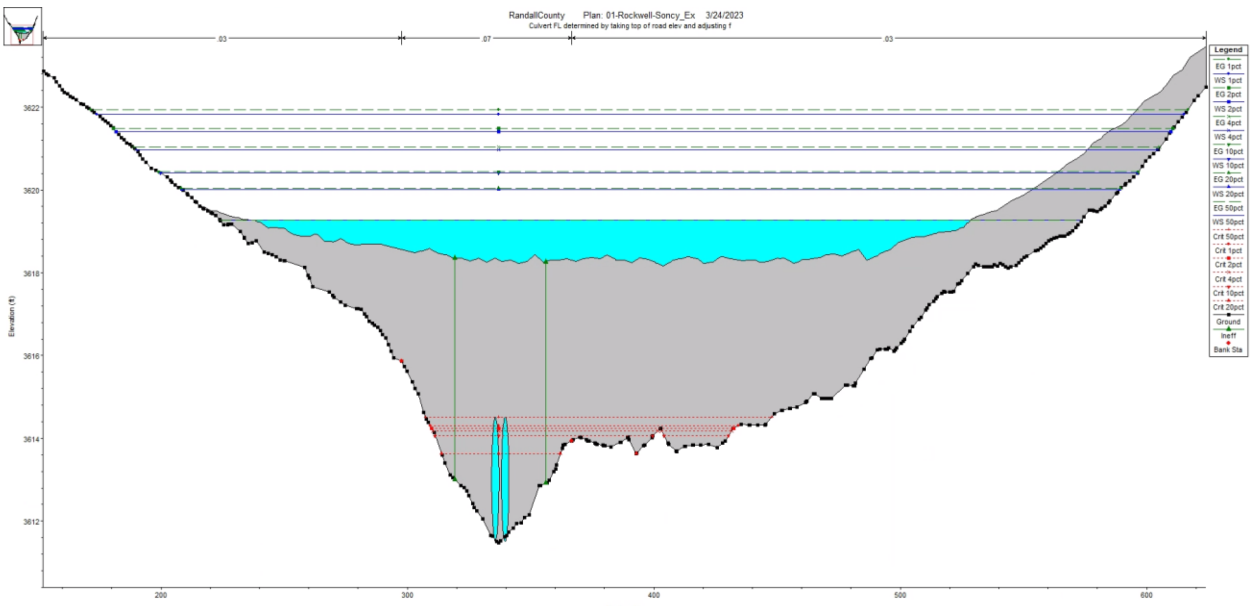

Figure 5. Upstream cross section at West Rockwell Road crossing of Spring Draw.

Site 6. Westline Road at Palo Duro Creek

Westline Road crosses Palo Duro Creek near the border of Deaf Smith and Randall Counties as show in Figure 6 and has been identified as a 100-foot-long bridge. The transposition of the FIS peaks discharges to this crossing are shown in Table 2.

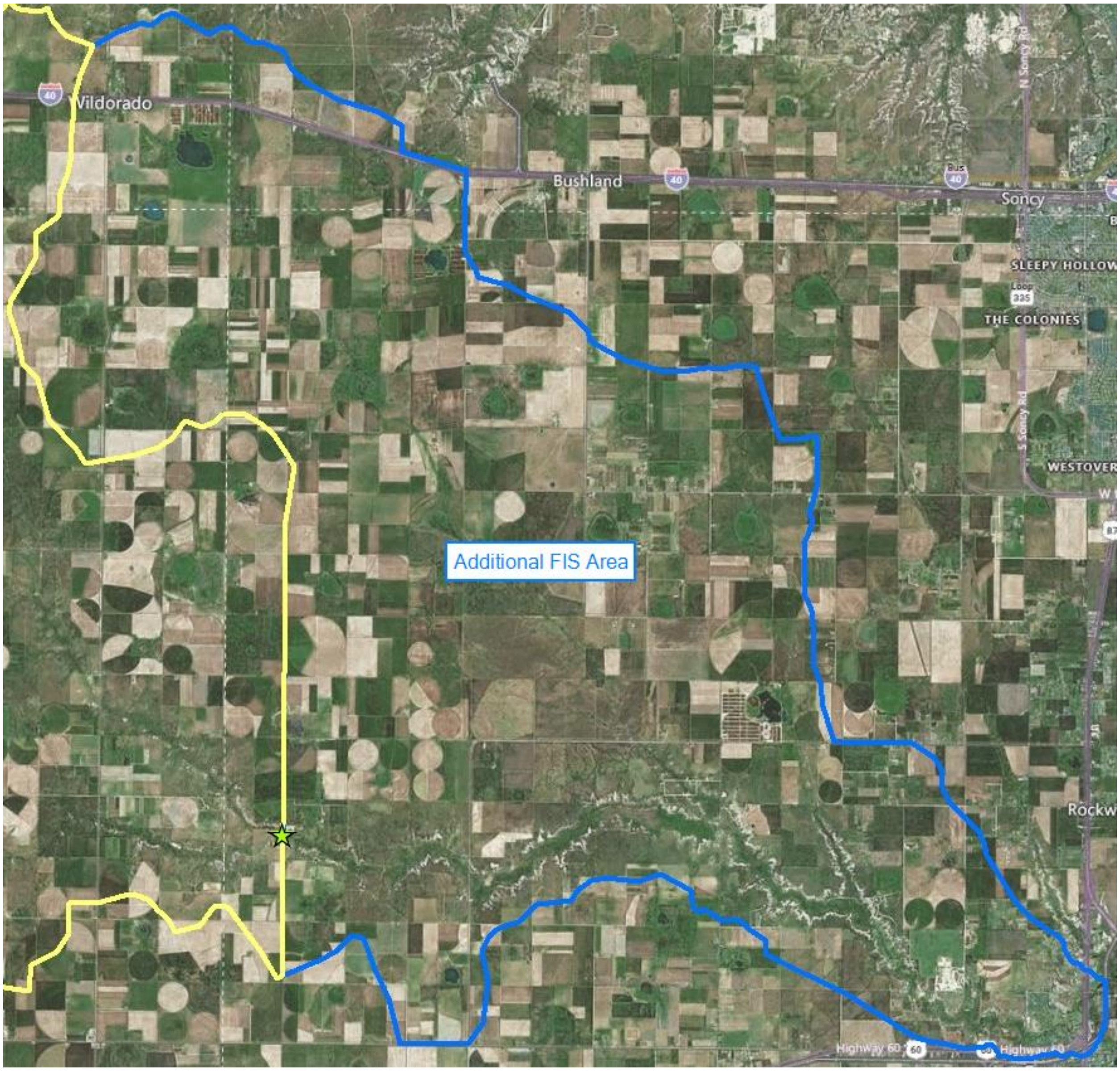

Figure 6. Locations of Westline Road culvert and corresponding FIS discharge location.

Table 2. Transposition of FIS discharges to Westline Road crossing of Palo Duro Creek.

Westline Road - Palo Duro Creek							
Area (sq mi)	**To Culvert Crossing (A_1)**		818.68	**To FIS Location (A_2)**		954.94	
ACE	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**$\sqrt{(A_1/A_2)}$**
FIS Q_2 (cfs)	1,500	3,700	5,900	9,800	13,600	17,700	***0.926***
Ratio Q_1 (cfs)	***1,389***	***3,426***	***5,463***	***9,074***	***12,592***	***16,389***	

Based on the hydraulic model using the peak discharges in the table above, the bridge crossing is unable to convey the peak flow for the 4% ACE and larger events. West Rockwell Road is currently serviceable for the 10% ACE and below and overtopped and flooded for the 4% ACE and above. The upstream cross-section of the bridge crossing is shown in Figure 7.

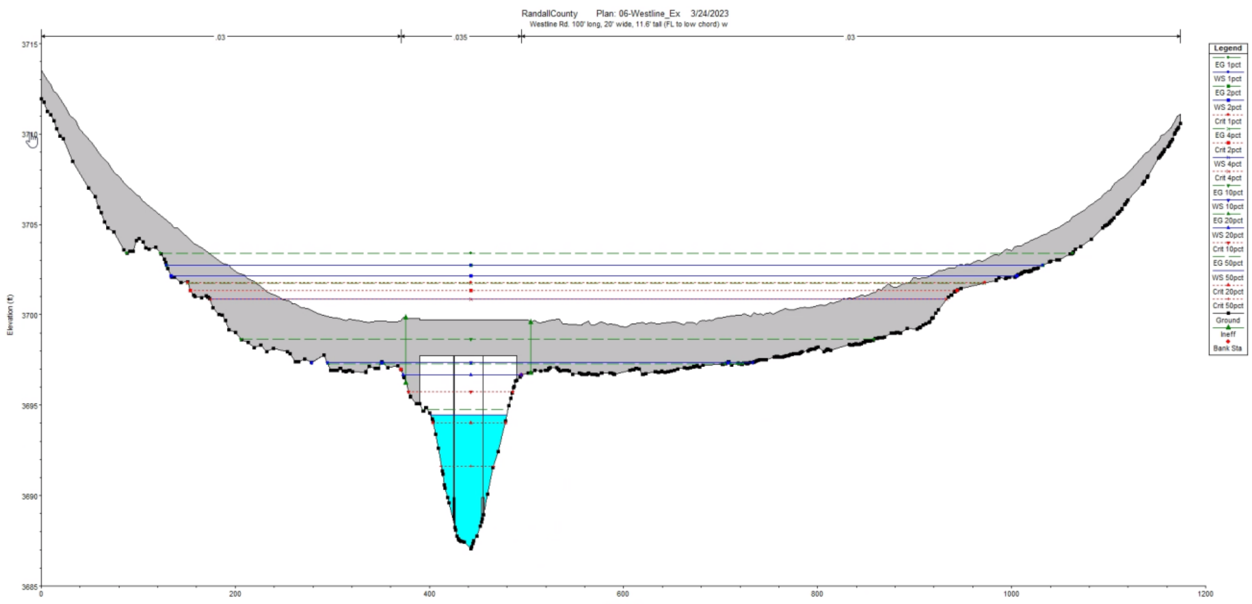

Figure 7. Upstream cross section at Westline Road crossing of Palo Duro Creek.

Site 11. Gordon-Cummings Road Low Water Crossing of Tierra Blanca Creek

This crossing is along Tierra Blanca Creek on Gordon-Cummings Road as shown in Figure 8 and has been identified as a 24” corrugated metal pipe (CMP). The transposition of the FIS peaks discharges to this crossing are shown in Table 3.

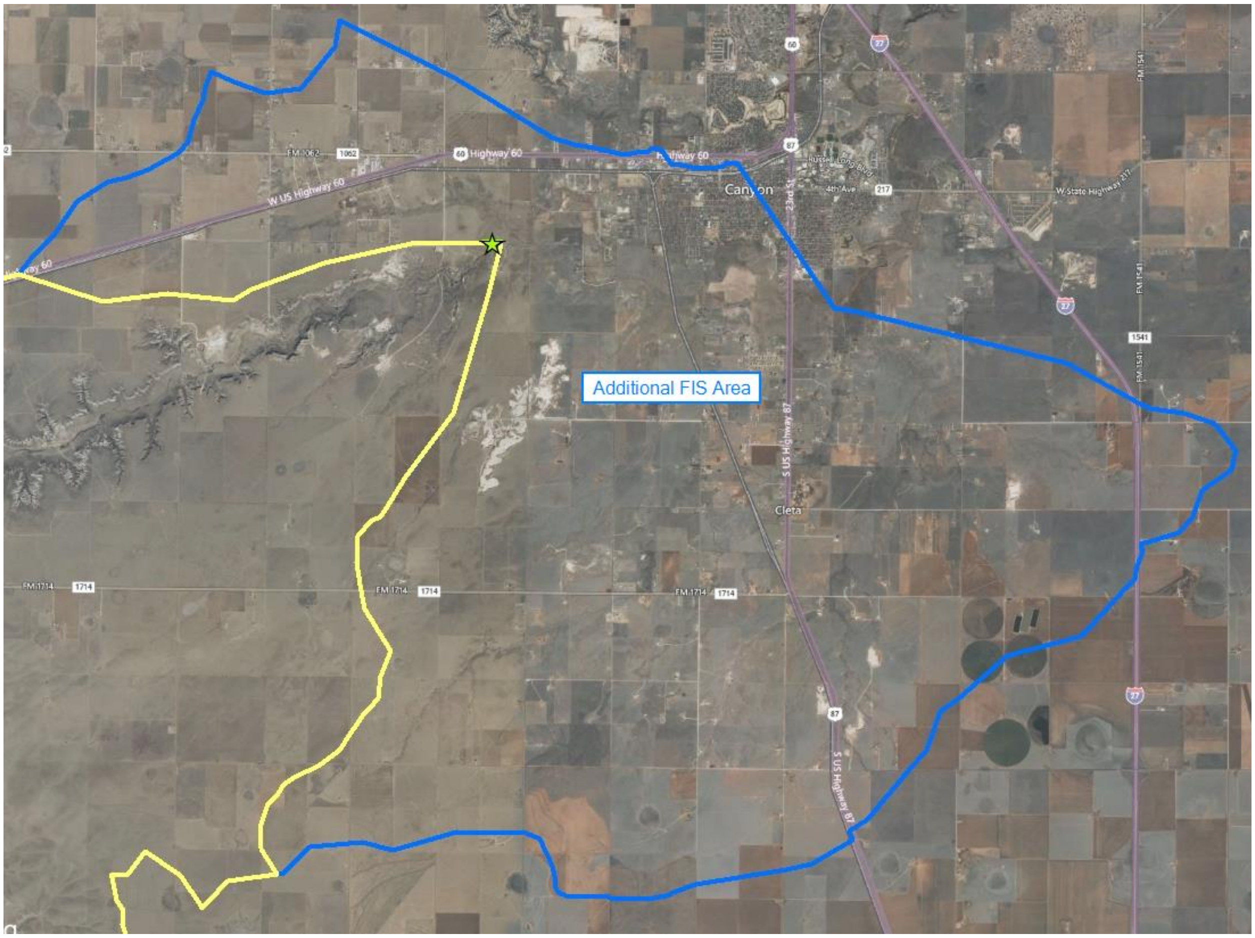

Figure 8. Locations of Gordon Cummings culvert and corresponding FIS discharge location.

Table 3. Transposition of FIS discharges to Gordon Cummings crossing of Tiera Blanca Creek.

Gordon Cummings - Tierra Blanca Creek							
Area (sq mi)	**To Culvert Crossing (A_1)**		741.04	**To FIS Location (A_2)**		806.73	**√(A_1/A_2)**
ACE	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	
FIS Q_2 (cfs)	1,250	3,275	5,600	9,200	11,750	17,150	***0.958***
Ratio Q_1 (cfs)	***1,198***	***3,139***	***5,367***	***8,817***	***11,261***	***16,437***	

Based on the hydraulic model using the peak discharges in the table above, the culvert crossing is unable to convey the flow from all six ACEs and is overtopped by each storm event. The upstream cross-section of the culvert crossing is shown in Figure 9.

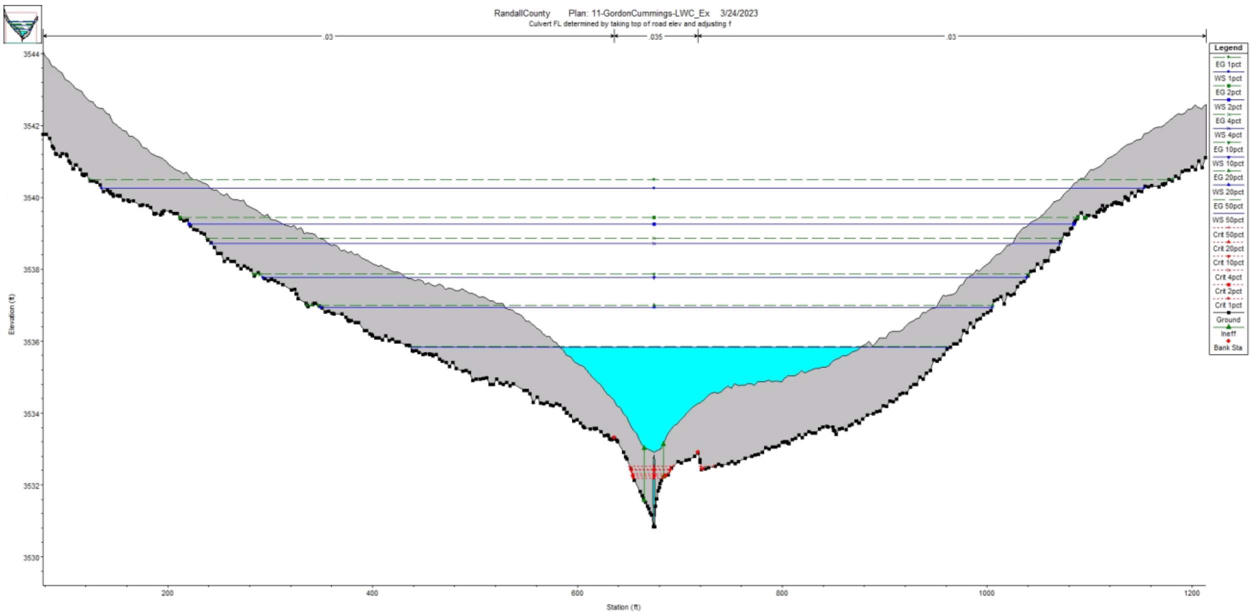

Figure 9. Upstream cross section at Gordon Cummings crossing of Tiera Blanca Creek.

Methodology 2: Storm Event Modeling

Four of the culvert crossings experience riverine flooding for which peak discharges cannot be determined from the existing FIS. The hydrology was computed using SCS Curve Number and TR-55 lag time calculation methods in HEC-HMS. Soils data were downloaded from the NRCS Web Soil Survey and combined with an updated land use coverage to estimate curve numbers for each drainage area. Land use determinations were made by HDR using aerial imagery. Curve number assignments were based on the SCS Runoff Curve Numbers for Urban Area and Other Agricultural Lands table in the City of Amarillo Storm Water Management Criteria Manual. Time of concentration for each drainage area was calculated using LiDAR topography and the TR-55 methodology.

Additionally, some of the culvert crossing drainage areas contain playa lakes upstream that impact the overall hydrology. Storage-elevation relationships for upstream playa lakes were obtained by generating elevation-area tables from each playa lake using LiDAR contours and using the Average-End Area Method to calculate storage volume of the playa lakes. In the event of multiple playa lakes in the watershed upstream of a culvert-crossing, the overall drainage area was subdivided into smaller drainage areas based on the number of playa lakes upstream. Each playa was assigned a designated inflow hydrograph based on the subdivision of the drainage area.

In HEC-HMS, the playa lakes were added as a reservoir element with the computed elevation-storage relationships and a broad crested weir outlet structure, both determined from LiDAR data. Each playa was assumed to start the simulation empty. To model the conveyance of flow between playa lakes, a lag time reach was added between playa lakes, calculated by using TR-55 overland flow and concentrated flow equations. An example of this modeling approach is shown in Figure 10.

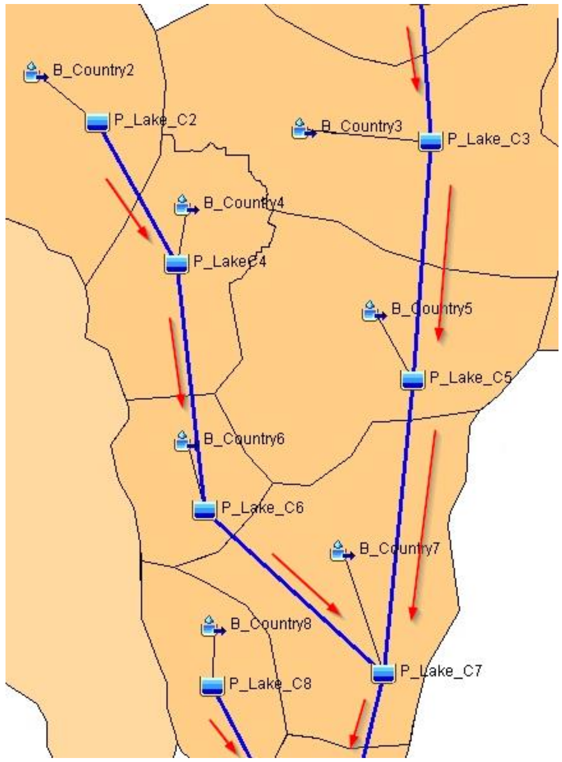

Figure 10. Example HEC-HMS modeling approach (Country Club Road).

This example, taken from the overall drainage area for the culvert crossing at Country Club Road shows the subdivision into smaller drainage areas that contain a playa lake.

This modeling approach continues downstream until it reaches the crossing location, to which the peak discharge is then routed into a junction element in HEC-HMS to capture the resulting peak discharges for each storm event. The resulting peak discharges of the junction element are then used in HEC-RAS model of the crossing. The existing conditions modeling results are below.

Site 2. Happy West Road and Bell Street at Happy Draw

This crossing is located along Happy Draw approximately 3.5 miles upstream of IH-27 and has been characterized by Randall County as “old failing boxes.” FNI culvert field data reported two 30” CMPs and two 8’ x 3.5’ reinforced concrete boxes (RCBs). The HEC-HMS watershed model is illustrated in Figure 11.

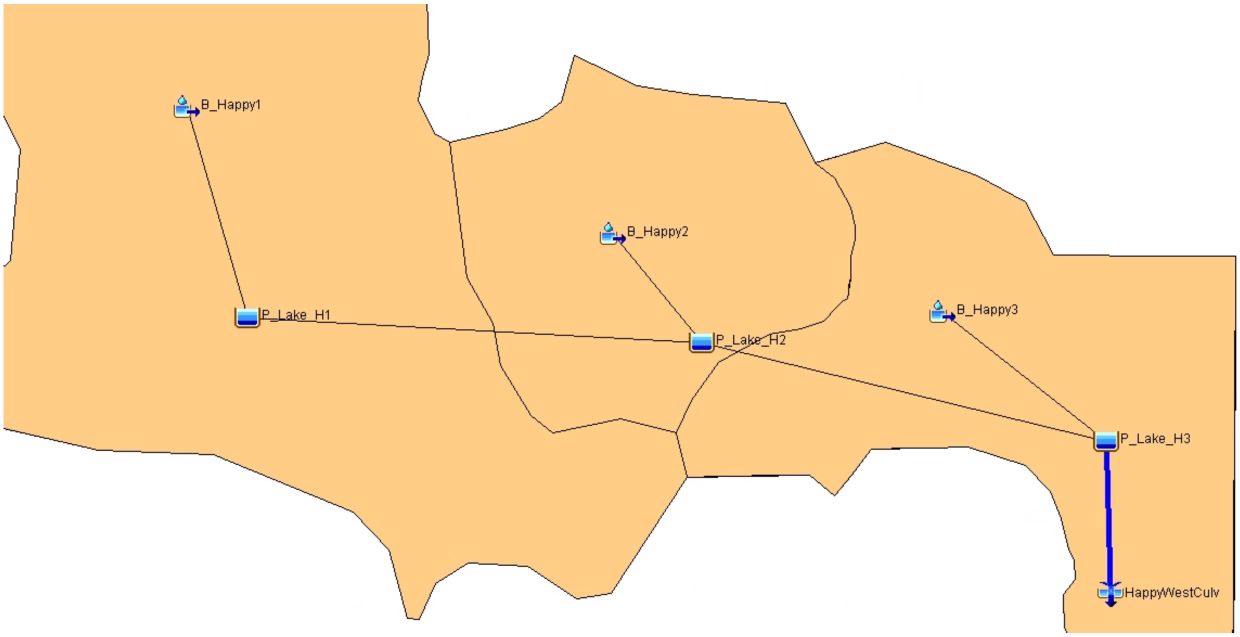

Figure 11. Watershed model of Happy Draw watershed above Happy West Road.

The overall drainage area for Happy West Road and Bell Street culvert crossing contained a playa lake system upstream. The drainage area was subdivided into three smaller areas that drain to each unnamed playa lake. The subdivided drainage areas are named “B_Happy#” and the associated playa lakes are named “P_Lake_H#”. No routing reaches were required between the playas because each playa lake immediately outfalls into the next playa. P_Lake_H3 to the crossing culvert requires a routing reach. Peak discharges were recorded in the junction element “HappyWestCulv”. Hydrologic modeling parameters are shown in Table 4.

Table 4. Hydrologic modeling parameters for Happy West Road crossing of Happy Draw.

Happy West Road and Bell Street						
HMS Parameters	**Name**		**Area (sq mi)**	**CN**	**Tc (min)**	**DS Element**
	B_Happy1		15.17	76	305.5	P_Lake_H1
	B_Happy2		4.06	76	102.6	P_Lake_H2
	B_Happy3		6.05	77	120.7	P_Lake_H3
ACE	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**
Flow (cfs)	***1,359***	***2,249***	***2,929***	***3,794***	***4,753***	***5,588***
Note	*Flows taken from HEC-HMS junction element "HappyWestCulv"*					

Based on the steady-state model using the peak discharges in the table above, the culvert crossing is unable to convey the peak discharges from all six ACEs and is overtopped by each storm event. The upstream cross-section of the culvert crossing is shown in Figure 12.

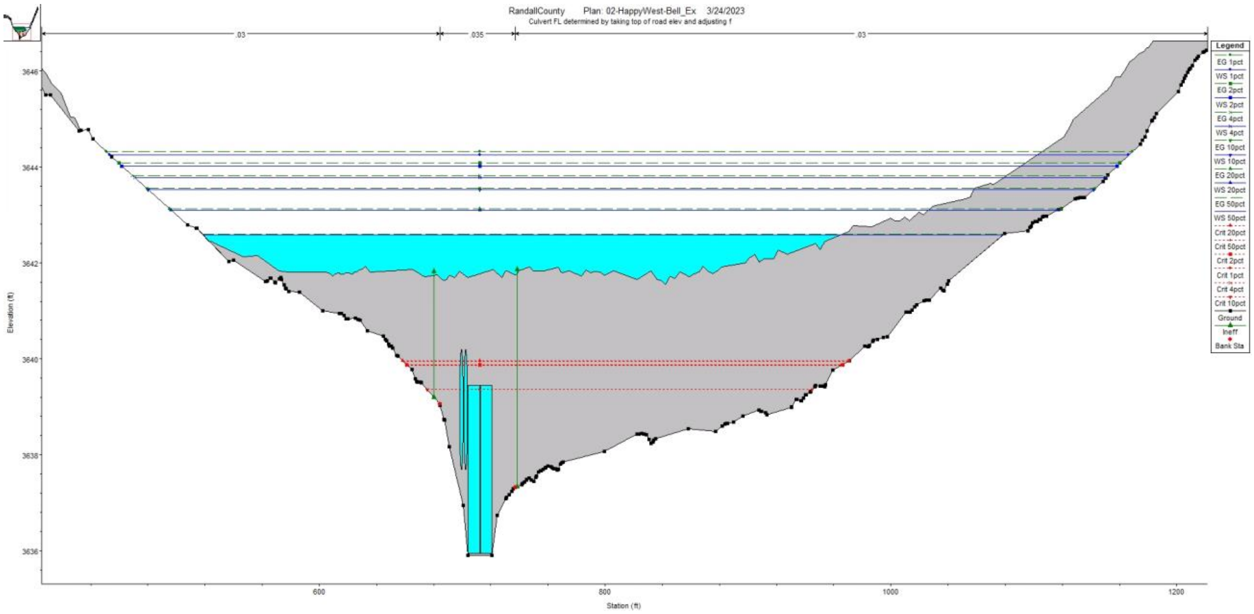

Figure 12. Upstream cross section at Happy West Road crossing of Happy Draw.

Site 3. Hix Drive and FM 217 at Unnamed Stream

The culvert crossing is located along an unnamed stream approximately 0.5 miles upstream of the confluence with Tierra Blanca Creek and is identified as two 30” reinforced concrete pipes (RCPs). The HEC-HMS watershed model is illustrated in Figure 13.

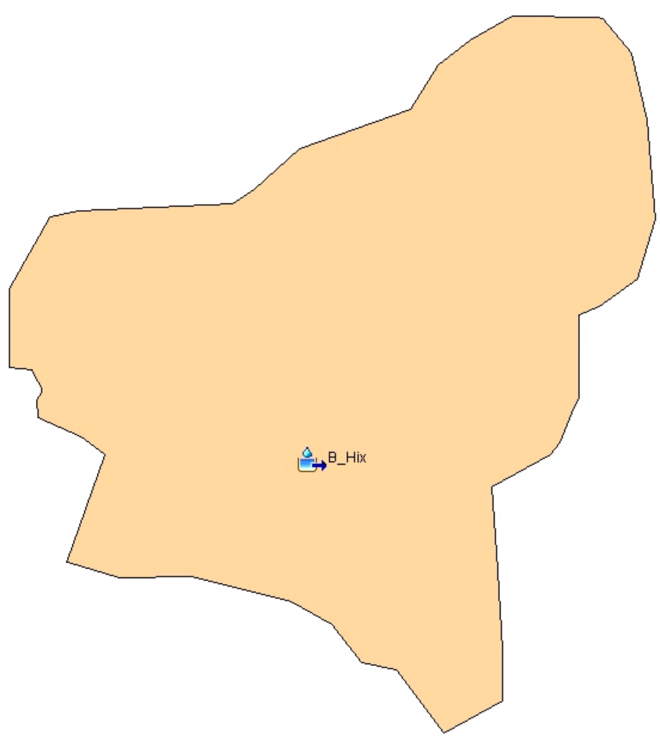

Figure 13. Watershed model of Hix Drive/FM 217 crossing of unnamed stream.

The culvert crossing at Hix Drive and FM 217 has no playa lakes in the contributing watershed and thus, only a subbasin with a curve number and lag time calculation was used to calculate peak discharges. Hydrologic modeling parameters are shown in Table 5.

Table 5. Hydrologic modeling parameters for Hix Drive/FM 217 crossing of unnamed stream.

Hix Drive and FM 217						
HMS Parameters	**Name**		**Area (sq mi)**	**CN**	**Tc (min)**	**DS Element**
	B_Hix		3.42	76	95.1	-
ACE	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**
Flow (cfs)	***523***	***893***	***1,175***	***1,555***	***1,966***	***2,338***
Note	*Flows taken from HEC-HMS subbasin element "B_Hix"*					

Based on the steady-state model using the peak discharges in the table above, the culvert crossing is unable to convey the flow in all six ACEs and is overtopped by each storm event. The upstream cross-section of the culvert crossing is shown in Figure 14.

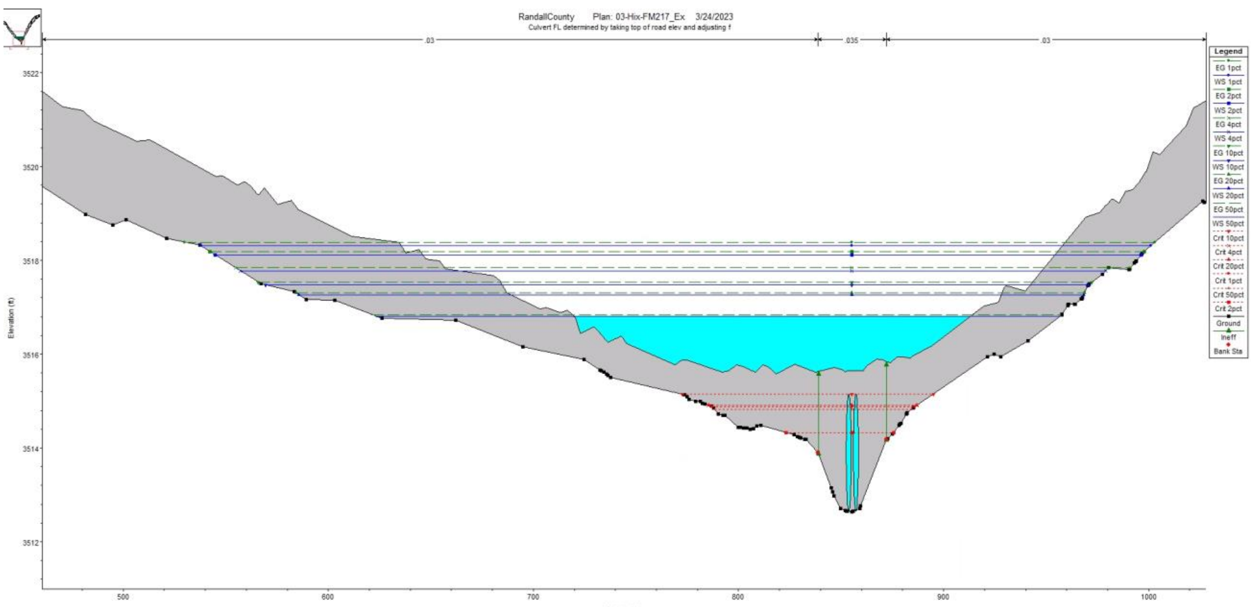

Figure 14. Upstream cross section at Hix Road/FM 217 crossing of unnamed stream.

Site 4. Country Club Road at Unnamed Stream East of I-27

This crossing is located along an unnamed stream approximately 1.0 mile upstream of the confluence with the Prairie Dog Town Fork of the Red River. FNI culvert field data report two 36" RCP-equivalent arch pipes (43.75" x 26.625"). The HEC-HMS watershed model is illustrated in Figure 15.

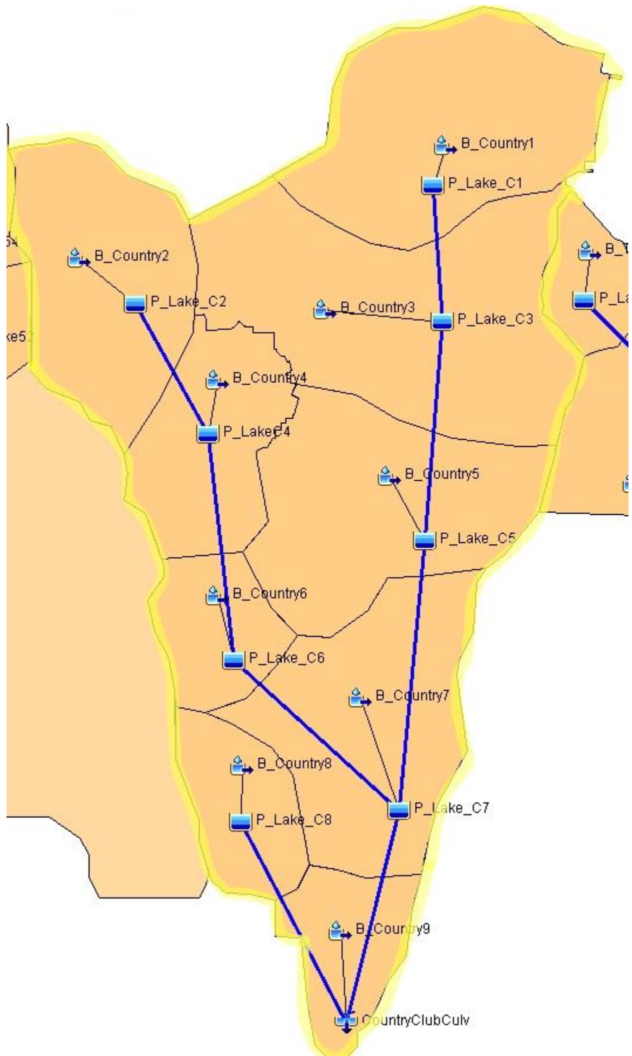

Figure 15. Watershed model of Country Club Road crossing of unnamed stream east of I-27.

The drainage area for the watershed upstream of the Country Club Road crossing has multiple playa lakes. The overall drainage area was subdivided into nine smaller drainage areas, where eight serviced a significant playa lake and one serviced the culvert crossing. Each subbasin was named “B_Country#”. Each playa lake was named “P_Lake_C#”. The playa lakes have lag time routing reaches as the playa lakes outfall into another playa lake further downstream. Peak discharges for the culvert crossing are recorded in the junction element “CountryClubCulv”. Hydrologic modeling parameters are shown in Table 6.

Table 6. Hydrologic modeling parameters for Country Club Drive crossing of unnamed stream east of I-27.

Country Club Road - East of I-27						
HMS Parameters	**Name**		**Area (sq mi)**	**CN**	**Tc (min)**	**DS Element**
	B_Country1		8.31	84	81.9	P_Lake_C1
	B_Country2		6.45	80	186.0	P_Lake_C2
	B_Country3		10.78	84	160.0	P_Lake_C3
	B_Country4		4.40	81	44.6	P_Lake_C4
	B_Country5		7.58	83	59.5	P_Lake_C5
	B_Country6		2.56	80	86.8	P_Lake_C6
	B_Country7		7.58	80	114.8	P_Lake_C7
	B_Country8		2.77	80	104.5	P_Lake_C8
	B_Country9		2.72	76	65.1	CountryClubCulv
ACE	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**
Flow (cfs)	***570***	***981***	***1,292***	***1,708***	***2,154***	***2,560***
Note	*Flows taken from HEC-HMS junction element "CountryClubCulv"*					

Based on the hydraulic model using the peak discharges in the table above, the culvert crossing is unable to convey the flow in all six ACEs and is overtopped by each storm event. The upstream cross-section of the culvert crossing is shown in Figure 16.

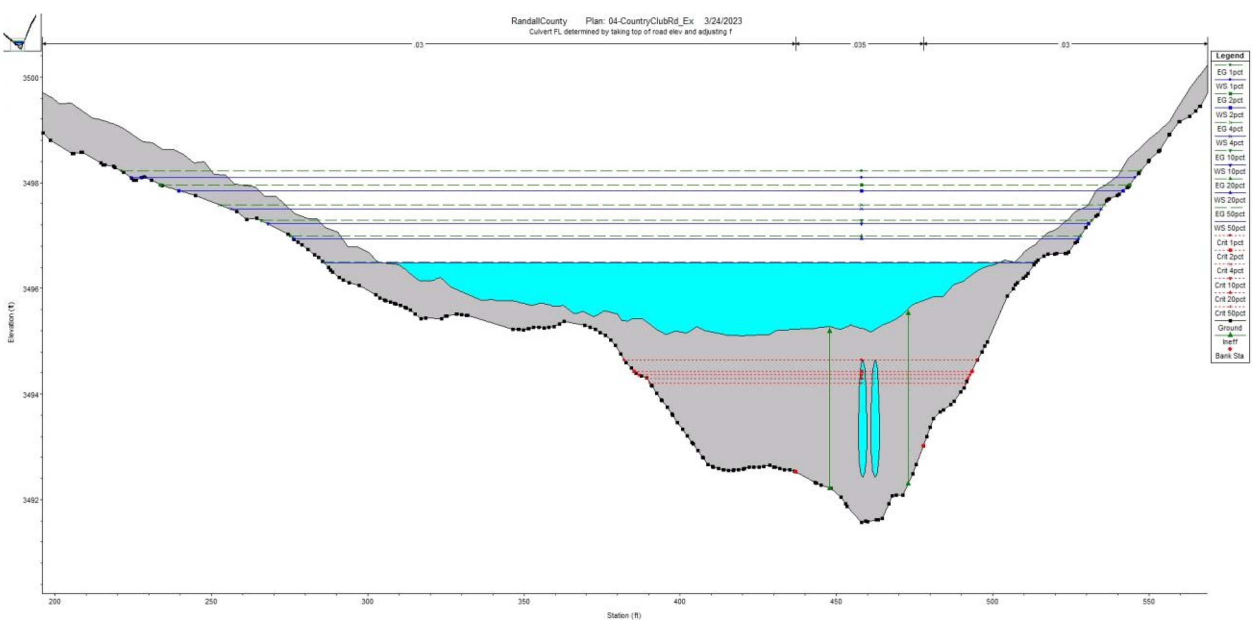

Figure 16. Upstream cross section at Country Club Road crossing of unnamed stream east of I-27.

Site 8. Running Water Road and FM 1714 at Unnamed Tributary to Hackberry Creek

The crossing on Running Water Road (also known as County Road 603) and FM 1714 is on an unnamed tributary to Hackberry Creek 0.2 miles upstream of U.S 87. FNI reported the crossing as a 12-foot bridge opening. The hydrologic model is shown in Figure 17.

Figure 17. Watershed model of the Running Water Road and FM 1714 crossing at unnamed tributary of Hackberry Creek.

The contributing drainage area to the crossing at Running Water Road does not contain any playa lakes so only a subbasin with curve number and lag time is needed to calculate peak discharges. Hydrologic modeling parameters are shown in Table 7.

Table 7. Hydrologic modeling parameters for Running Water Road and FM 1714 crossing of unnamed tributary to Hackberry Creek.

Running Water Road and FM1714						
HMS Parameters	Name		Area (sq mi)	CN	Tc (min)	DS Element
	B_RunningWater		3.61	76	148.9	-
ACE	50%	20%	10%	4%	2%	1%
Flow (cfs)	***386***	***649***	***850***	***1,117***	***1,419***	***1,682***
Note	*Flows taken from HEC-HMS subbasin element "B_RunningWater"*					

Based on the steady-state model using the peak discharges in the table above, the bridge crossing is unable to convey the flow in all six ACEs and thus, is overtopped and flooded in each storm event. The upstream cross-section of the bridge crossing is shown in Figure 18.

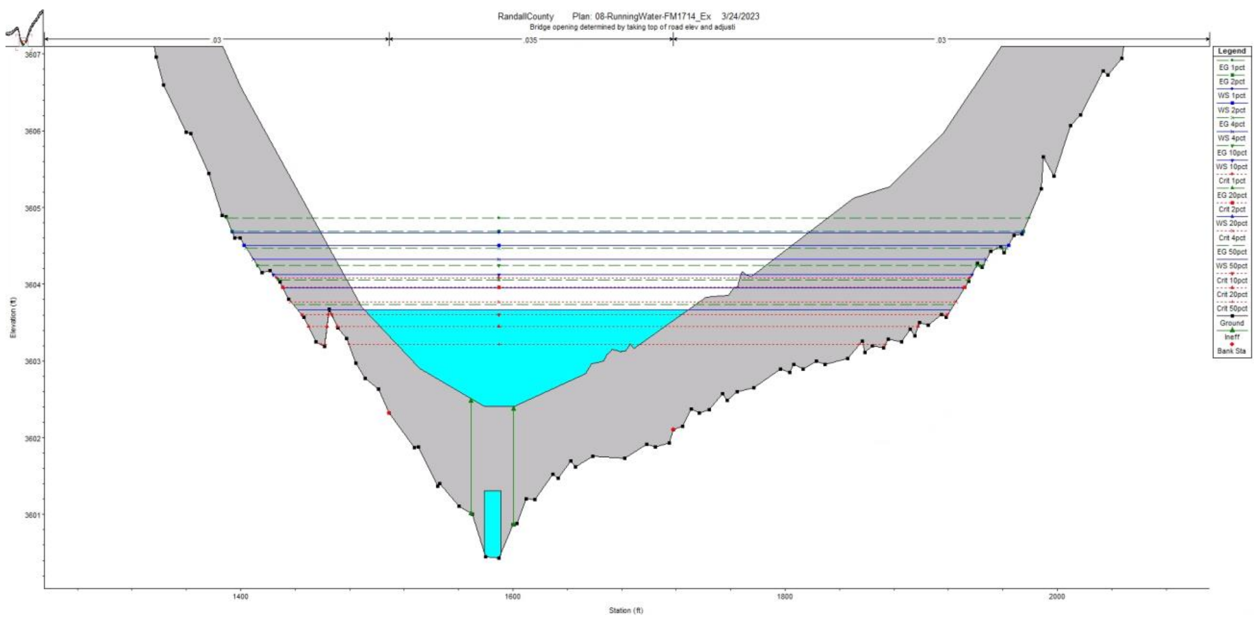

Figure 18. Upstream cross section at Running Water Road and FM 1714 crossing of unnamed tributary to Hackberry Creek.

Methodology 3: Playa Lake Flooding Elevation

Two crossings lie within playa lakes and will flood as the water surface elevations (WSEs) in the playa lakes rise. The hydrologic and overtopping analysis of these crossings were both done in HEC-HMS. Like Methodology 2, the hydrology was computed through SCS Curve Number and TR-55 lag time calculations. Both crossings have playa lakes upstream that impact the overall hydrology. Storage-elevation relationships for the playa lakes were obtained by extracting elevation-area tables from each playa lake using LiDAR contours and using the Average-End Area Method to calculate storage of the playa lakes. The overall drainage area was subdivided into smaller drainage areas based on the locations of playa lakes upstream.

To determine the level-of-service (LOS) and approximate inundation depths of each crossing, the playa lake WSE was compared to the top-of-road elevation at the location of the crossing. The playa lake WSEs was taken from the reservoir elements in HEC-HMS, and the top-of-road elevations were taken from LiDAR terrain data. The playas were assumed to start each simulation dry.

Site 9. Hill and 46th at Playa Lake 53

This crossing is located at the edge of Playa Lake 53 and is identified by FNI as a 24” RCP and 30” CMP at the low point of Hill Road. The hydrologic model is shown in Figure 19.

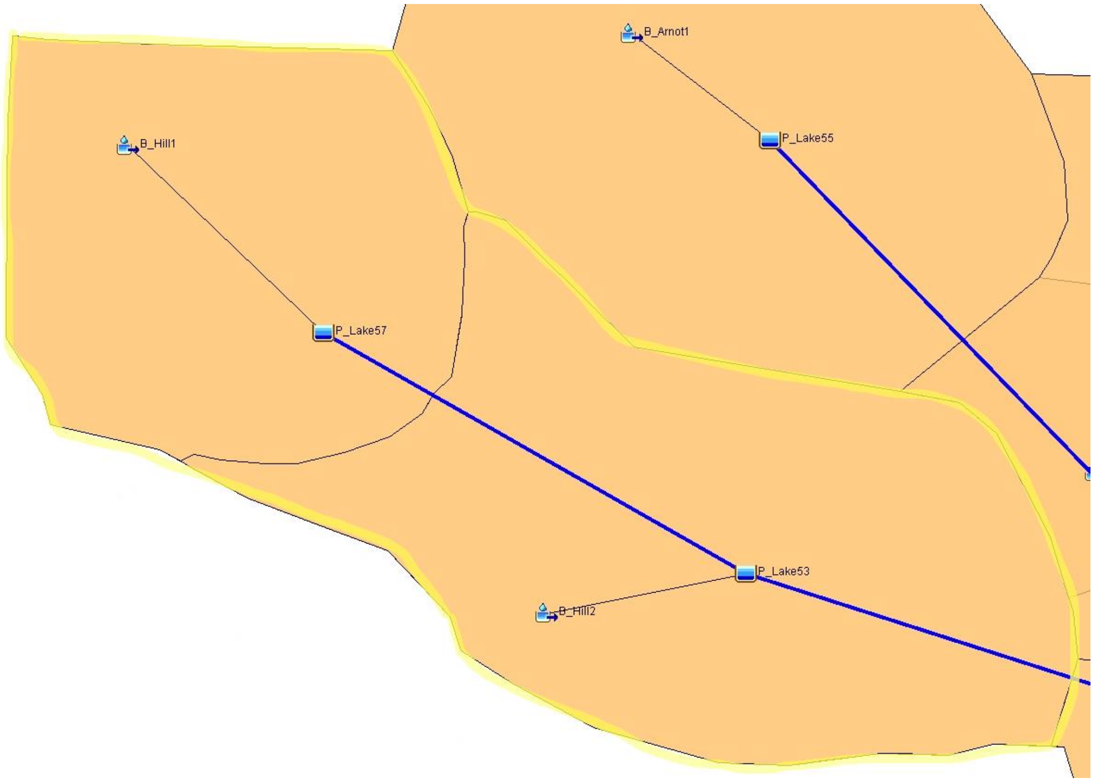

Figure 19. Watershed model of drainage area upstream of Hill and 46th at Playa Lake 53.

The overall drainage area for Hill and 46th contains an upstream playa lake, Playa Lake 57. The drainage area was subdivided into two smaller areas that serviced each playa lake. The subdivided drainage areas are named “B_Hill#” and the playa lakes are reservoirs “P_Lake57” and “P_Lake53”. There is a lag routing reach between the playas. Playa Lake 53 runoff continues downstream to Playa Lake 52, which is also included in the model. Peak WSEs were recorded in the reservoir element “P_Lake53” and compared to the top-of-road elevation. Hydrologic modeling parameters and results are shown in Table 8.

Table 8. Hydrologic modeling parameters and results for Hill and 46th at Playa Lake 57.

Hill & 46th						
HMS Parameters	**Name**		**Area (sq mi)**	**CN**	**Tc (min)**	**DS Element**
	B_Hill1		3.49	81	83.2	P_Lake52
	B_Hill2		5.11	79	149.1	P_Lake53
Summary	**Playa Name**	Playa Lake 53		**Top of Road (ft)**		*3,752.4*
ACE	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**
Elevation (ft)	3,752.4	3,753.7	3,754.5	3,755.3	3,756.3	3,757.0
Inundated (ft)	***0.0***	***1.3***	***2.1***	***2.9***	***3.9***	***4.6***

Based on HEC-HMS playa lake elevations in the table above, the culvert crossing is serviceable for the 50% ACE but experiences playa lake flooding in every ACE above the 50% ACE. Inundation depth for each ACE is shown in Figure 20.

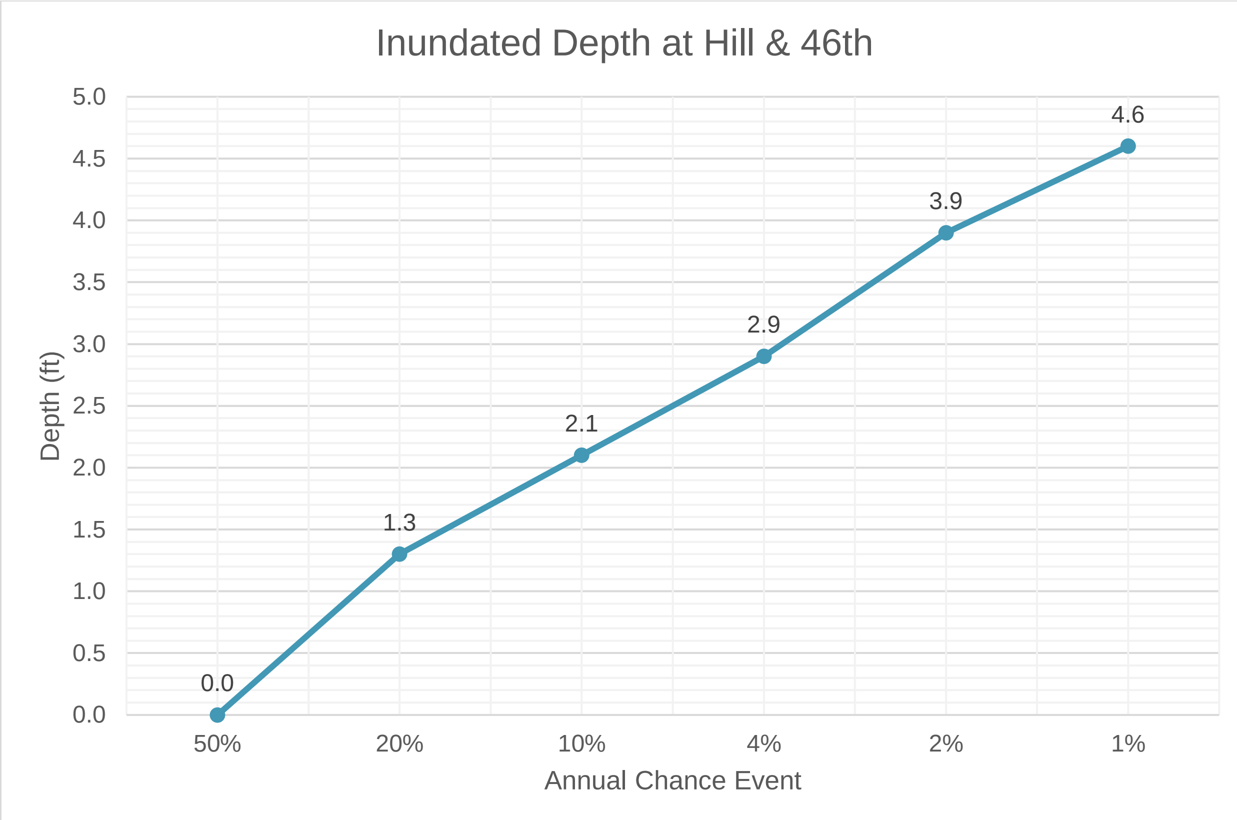

Figure 20. Inundation depths by ACE at Hill and 46th at Playa Lake 57.

Site 12. Tradewinds and Farmers at Playa Lake 18

The Tradewinds crossing is located within Playa Lake 18 in the northeast quadrant of Loop 335 and S Washington St. The crossing is identified by FNI as a 24” RCP and described as “falling apart.” The hydrologic model is shown in Figure 21.

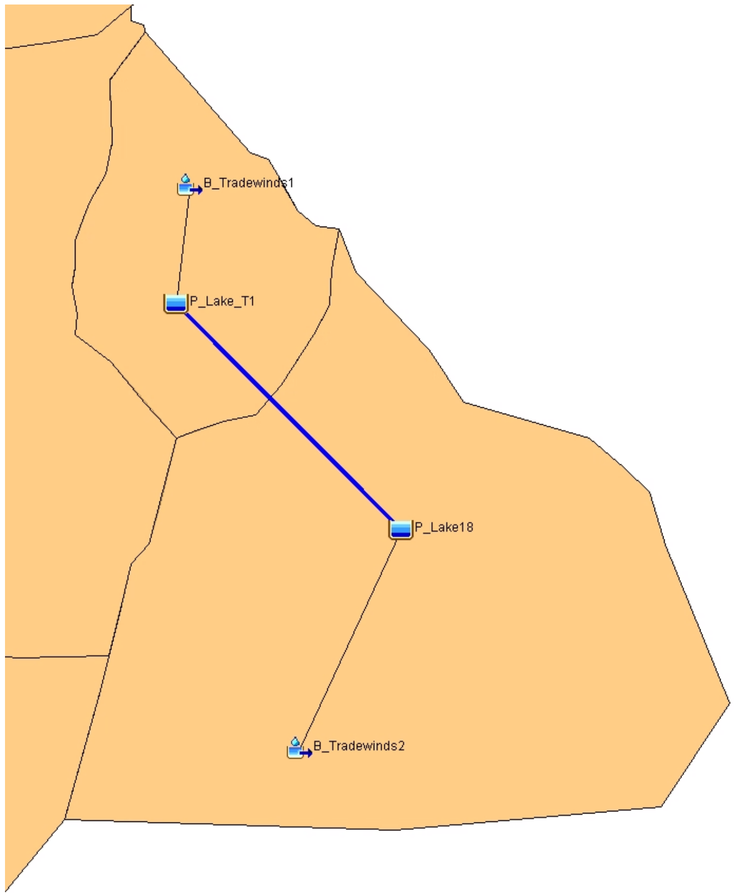

Figure 21. Watershed model of Tradewinds and Farmers crossing at Playa Lake 18.

The overall drainage area for the culvert crossing includes two playa lakes, an unnamed playa lake upstream of the crossing and Playa Lake 18, both of which are modeled as reservoir elements. The overall drainage area was subdivided for each playa lake, named "B_Tradewinds#". The passing of flow between playa lakes is routed by a lag time routing reach. Peak WSEs were recorded in the reservoir element "P_Lake18" and compared to the top-of-road elevation. Hydrologic parameters and results are summarized in Table 9.

Table 9. Hydrologic modeling parameters and results for Tradewinds and Farmers at Playa Lake 18.

Tradewinds & Farmers						
HMS Parameters	**Name**		**Area (sq mi)**	**CN**	**Tc (min)**	**DS Element**
	B_Tradewinds1		1.76	82	38.3	P_Lake_T1
	B_Tradewinds2		6.44	80	31.8	P_Lake18
Summary	**Playa Name**	Playa Lake 18		**Top of Road (ft)**		*3,573.3*
ACE	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**
Elevation (ft)	3,574.7	3,575.9	3,576.7	3,577.5	3,578.4	3,579.1
Inundated (ft)	***1.4***	***2.6***	***3.4***	***4.2***	***5.1***	***5.8***

Based on HEC-HMS playa lake elevations in the table above, the culvert crossing experiences playa lake flooding in every ACE, as shown in Figure 22.

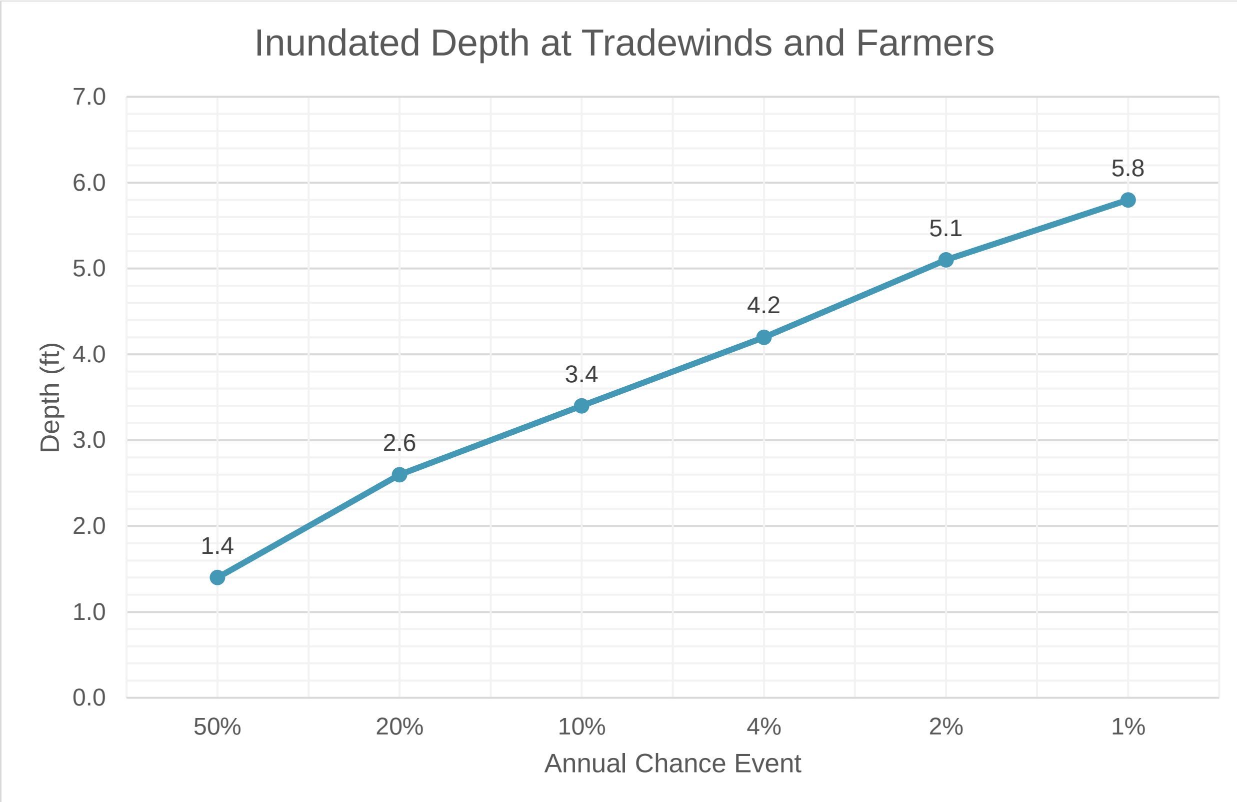

Figure 22. Inundation depths by ACE at Tradewinds and Farmers at Playa Lake 18.

Site 14. Whitaker and FM 1151 at Playa Lake 64

Randall County has identified a clogged equalizer pipe that connects Playa Lake 64 across FM 1151. However, FNI was unable to find the equalizer pipe when collecting field data for the crossings. The hydrologic and hydraulic analysis for this site assumes that if there is an equalizer that currently exists, it is completely clogged and not functioning as an equalizer between the north and south side of Playa Lake 64. The hydrologic model is shown in Figure 23.

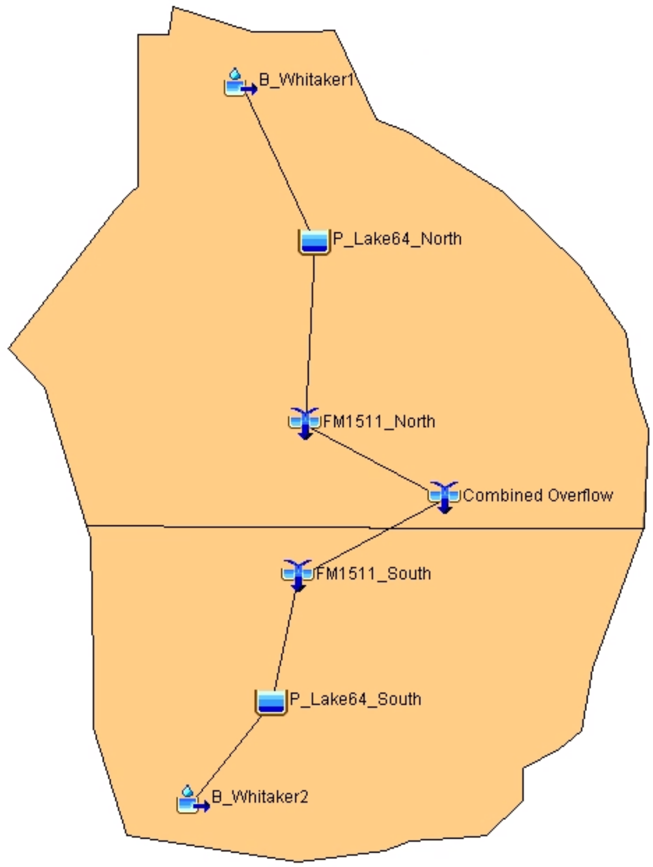

Figure 23. Watershed model of Whitaker and FM 1151 crossing at Playa Lake 64.

Playa Lake 64 is split down the middle by FM 1511. To determine the effects of the clogged equalizer, the overall drainage area was subdivided into two drainage areas for the north and south side of Playa Lake 64. The subbasins are named “B_Whitaker#” and reservoirs are named “P_Lake64_[North/South]”. Each reservoir has a spillway outlet structure with an elevation and length that represent the top of road of FM 1511. The reservoir elements are routed downstream into junctions “FM1511_[North/South]” respectively, and then both junctions are routed into another junction “Combined Overflow”. Peak inflows are recorded from both “FM1511_[North/South]” junctions. A peak inflow of zero indicates the respective playa lake did not overtop FM 1511, and peak inflow greater than zero indicates the playa overtopped FM 1511. Hydrologic parameters and results are summarized in Table 10.

Table 10. Hydrologic modeling parameters and results for Whitaker and FM 1151 crossing at Playa Lake 64.

Whitaker & FM 1511						
HMS Parameters	**Name**		**Area (sq mi)**	**CN**	**Tc (min)**	**DS Element**
	B_Whitaker1		0.95	79	58.9	P_Lake64_North
	B_Whitaker2		0.64	79	35.6	P_Lake64_South
Summary	**Playa Name**	Playa Lake 64		**Top of Road (ft)**		*3,571.0*
ACE	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**
FM1511_North Inflow Q (cfs)	0.0	0.0	0.0	0.0	0.0	54.8
FM1511_South Inflow Q (cfs)	0.0	0.0	0.0	0.0	0.0	0.0

Based on HEC-HMS inflows shown in the table above, FM1511 is overtopped by the north side of Playa Lake 64 only during the 1% ACE as shown in Figure 24.

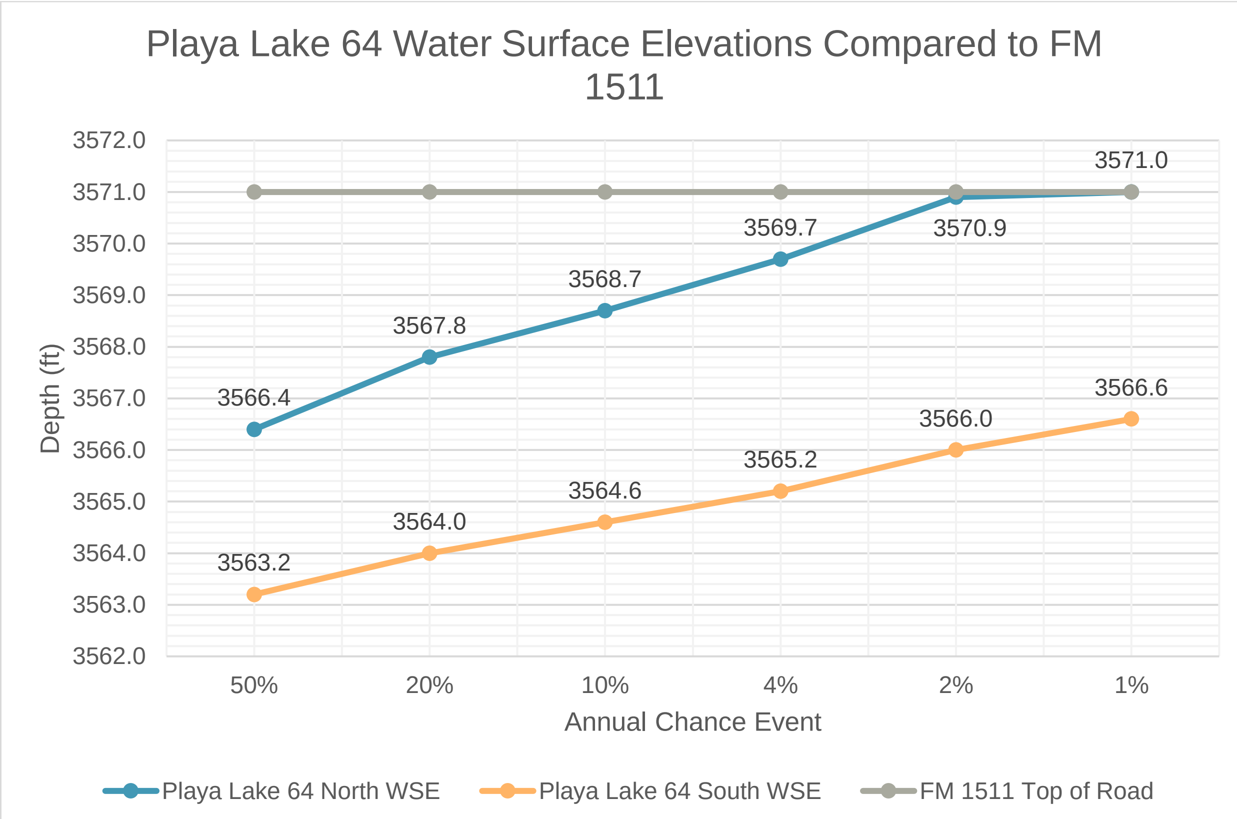

Figure 24. Water Surface Elevations by ACE at Whitaker and FM 1151 at Playa Lake 64.

Information Regarding the Remaining Sites

Sites Number 5. Arnot, Number 7. 77th and Soncy and Number 10. Bushland, South of FM 2186 are adjacent to playa lakes and were initially investigated as crossings that experience playa lake flooding. Based on initial investigation, these sites appear to be flooded from neither riverine nor playa lake flooding. The culvert crossing data provided by FNI indicate that these crossings do not lie within playa lakes, nor do they service a stream, but are parallel to the major roads to convey flow in roadside ditches and are not performing as designed. Flooding appears to be a ditch capacity constraint.

Crossings of this nature are more appropriately addressed at a local level and not as part of the regional flood plan. As such, proposed solutions for this site will not be pursued in Technical Memorandum 3.

Sites 13 and 15 were assessed for methodology in Technical Memo 1 but have not been evaluated because the scope of work for this effort was limited to 12 sites.

Memo

Date:	Friday, May 26, 2023
Project:	Region 1 (Canadian – Upper Red) Regional Flood Plan
To:	Scott Hubley, PE Chris Johnson, PE
From:	Emily Daniel, PE David Dunn, PE
Subject:	Technical Memo 3 – H&H Proposed Conditions Analysis and Modeling Results for Randall County Culvert Analyses

Technical Memo 3

In Technical Memo 1 (TM1) (March 22, 2023), the Region 1 consultant team propose analysis methodologies for 15 culvert crossings requested by Randall County to be evaluated for potential Flood Mitigation Project (FMP) status. In Technical Memo 2 (TM2) (May 18, 2023) the results of the hydrologic and hydraulic analysis of the existing conditions of the various culvert crossings are presented. The analyses were based in part on field data collected by Freese and Nichols, Inc (FNI) at each site.

This Technical Memorandum 3 (TM3) presents the results of the proposed conditions of the various culvert crossings that are evaluated in TM2. For information regarding the existing conditions results for each crossing, refer to TM2.

For each crossing analyzed, proposed hydraulic improvements were identified to achieve a 1% Annual Chance Event (ACE) Level-of-Service (LOS). Additionally, for feasibility purposes, a 20% LOS proposed set of improvements was also designed if the crossing did not already meet 20% LOS under existing conditions. Table 1 summarizes common proposed hydraulic improvements proposed to achieve a 1% and 20% LOS.

Table 1: Summary of common proposed improvements.

Summary of Common Proposed Improvements		
Improvement	**Playa, Riverine, or Both?**	**Description**
Raise Road	Both	*Take the lowest elevation on the street impacted by flooding, and raise and regrade the street to mitigate impacts.*
Upsize Culvert	Riverine	*Increase the capacity of the existing crossing and avoid overtopping the impacted road.*
Modify Channel	Riverine	*Widen channel bottom or bench the banks to provide more capacity.*

The roadway functional classification and approximate annual average daily traffic (AADT) were also evaluated for each crossing. The functional classification and AADT for the sites were obtained from the Texas Department of Transportation's (TxDOT) Traffic Count Database System (TCDS). For sites that do not have data at the specific location, the nearby surrounding data collection points were used to approximate AADT. Below is a summary of the hierarchy of the functional highway system within urban, suburban, and rural areas from TxDOT's Roadway Design Manual.

- **Freeways** – controlled access facilities (Interstate, Freeways, and Expressways);
- **Principal arterial** – main movement (high mobility, limited access);
- **Minor arterial** – interconnects principal arterials (moderate mobility, limited access);
- **Collector –** connects local roads to arterials (moderate mobility, moderate access); and
- **Local roads and streets –** permits access to abutting land (high access, limited mobility).

As reported in TM2, three methodologies were used to model the existing and proposed hydraulics of each crossing. Methodology 1 and Methodology 2 are applied to riverine situations and use one-dimensional steady state HEC-RAS modeling. Methodology 1 uses peak flows for the culvert crossings located on streams studied in the Flood Insurance Study (FIS) for Randall County. Methodology 2 computes existing hydrology using SCS Curve Number and TR-55 lag time calculation methods in HEC-HMS. The resulting peak discharges of the junction element are then used in the HEC-RAS model of the crossing. Methodology 3 is applied to locations within ponded areas of playa lakes. Methodology 3 computes existing hydrology in HEC-HMS like Methodology 2 and compares the water surface elevations (WSEs) in the playa lakes to the top-of-road elevation at the location of the crossing. Refer to TM2 for more information regarding the methodologies used for existing and proposed conditions. Randall County provided a priority ranking of the sites in case available budget limited the capability to evaluate all requested sites. Table 2 presents the ranking and the methodology used to model existing and proposed conditions.

Table 2: Summary of site methodologies.

Summary of Site Methodologies		
Rank	**Site**	**Methodology**
1	West Rockwell Road and Soncy Road	1
2	Happy West Road and Bell Street	2
3	Hix Drive and FM 217	2
4	Country Club Road	2
6	Westline Road	1
8	Running Water Road and FM 1714	2
9	Hill Road and 46th	3
11	Gordon-Cummings Road Low Water Crossing	1
12	Tradewinds and Farmers	3
14	Whitaker and FM 1511	3

Randall County originally requested 15 sites be evaluated. Subsequent analyses resulted in removal of five sites that were not appropriate for inclusion in the regional flood plan for various reasons.

On April 26, 2023, the Region 1 consultant team presented initial recommendations to representatives from Randall County and received feedback as to the County's preferred approach at each site.

Methodology 1: FIS Flows for Studied Streams

Site 1: West Rockwell Road and Soncy Road at Spring Draw

This crossing is located on Spring Draw approximately 3.0 miles upstream of the confluence with Palo Duro Creek and has been identified as two 36" reinforced concrete pipes (RCPs). The location is shown in Figure 1.

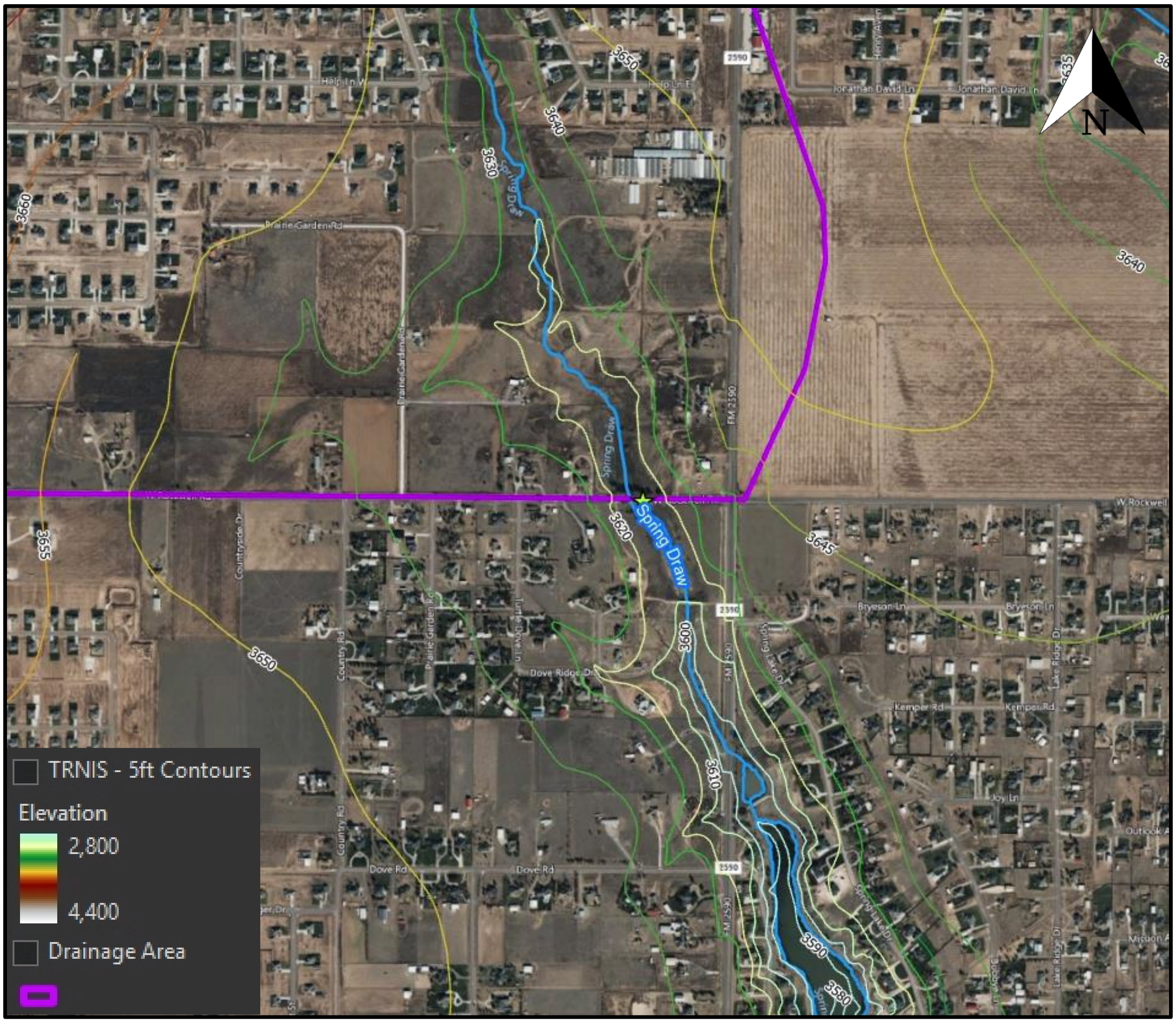

Figure 1: Location of West Rockwell and Soncy Road crossing.

TM2 concluded this crossing is not serviceable for any of the six ACEs evaluated. The following proposed hydraulic improvements are for the 20% ACE and the 1% ACE.

20% ACE Proposed Hydraulic Improvements

Table 3 summarizes the proposed improvements to provide a 20% LOS.

Table 3: 20% LOS improvements proposed for West Rockwell & Soncy.

20% LOS Improvements - West Rockwell & Soncy	
20% ACE Flow (cfs)	1,523
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	1,850
Existing Crossing	2 - 36" RCPs
List of Improvements	Raise Road, Upsize Culvert, Channel Mod.
Channel Modifications	Widen channel opening: 55' bottom, 4:1 SS
Proposed Crossing	3 - 12'x5' RCBs
Road Rise (ft)	0.5
Approx. Length of Roadway (ft)	280
1% Inundation with 20% LOS	3.0

The proposed crossing to provide a 20% LOS is shown in Figure 2.

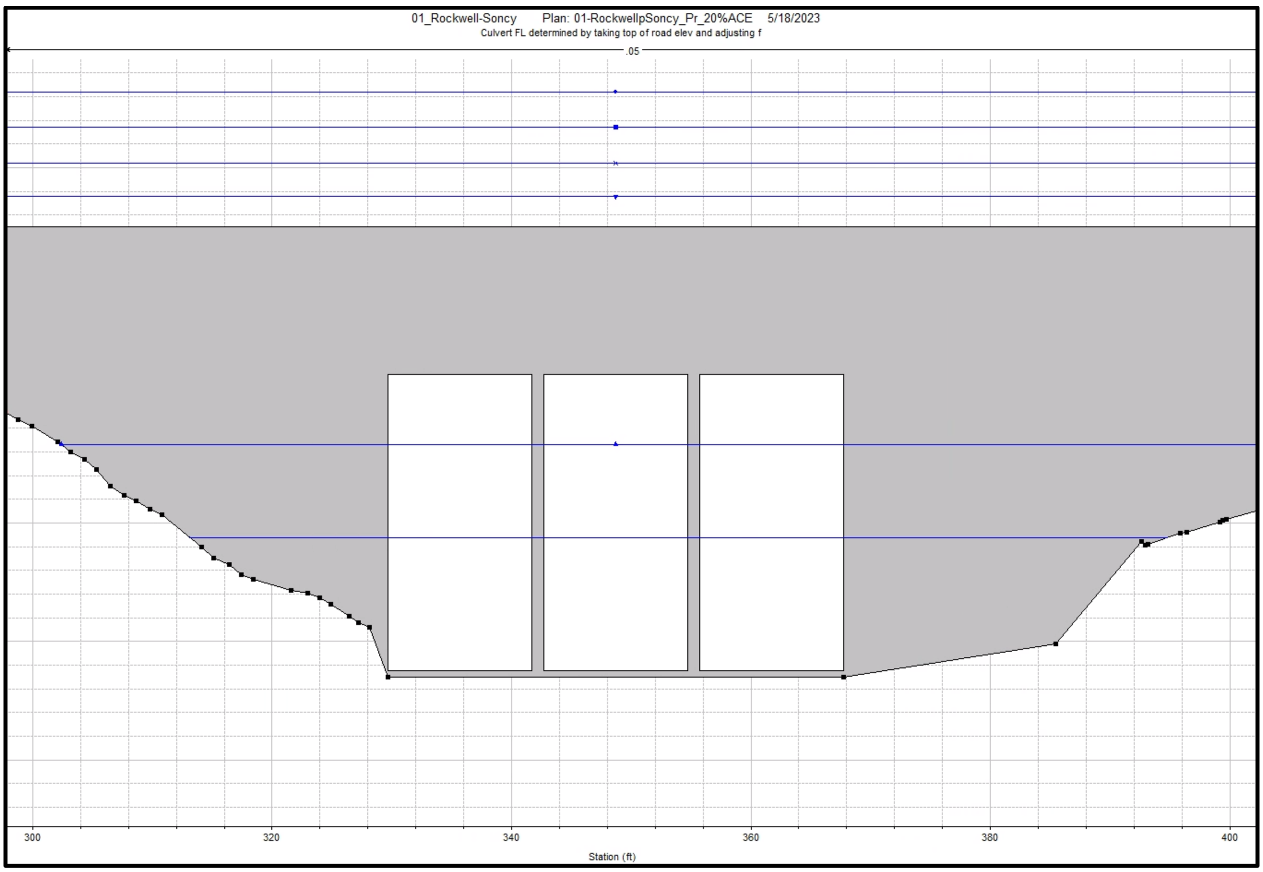

Figure 2: Proposed 20% LOS upstream cross section at West Rockwell Road crossing of Spring Draw.

1% ACE Proposed Hydraulic Improvements

Table 4 summarizes the proposed improvements to provide a 1% LOS.

Table 4: 1% LOS improvements proposed for West Rockwell & Soncy.

1% LOS Improvements - West Rockwell & Soncy	
1% ACE Flow (cfs)	5,710
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	1,850
Existing Crossing	2 - 36" RCPs
List of Improvements	Raise Road, Upsize Culvert, Channel Mod.
Channel Modifications	Widen channel opening: 100' bottom, 4:1 SS
Proposed Crossing	8 - 12'x6' RCBs
Road Rise (ft)	2.0
Approx. Length of Roadway (ft)	365

The proposed crossing to provide a 1% LOS is shown in Figure 3.

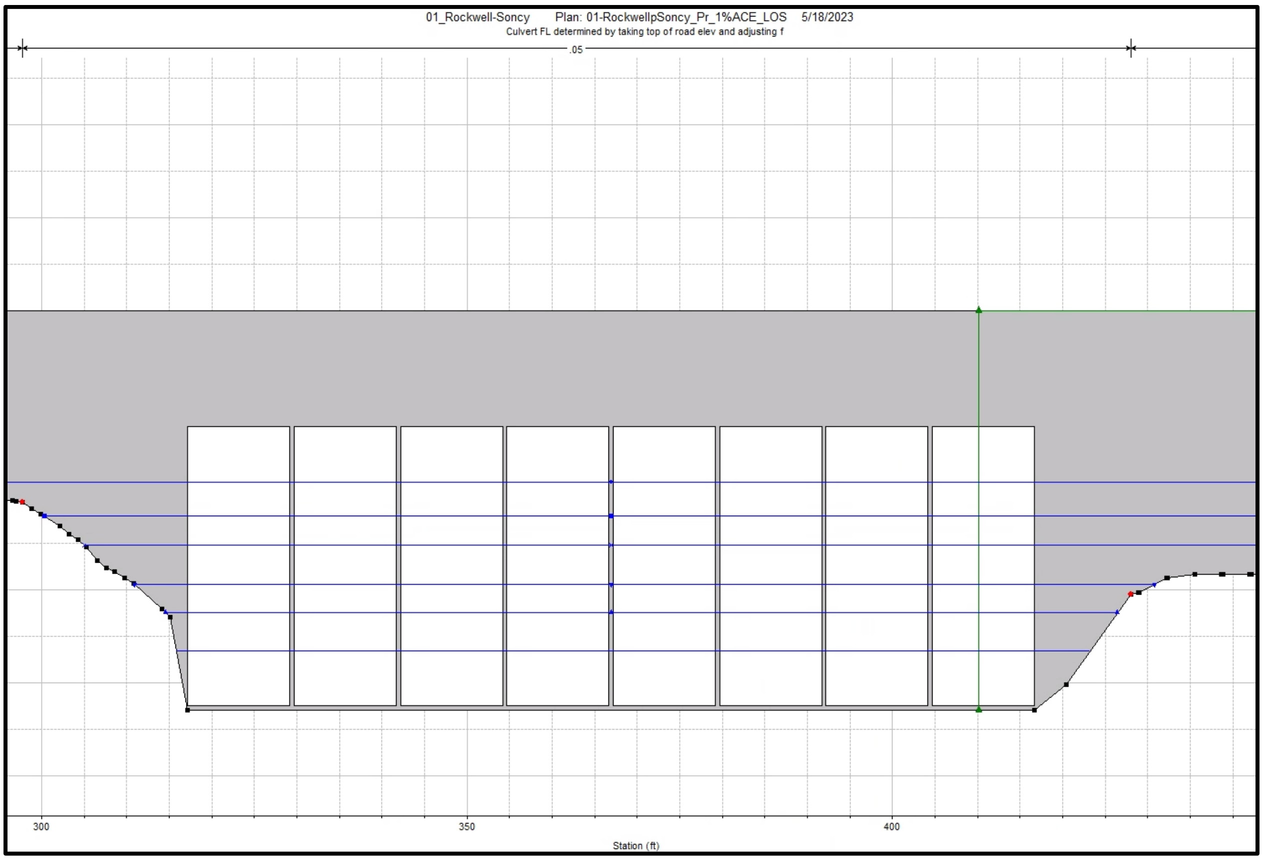

Figure 3: Proposed 1% LOS upstream cross section at West Rockwell Road crossing of Spring Draw.

During the April 26, 2023, meeting Randall County expressed support for the 20% LOS improvements. This project will be pursued for FMP status.

Site 6: Westline Road at Palo Duro Creek

Westline Road crosses Palo Duro Creek near the border of Deaf Smith and Randall Counties as show in Figure 4 and has been identified as a 100-foot-long bridge.

Figure 4: Location of Westline Road crossing.

TM2 concluded this crossing is not serviceable for the 4% ACE and larger events. The following proposed hydraulic improvements are for the 1% ACE, since the existing crossing already provides a 20% LOS.

1% ACE Proposed Hydraulic Improvements

Table 5 summarizes the proposed improvements to provide a 1% LOS.

Table 5: 1% LOS improvements proposed for Westline Road.

1% LOS Improvements - Westline	
1% ACE Flow (cfs)	16,389
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	50
Existing Crossing	100-ft long, 11.6-ft tall bridge opening
List of Improvements	Raise Road, Increase Area of Opening
Proposed Crossing	Raise low chord 5-ft
Road Rise (ft)	8.5
Approx. Length of Roadway (ft)	1,025

The proposed crossing to provide a 1% LOS is shown in Figure 5.

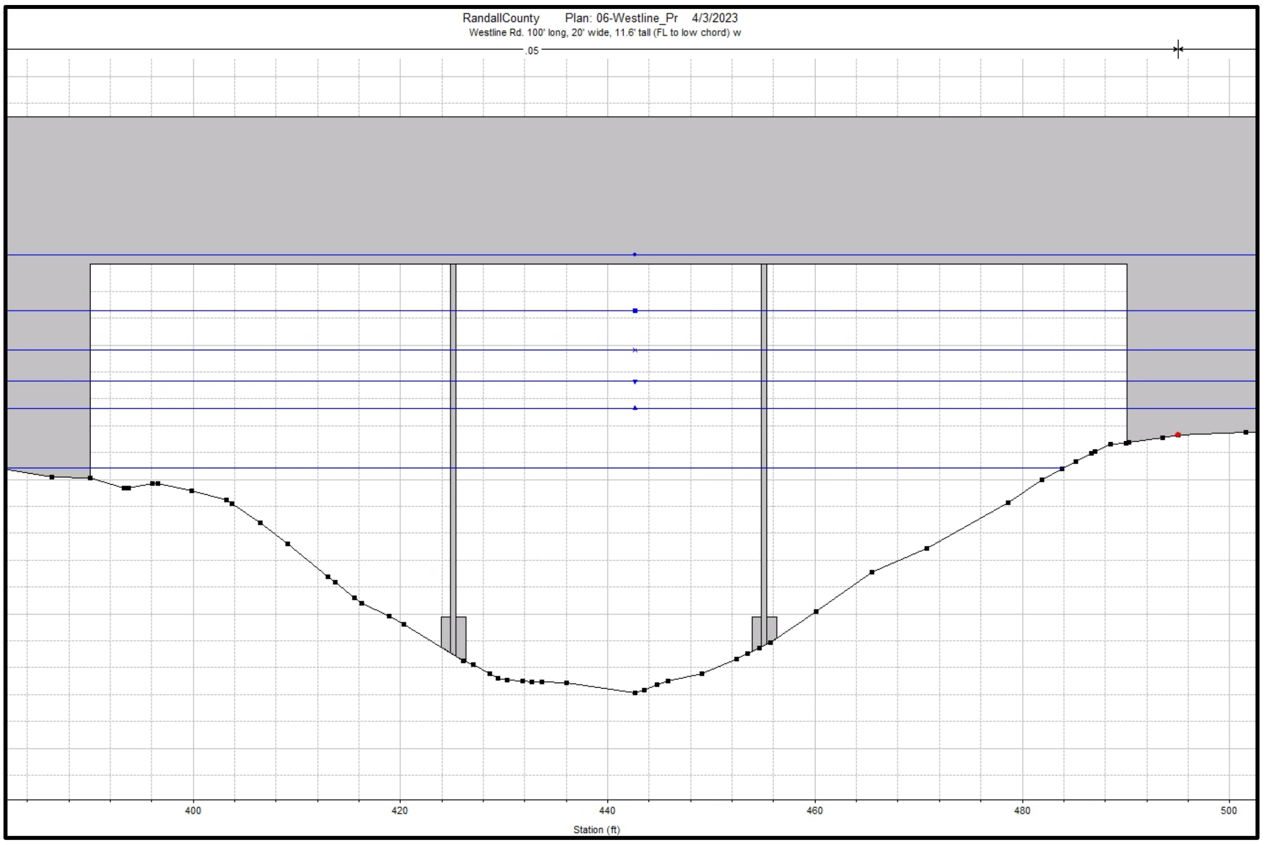

Figure 5: Proposed 1% LOS upstream cross section at Westline Road crossing of Palo Duro Creek.

Westline Road already provides a 20% LOS. This bridge is inspected every year by TxDOT. The County does not desire to pursue a large-scale redesign of this bridge and prefers to pursue safety alternatives.

Site 11: Gordon-Cummings Road Low Water Crossing at Tierra Blanca Creek

This crossing is along Tierra Blanca Creek on Gordon-Cummings Road as shown in Figure 6 and has been identified as a 24" corrugated metal pipe (CMP).

Figure 6: Location of Gordon-Cummings Road low water crossing.

TM2 concluded this crossing is not serviceable for any ACE studied. The following proposed hydraulic improvements are for the 20% ACE and the 1% ACE.

20% ACE Proposed Hydraulic Improvements

Table 6 summarizes the proposed improvements to provide a 20% LOS.

Table 6: 20% LOS improvements proposed for Gordon-Cummings LWC.

20% LOS Improvements - Gordon-Cummings LWC	
20% ACE Flow (cfs)	3,139
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	150
Existing Crossing	24" CMP
List of Improvements	Raise Road, Replace Culvert with Bridge
Proposed Crossing	140-ft long, 6-ft tall bridge opening
Road Rise (ft)	6.1
Approx. Length of Roadway (ft)	670
1% Inundation with 20% LOS	3.7

The proposed crossing to provide a 20% LOS is shown in Figure 7.

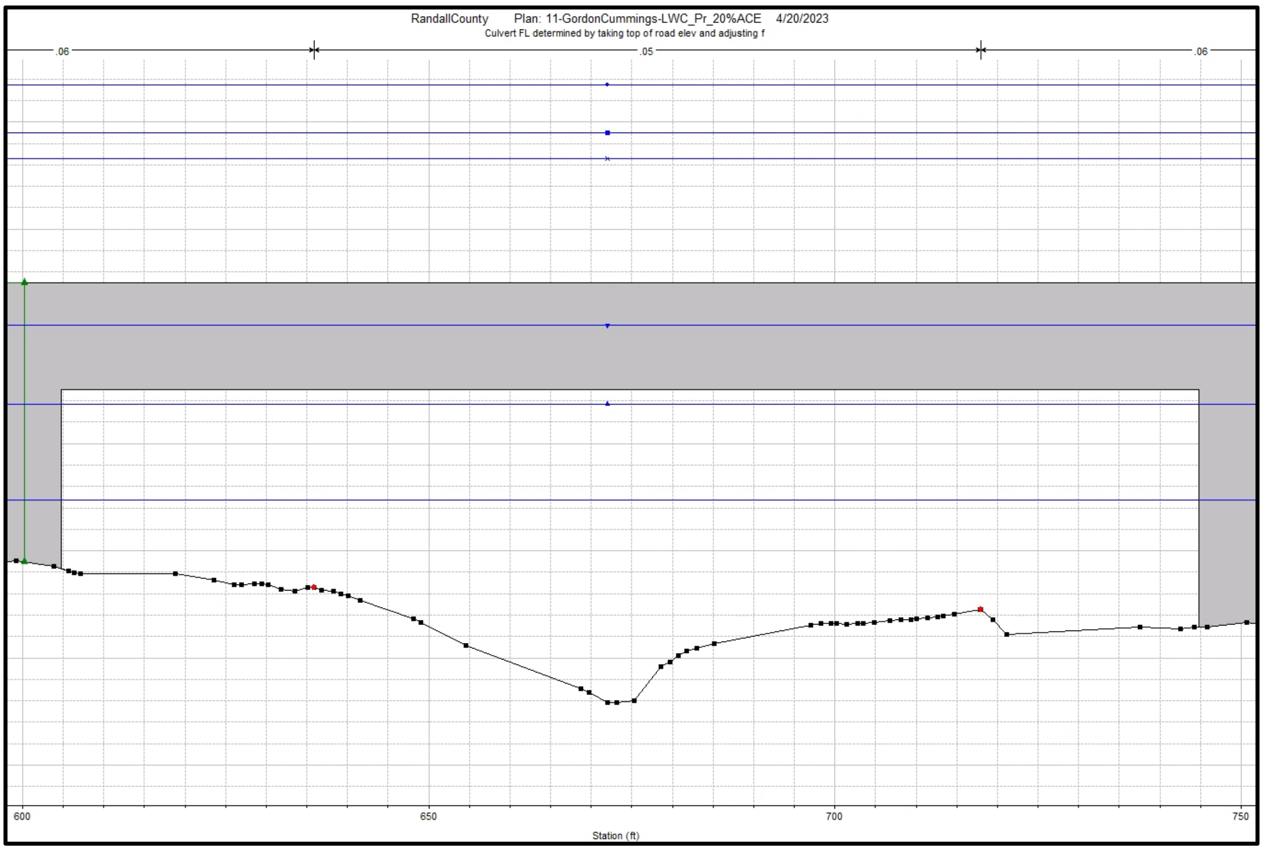

Figure 7: Proposed 20% LOS upstream cross section at Gordon Cummings crossing of Tiera Blanca Creek.

1% ACE Proposed Hydraulic Improvements

Table 7 summarizes the proposed improvements to provide a 1% LOS.

Table 7: 1% LOS improvements proposed for Gordon-Cummings LWC.

1% LOS Improvements - Gordon-Cummings LWC	
1% ACE Flow (cfs)	16,437
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	150
Existing Crossing	24" CMP
List of Improvements	Raise Road, Replace Culvert with Bridge
Proposed Crossing	400-ft long, 10-ft tall bridge opening
Road Rise (ft)	6.1
Approx. Length of Roadway (ft)	1,130

The proposed crossing to provide a 1% LOS is shown in Figure 8.

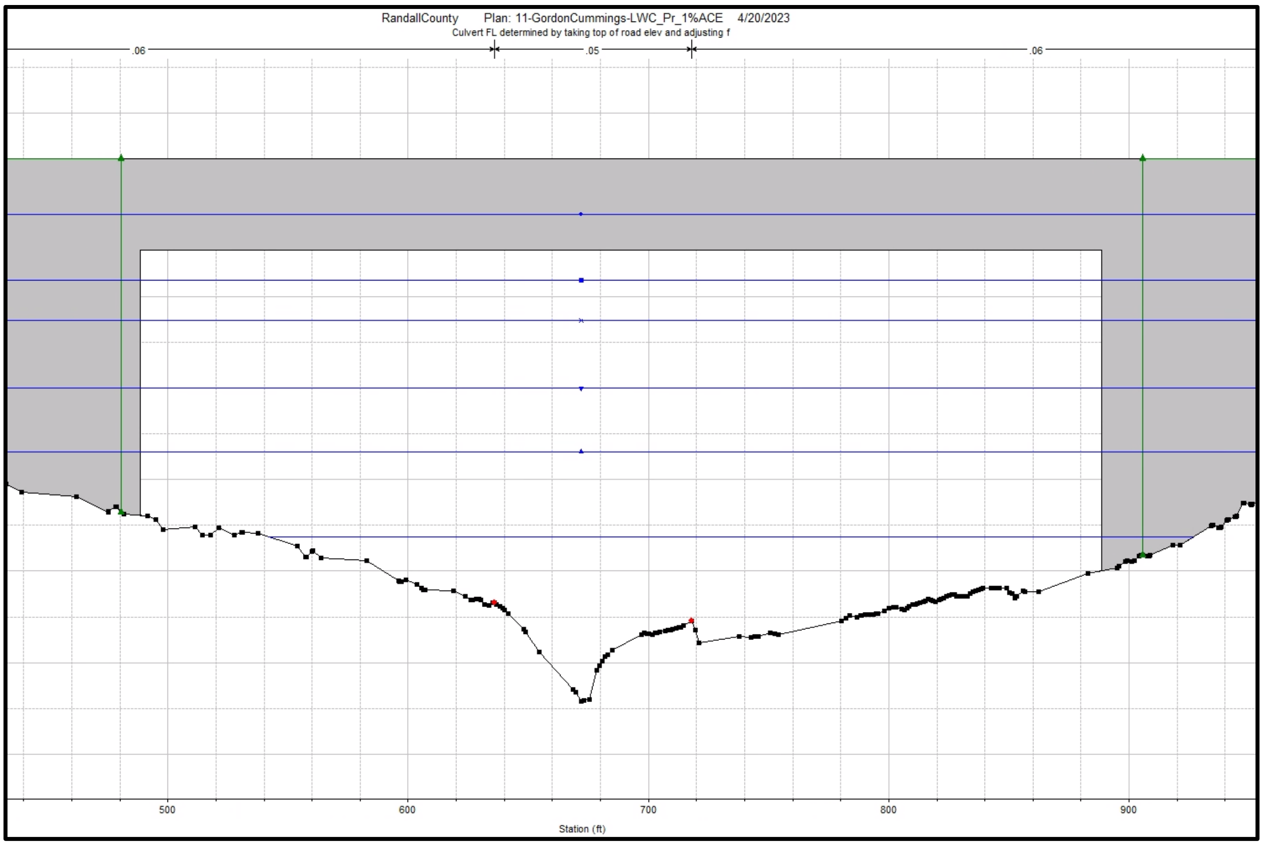

Figure 8: Proposed 1% LOS upstream cross section at Gordon Cummings crossing of Tiera Blanca Creek.

Traffic is expected to increase in the future at this location. The County prefers the 20% LOS improvements be pursued as an FMP.

Methodology 2: Storm Event Modeling

Site 2: Happy West Road and Bell Street at Happy Draw

This crossing is located along Happy Draw approximately 3.5 miles upstream of IH-27, as shown in Figure 9. The crossing has been characterized by Randal County as “old failing boxes". FNI culvert field data reported two 30" CMPs and two 8' x 3.5' reinforced concrete boxes (RCBs).

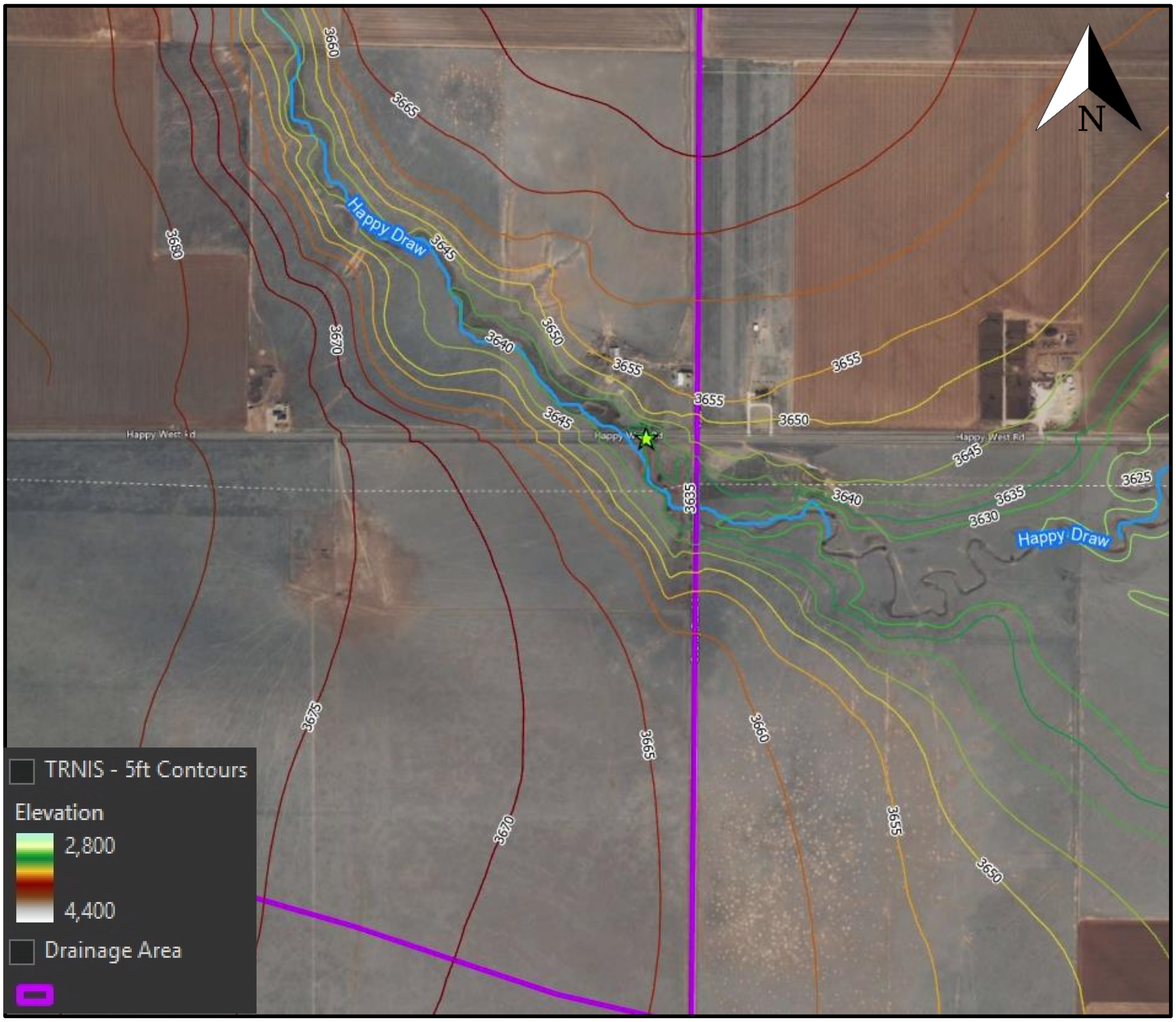

Figure 9: Location of Happy West Road and Bell Street crossing.

TM2 concluded this crossing is not serviceable for any ACE studied. The following proposed hydraulic improvements are for the 20% ACE and the 1% ACE.

20% ACE Proposed Hydraulic Improvements

Table 8 summarizes the proposed improvements to provide a 20% LOS.

Table 8: 20% LOS improvements proposed for Happy West & Bell.

20% LOS Improvements - Happy West & Bell	
20% ACE Flow (cfs)	2,198
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	250
Existing Crossing	2 - 8'x3.5' RCBs & 2 - 30" RCPs
List of Improvements	Raise Road, Upsize Culvert, Channel Mod.
Channel Modifications	Widen channel opening: 20' bottom, 4:1 SS
Proposed Crossing	4 - 8'x7' RCBs
Road Rise (ft)	4.0
Approx. Length of Roadway (ft)	760
1% Inundation with 20% LOS	1.4

The proposed crossing to provide a 20% LOS is shown in Figure 10.

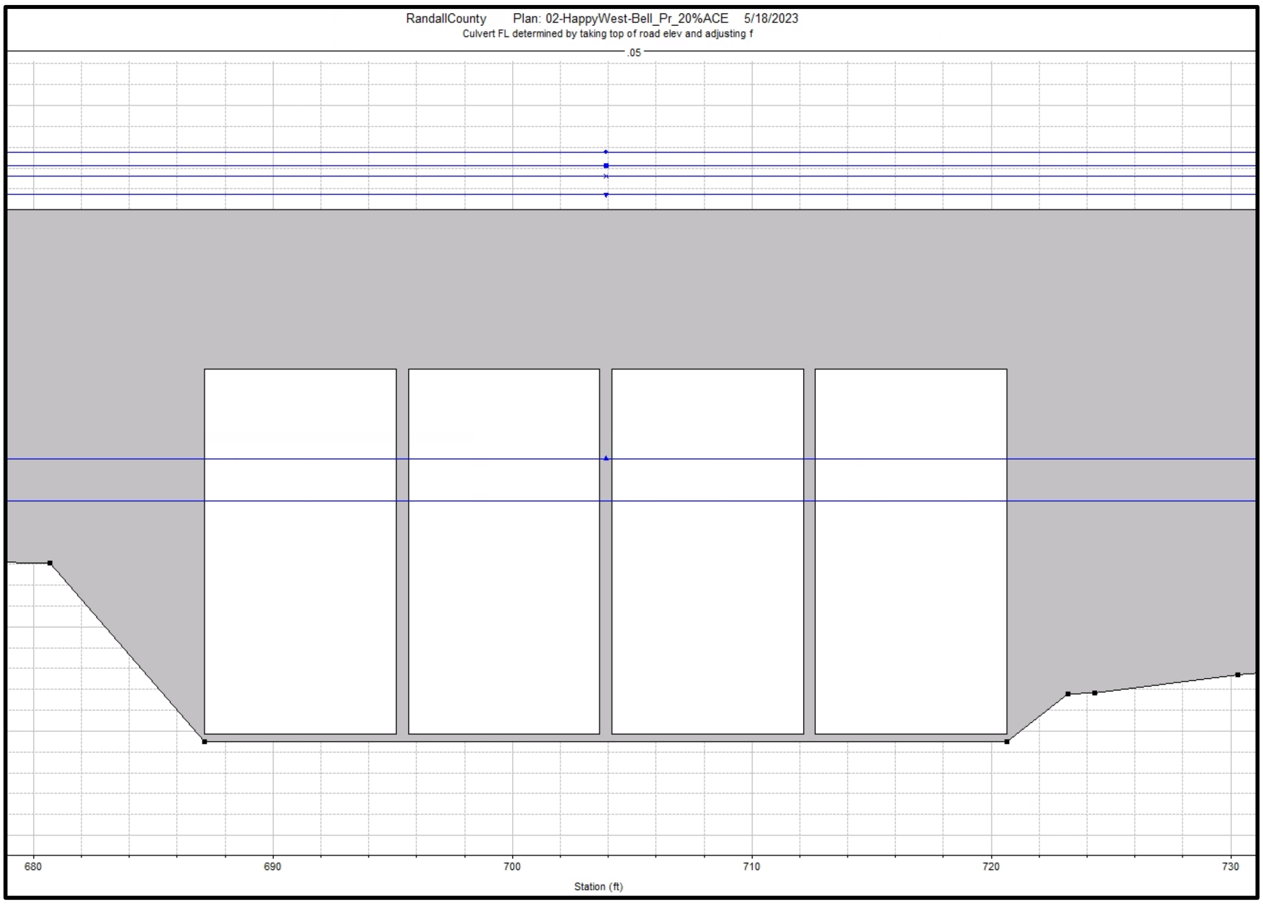

Figure 10: Proposed 20% LOS upstream cross section at Happy West Road crossing of Happy Draw.

1% ACE Proposed Hydraulic Improvements

Table 9 summarizes the proposed improvements to provide a 1% LOS.

Table 9: 1% LOS improvements proposed for Happy West & Bell.

1% LOS Improvements - Happy West & Bell	
1% ACE Flow (cfs)	5,474
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	250
Existing Crossing	2 - 8'x3.5' RCBs & 2 - 30" RCPs
List of Improvements	Raise Road, Upsize Culvert, Channel Mod.
Channel Modifications	Widen channel opening: 70' bottom, 4:1 SS
Proposed Crossing	9 - 8'x8' RCBs
Road Rise (ft)	4.0
Approx. Length of Roadway (ft)	760

The proposed crossing to provide a 1% LOS is shown in Figure 11.

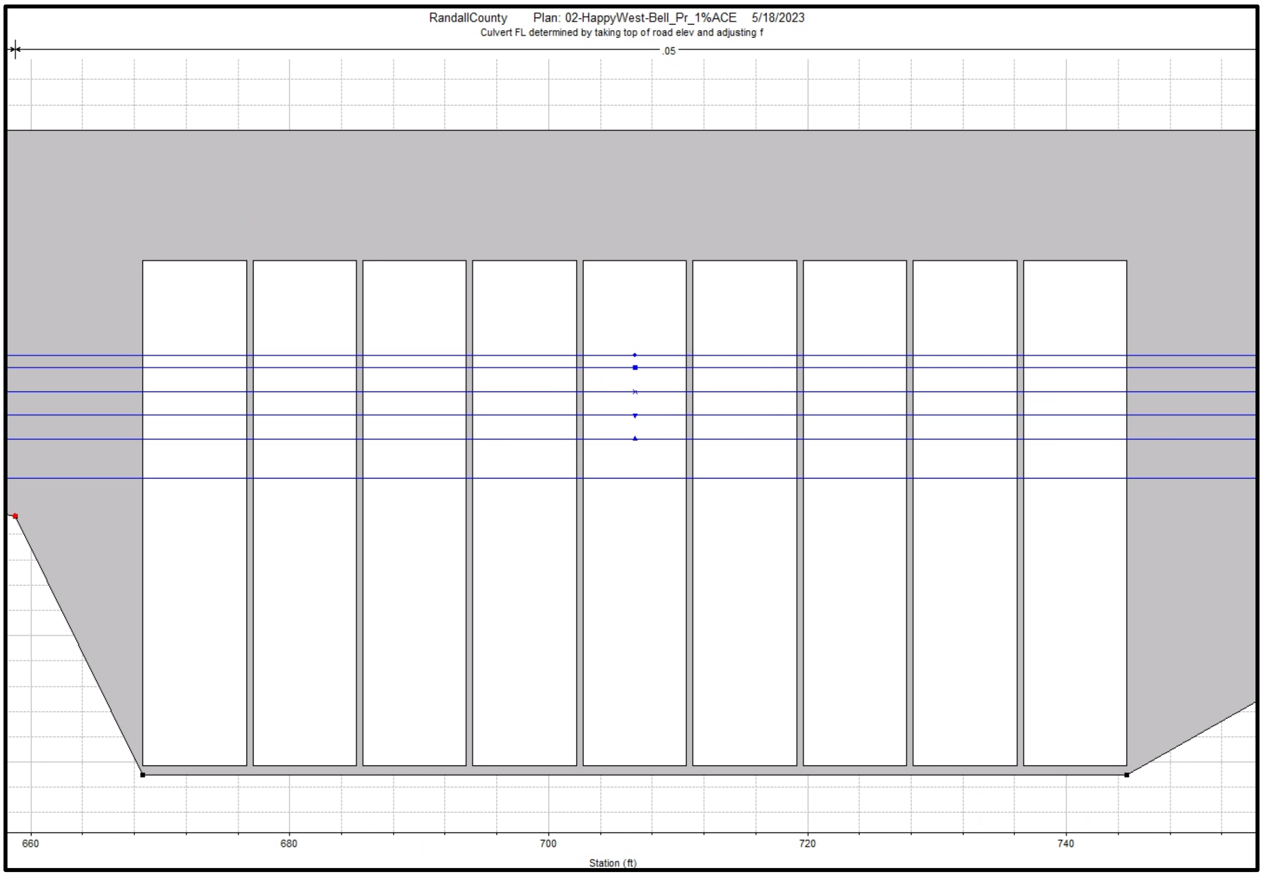

Figure 11: Proposed 1% LOS upstream cross section at Happy West Road crossing of Happy Draw.

The 20% LOS improvements will be pursued as an FMP.

Site 3: Hix Drive and FM 217 at Unnamed Stream

The culvert crossing is located along an unnamed stream approximately 0.5 miles upstream of the confluence with Tierra Blanca Creek and is identified as two 30" RCPs. The location is shown in Figure 12.

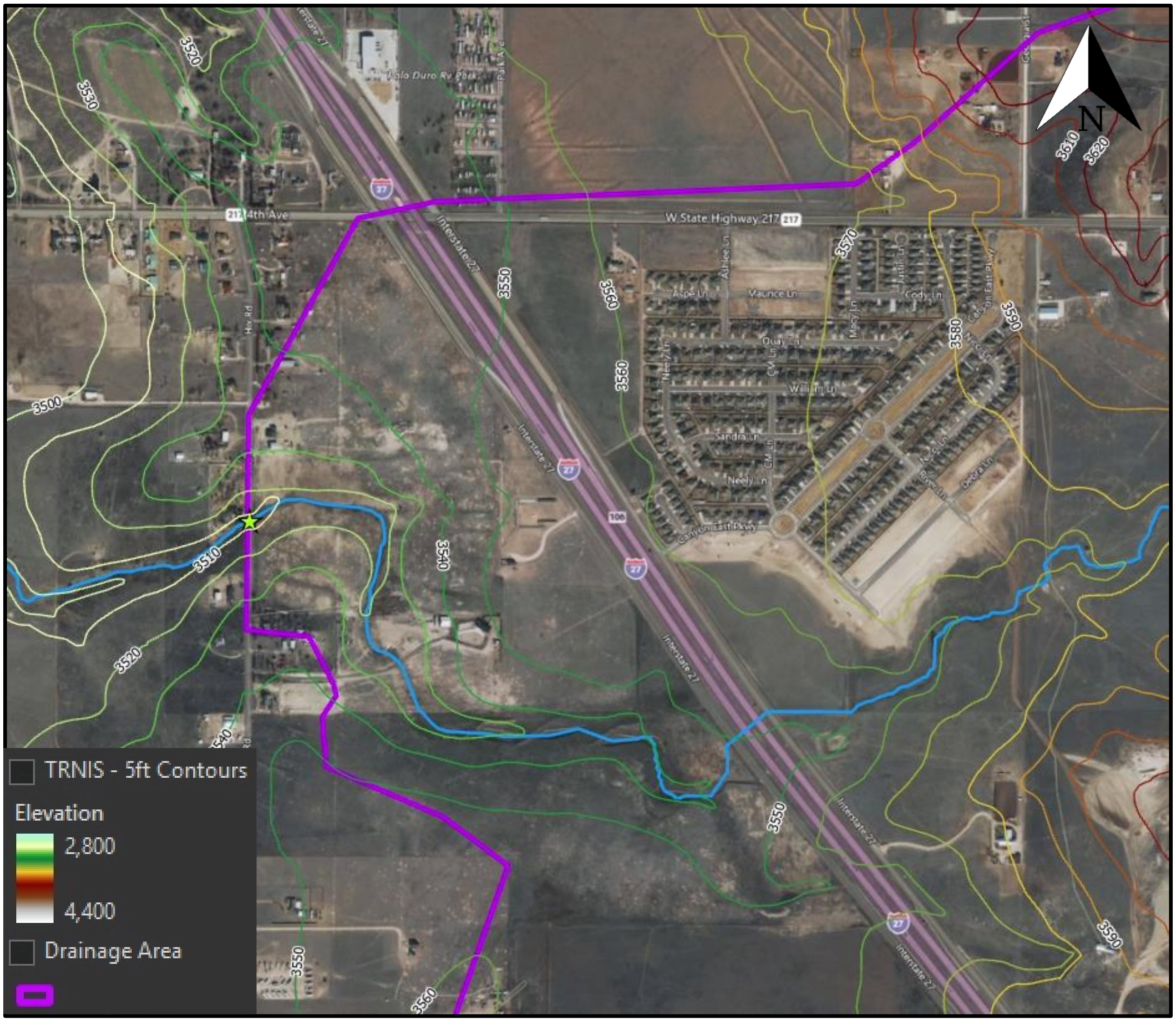

Figure 12: Location of Hix Drive and FM 217 crossing.

TM2 concluded this crossing is not serviceable for any ACE studied. The following proposed hydraulic improvements are for the 20% ACE and the 1% ACE.

20% ACE Proposed Hydraulic Improvements

Table 10 summarizes the proposed improvements to provide a 20% LOS.

Table 10: 20% LOS improvements proposed for Hix & FM 217.

20% LOS Improvements - Hix Drive & FM 217	
20% ACE Flow (cfs)	878
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	480
Existing Crossing	2 - 30" RCPs
List of Improvements	Upsize Culvert, Channel Mod.
Channel Modifications	Widen channel opening: 40' bottom, 4:1 SS
Proposed Crossing	2 - 10'x5' RCBs
1% Inundation with 20% LOS	2.4

The proposed crossing to provide a 20% LOS is shown in Figure 13.

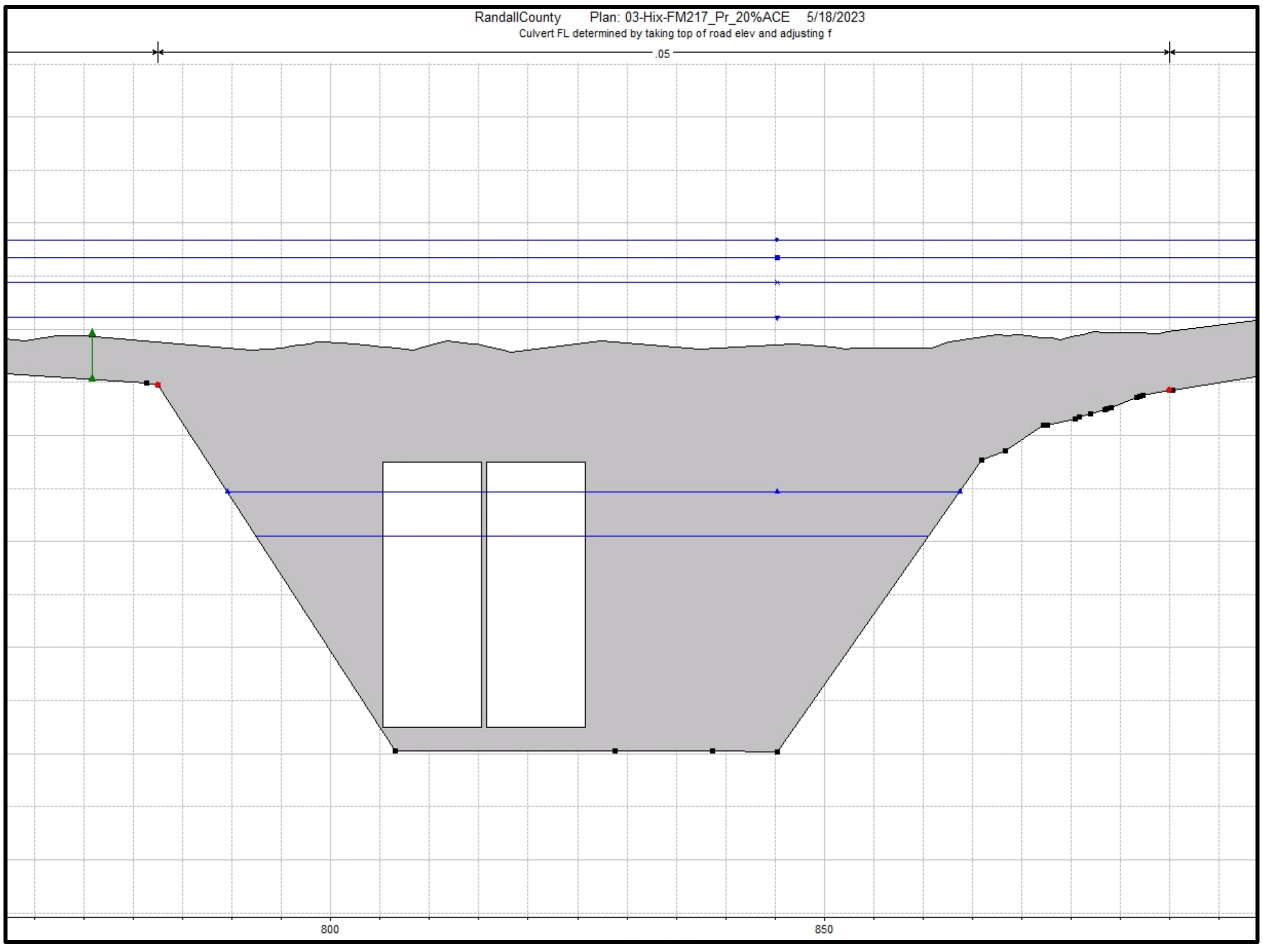

Figure 13: Proposed 20% LOS upstream cross section at Hix Road/FM 217 crossing of unnamed stream.

1% ACE Proposed Hydraulic Improvements

Table 11 summarizes the proposed improvements to provide a 1% LOS.

Table 11: 1% LOS improvements proposed for Hix & FM 217.

1% LOS Improvements - Hix Drive & FM 217	
1% ACE Flow (cfs)	2,302
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	480
Existing Crossing	2 - 30" RCPs
List of Improvements	Raise Road, Upsize Culvert, Channel Mod.
Channel Modifications	Widen channel opening: 40' bottom, 4:1 SS
Proposed Crossing	4 - 10'x7' RCBs
Road Rise (ft)	2.5
Approx. Length of Roadway (ft)	760

The proposed crossing to provide a 1% LOS is shown in Figure 14.

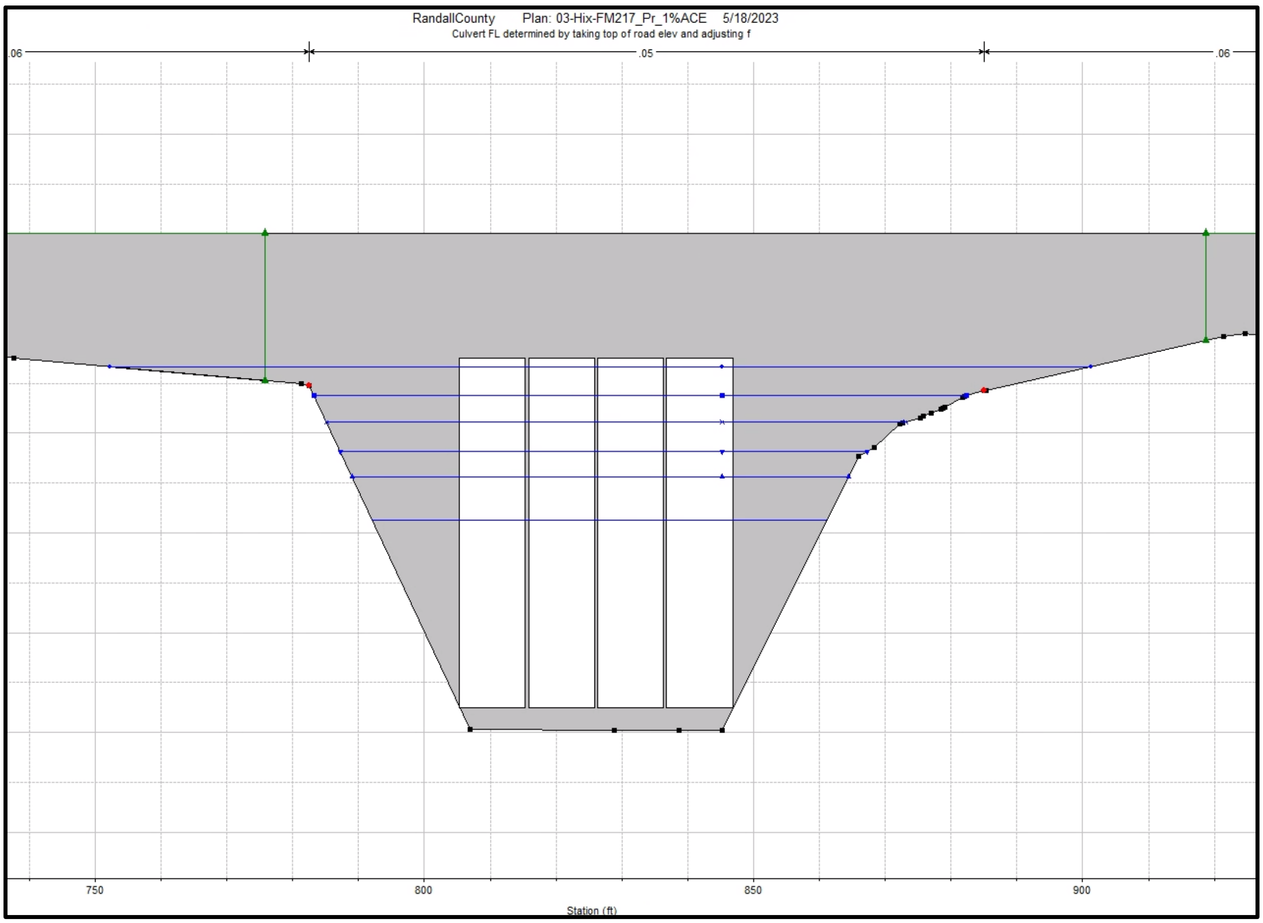

Figure 14: Proposed 1% LOS upstream cross section at Hix Road/FM 217 crossing of unnamed stream.

The County has requested the 1% LOS improvements be pursued as an FMP.

Site 4: Country Club Road at Unnamed Stream East of IH-27

This crossing is located along an unnamed stream approximately 1.0 mile upstream of the confluence with the Prairie Dog Town Fork of the Red River, as shown in Figure 15. FNI culvert field data report two 36" RCP-equivalent arch pipes (43.75" x 26.625").

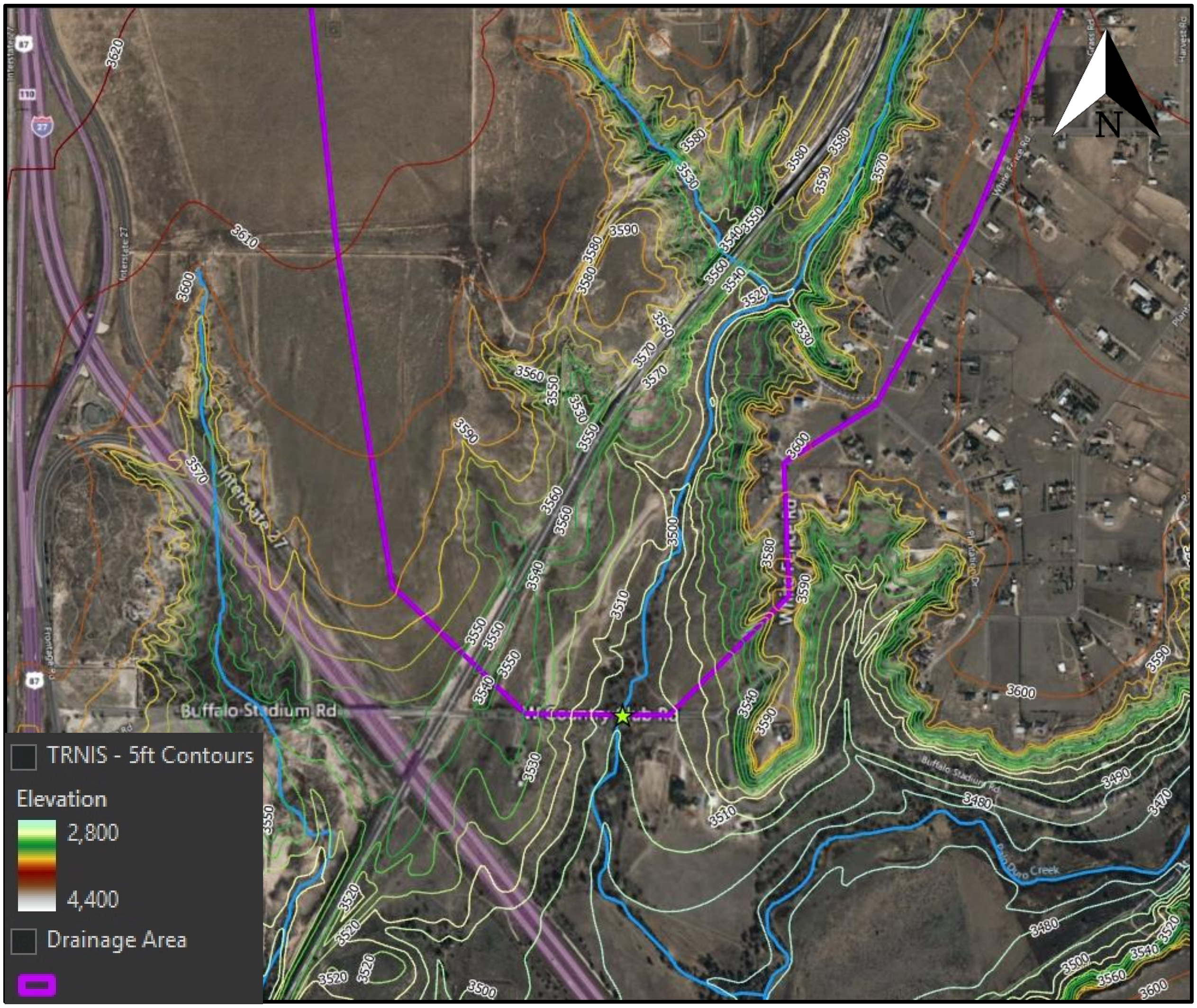

Figure 15: Location of Country Club Road crossing - East of IH-27.

TM2 concluded this crossing is not serviceable for any ACE studied. The following proposed hydraulic improvements are for the 20% ACE and the 1% ACE.

20% ACE Proposed Hydraulic Improvements

Table 12 summarizes the proposed improvements to provide a 20% LOS.

Table 12: 20% LOS improvements proposed for Country Club Road.

20% LOS Improvements - Country Club Road	
20% ACE Flow (cfs)	966
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	680
Existing Crossing	2 - 36" RCP EQV Arch Pipes
List of Improvements	Raise Road, Upsize Culvert
Proposed Crossing	2 - 10'x5' RCBs
Road Rise (ft)	5.0
Approx. Length of Roadway (ft)	380
1% Inundation with 20% LOS	1.2

The proposed crossing to provide a 20% LOS is shown in Figure 16.

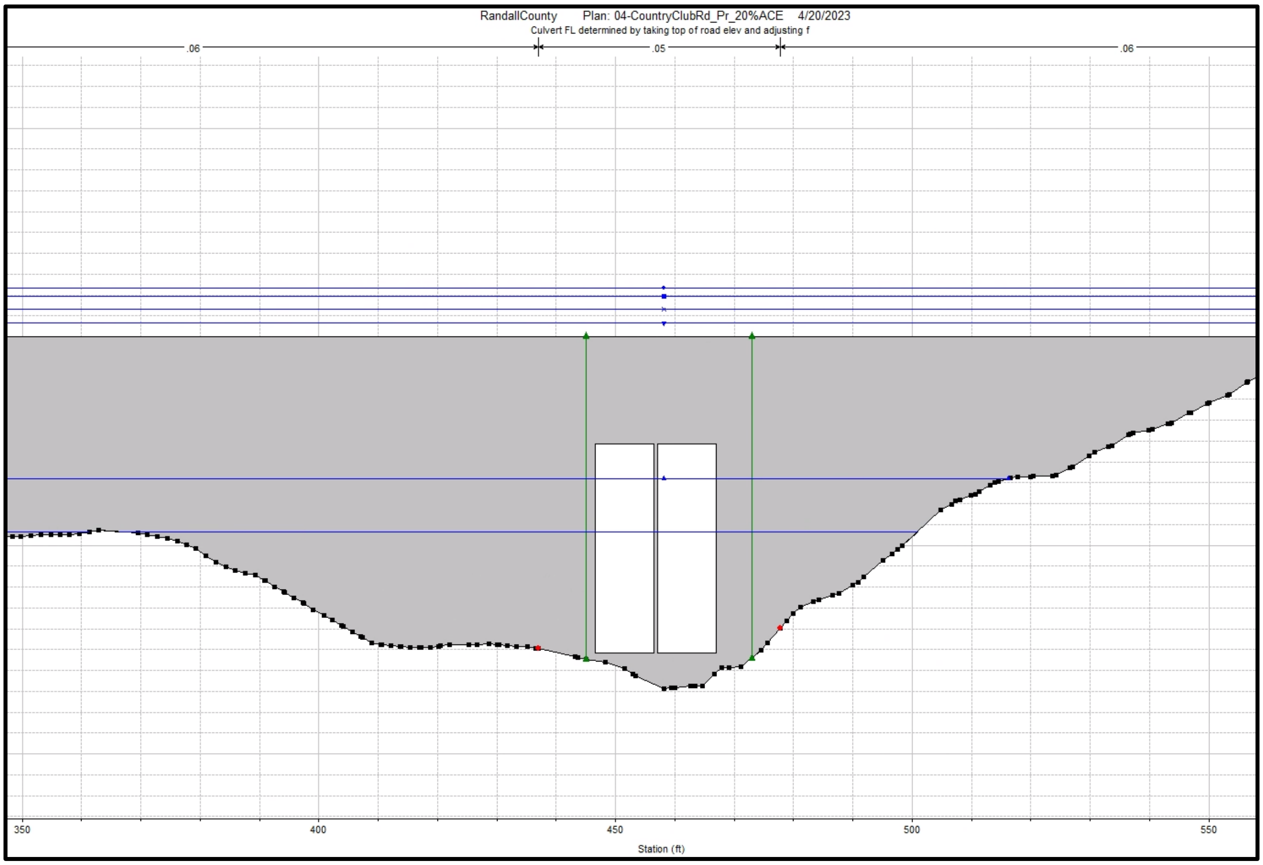

Figure 16: Proposed 20% LOS upstream cross section at Country Club Road crossing of unnamed stream east of IH-27.

1% ACE Proposed Hydraulic Improvements

Table 13 summarizes the proposed improvements to provide a 1% LOS.

Table 13: 1% LOS improvements proposed for Country Club Road.

1% LOS Improvements - Country Club Road	
1% ACE Flow (cfs)	2,524
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	680
Existing Crossing	2 - 36" RCP EQV Arch Pipes
List of Improvements	Raise Road, Upsize Culvert, Channel Mod.
Channel Modifications	20' shelf left overbank, 4:1 SS
Proposed Crossing	6 - 10'x5' RCBs
Road Rise (ft)	5.0
Approx. Length of Roadway (ft)	380

The proposed crossing to provide a 1% LOS is shown in Figure 17.

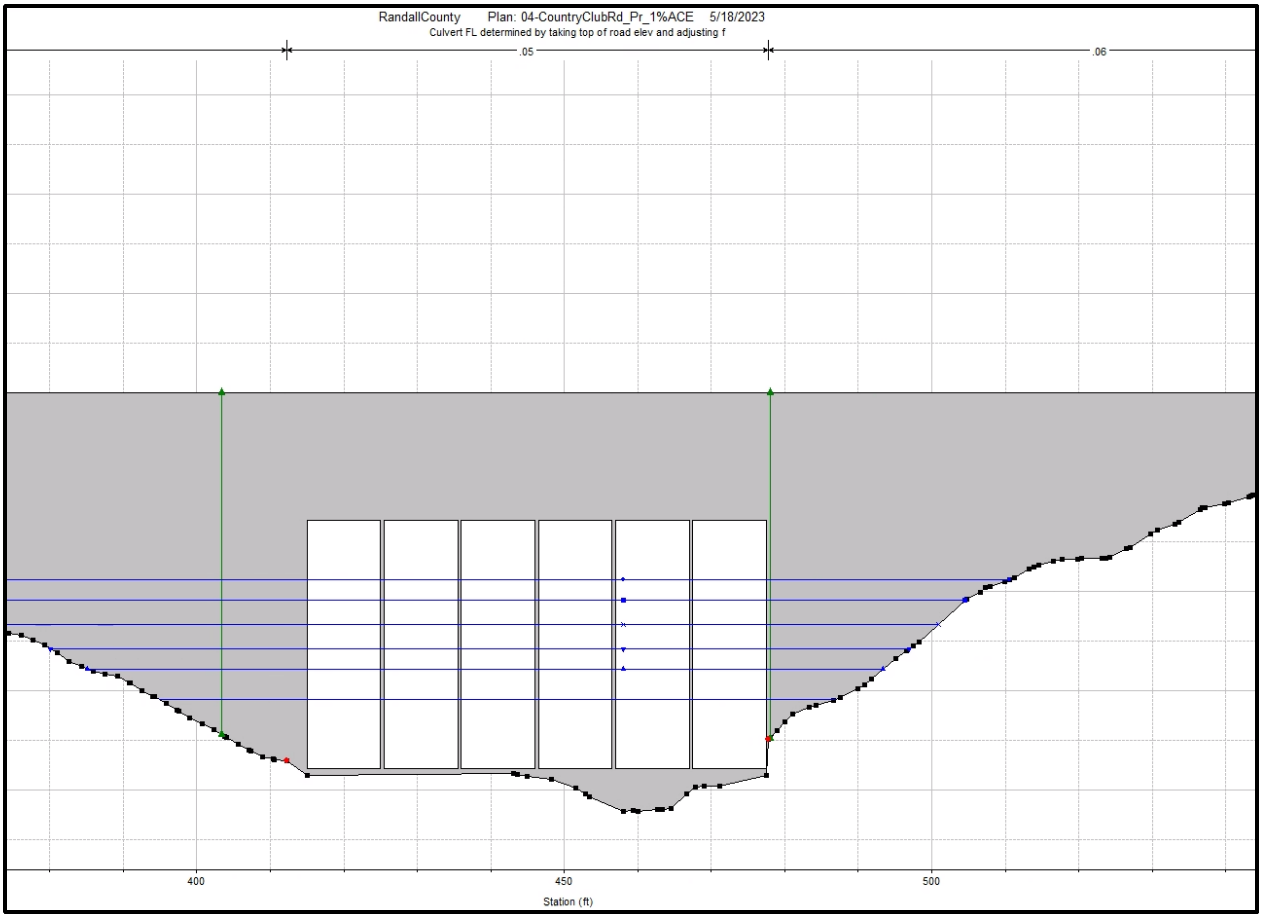

Figure 17: Proposed 1% LOS upstream cross section at Country Club Road crossing of unnamed stream east of IH-27.

The County has requested the 1% LOS improvements be pursued as an FMP.

Site 8: Running Water Road and FM 1714 at Unnamed Tributary to Hackberry Creek

The crossing on Running Water Road (also known as County Road 603) and FM 1714 is on an unnamed tributary to Hackberry Creek 0.2 miles upstream of U.S 87, as shown in Figure 18. FNI reported the crossing as a 12-foot bridge opening.

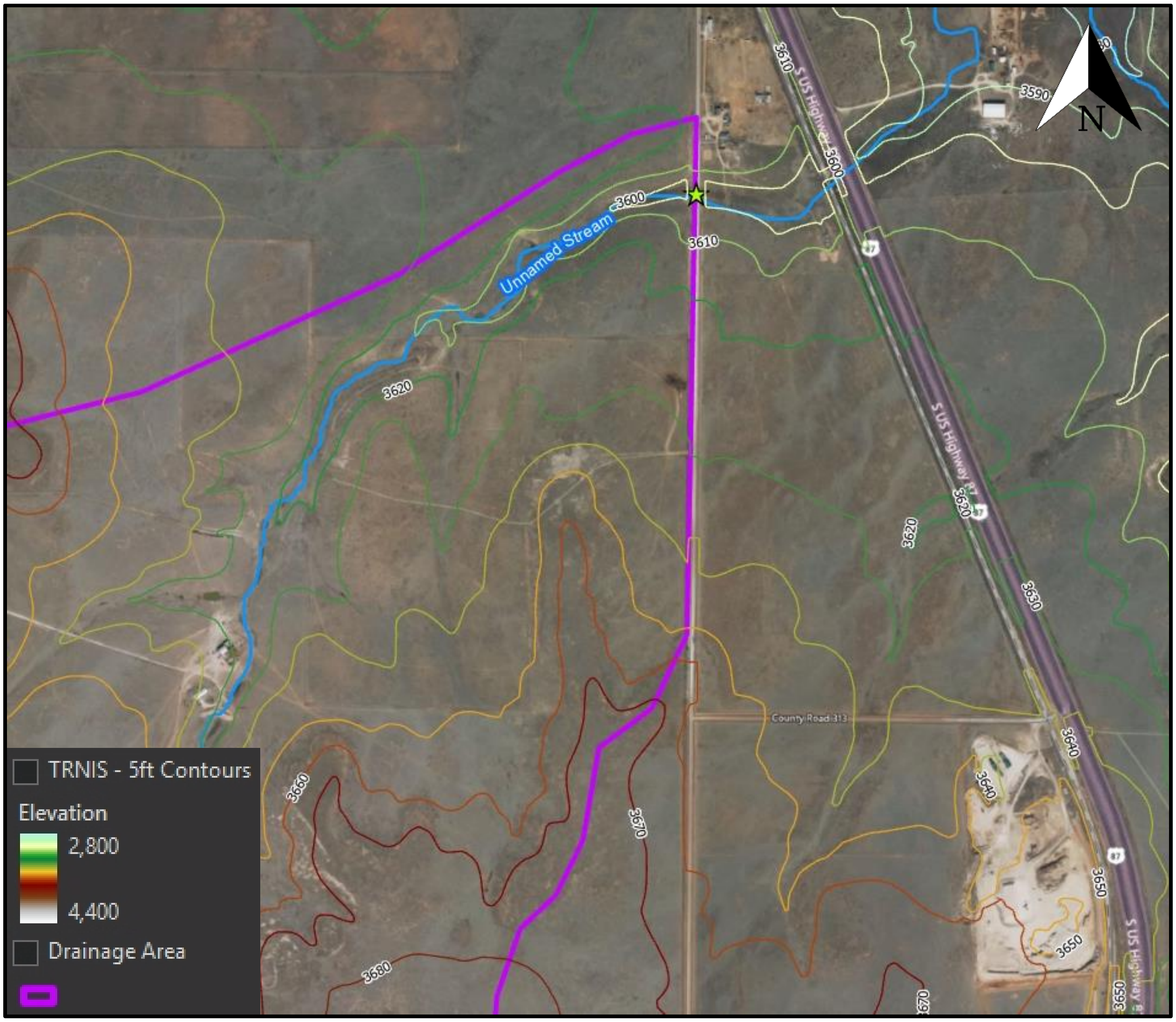

Figure 18: Location of Running Water Road and FM 1714 crossing.

TM2 concluded this crossing is not serviceable for any ACE studied. The following proposed hydraulic improvements are for the 20% ACE and the 1% ACE.

20% ACE Proposed Hydraulic Improvements

Table 14 summarizes the proposed improvements to provide a 20% LOS.

Table 14: 20% LOS improvements proposed for Running Water & FM 1714.

20% LOS Improvements - Running Water & FM 1714	
20% ACE Flow (cfs)	638
Functional Class	Local Road (dirt)
Approximate AADT (veh/day)	25
Existing Crossing	12-ft long, 1.8-ft tall bridge opening
List of Improvements	Raise Road, Increase Area of Opening
Proposed Crossing	24-ft long, 5.5-ft tall bridge opening
Road Rise (ft)	1.6
Approx. Length of Roadway (ft)	290
1% Inundation with 20% LOS	2.3

The proposed crossing to provide a 20% LOS is shown in Figure 19.

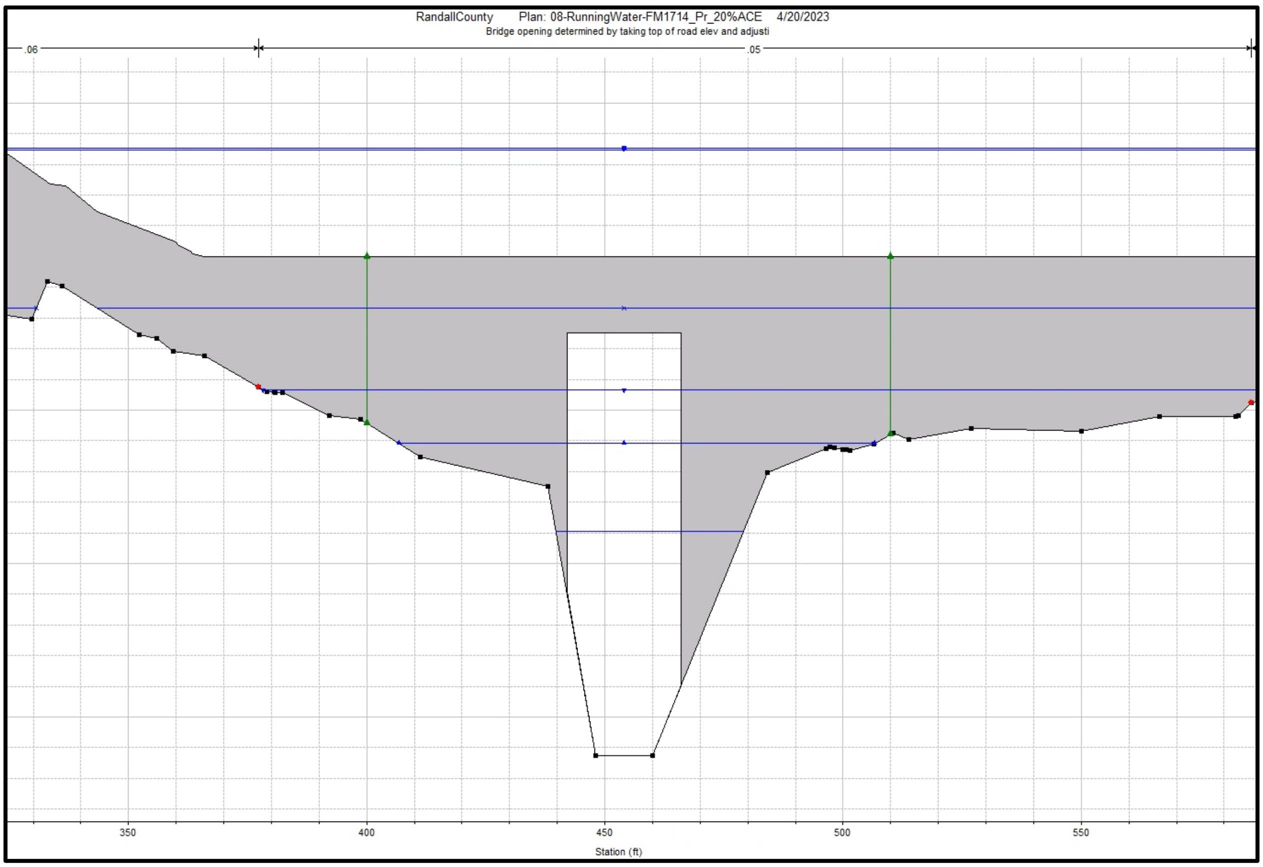

Figure 19: Proposed 20% LOS upstream cross section at Running Water Road and FM 1714 crossing of unnamed tributary to Hackberry Creek.

Table 15 summarizes the proposed improvements to provide a 1% LOS.

Table 15: 1% LOS improvements proposed for Running Water & FM 1714.

1% LOS Improvements - Running Water & FM 1714	
1% ACE Flow (cfs)	1,659
Functional Class	Local Road (dirt)
Approximate AADT (veh/day)	25
Existing Crossing	12-ft long, 1.8-ft tall bridge opening
List of Improvements	Raise Road, Increase Area of Opening
Proposed Crossing	30-ft long, 6.5-ft tall bridge opening
Road Rise (ft)	5.6
Approx. Length of Roadway (ft)	580

The proposed crossing to provide a 1% LOS is shown in Figure 20.

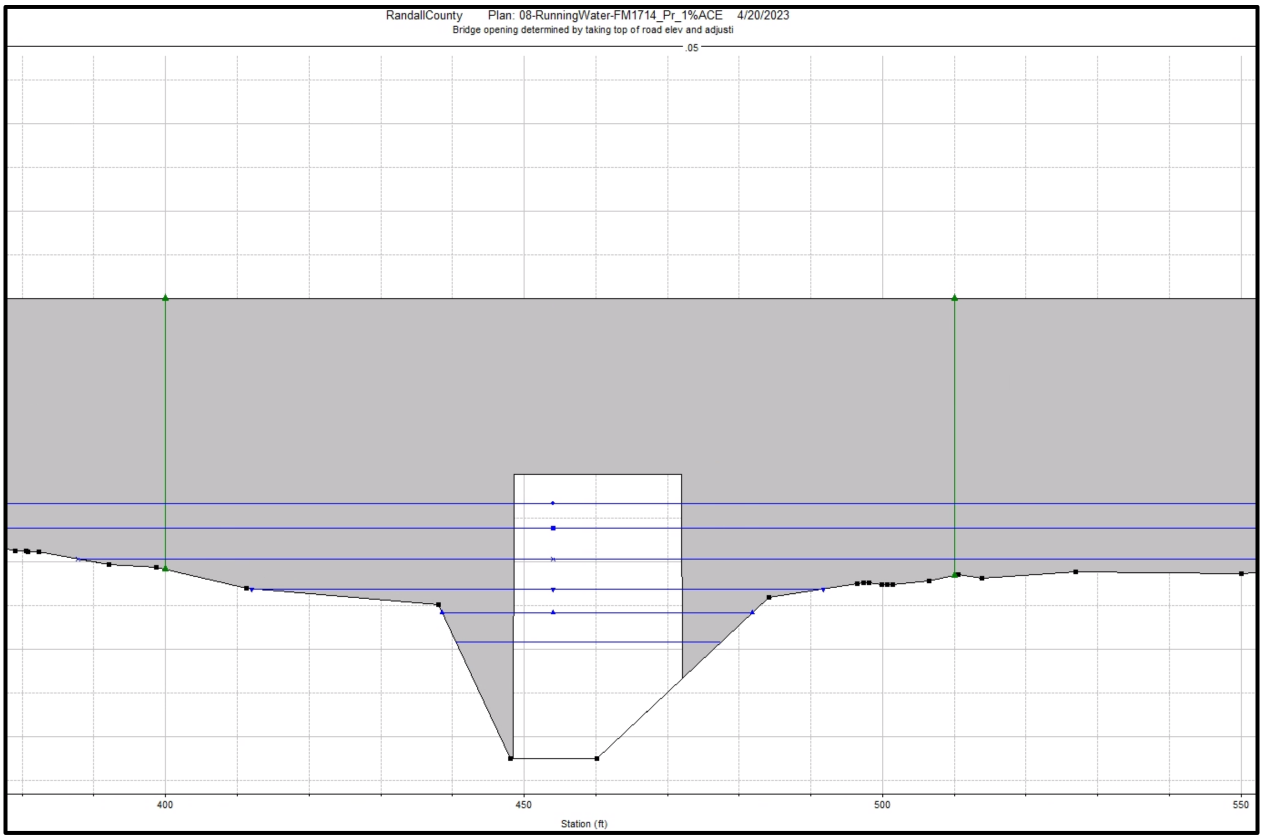

Figure 20: Proposed 1% LOS upstream cross section at Running Water Road and FM 1714 crossing of unnamed tributary to Hackberry Creek.

The County reported not much flooding occurs across this road. The County requested the 20% Level of Service be pursued as an FMP, with box culverts preferred over an increased bridge opening. The box culverts will be sized to provide an equivalent function as the bridge opening described here.

Methodology 3

Site 9. Hill Road and 46th at Playa Lake 53

This crossing is located at the edge of Playa Lake 53 and is identified by FNI as a 24” RCP and 30” CMP at the low point of Hill Road. The location is shown in Figure 21.

Figure 21: Location of Hill Road and 46th crossing.

TM2 concluded this crossing is not serviceable for any ACE studied. The following proposed hydraulic improvements are for the 20% ACE and the 1% ACE.

20% ACE Proposed Hydraulic Improvements

Table 16 summarizes the proposed improvements to provide a 20% LOS.

Table 16: 20% LOS improvements proposed for Hill & 46th.

20% LOS Improvements - Hill & 46th	
20% ACE Flow (cfs)	1,074
Functional Class	Local Road (dirt)
Approximate AADT (veh/day)	50
Existing Crossing	24" RCP & 30" CMP
List of Improvements	Raise Road
Road Rise (ft)	2.3
Approx. Length of Roadway (ft)	2,100
1% Inundation with 20% LOS	2.2

The proposed crossing to provide a 20% LOS is shown in Figure 22.

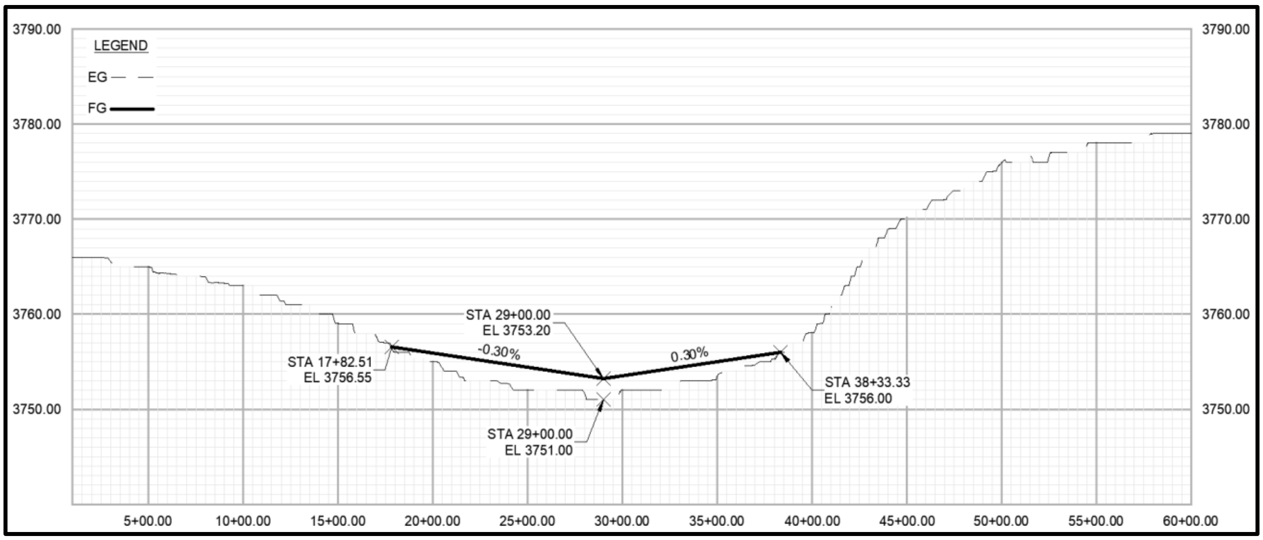

Figure 22: Proposed 20% LOS upstream cross section at Hill and 46th at Playa Lake 57.

1% ACE Proposed Hydraulic Improvements

Table 17 summarizes the proposed improvements to provide a 1% LOS.

Table 17: 1% LOS improvements proposed for Hill & 46th.

1% LOS Improvements - Hill & 46th	
1% ACE Flow (cfs)	2,611
Functional Class	Local Road (dirt)
Approximate AADT (veh/day)	50
Existing Crossing	24" RCP & 30" CMP
List of Improvements	Raise Road
Road Rise (ft)	5.5
Approx. Length of Roadway (ft)	2,700

The proposed crossing to provide a 1% LOS is shown in Figure 23.

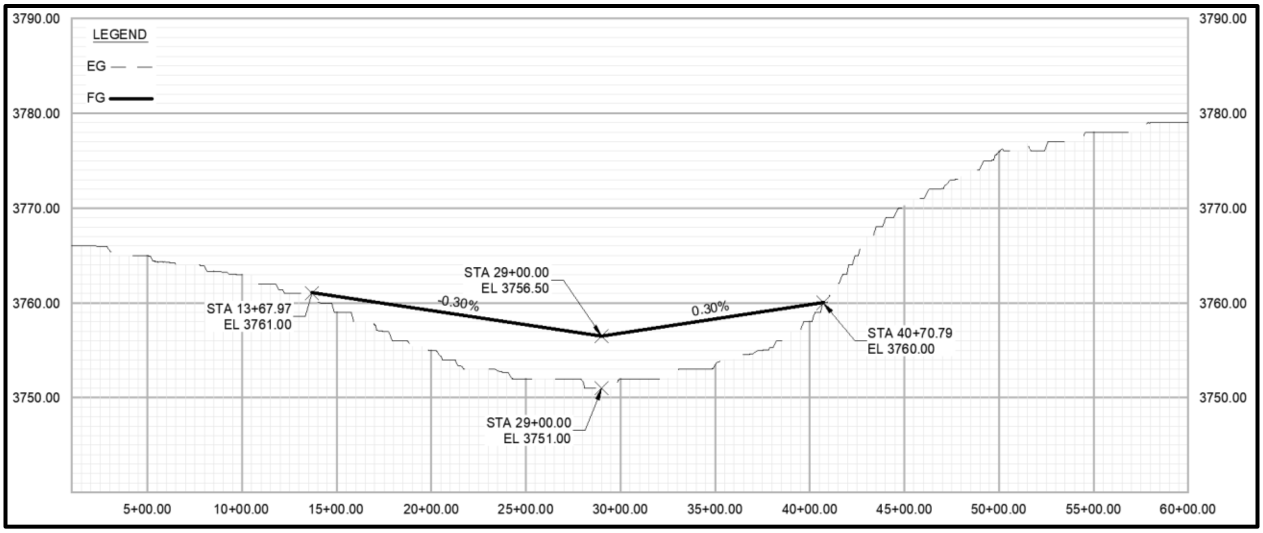

Figure 23: Proposed 1% LOS upstream cross section at Hill and 46th at Playa Lake 57.

The County reported this road is flooded for 8-9 months. The 20% Level of Service will be pursued as an FMP.

Site 12. Tradewinds and Farmers at Playa Lake 18

The Tradewinds crossing is located within Playa Lake 18 in the northeast quadrant of Loop 335 and S Washington St, shown in Figure 24. The crossing is identified by FNI as a 24” RCP and described as “falling apart”.

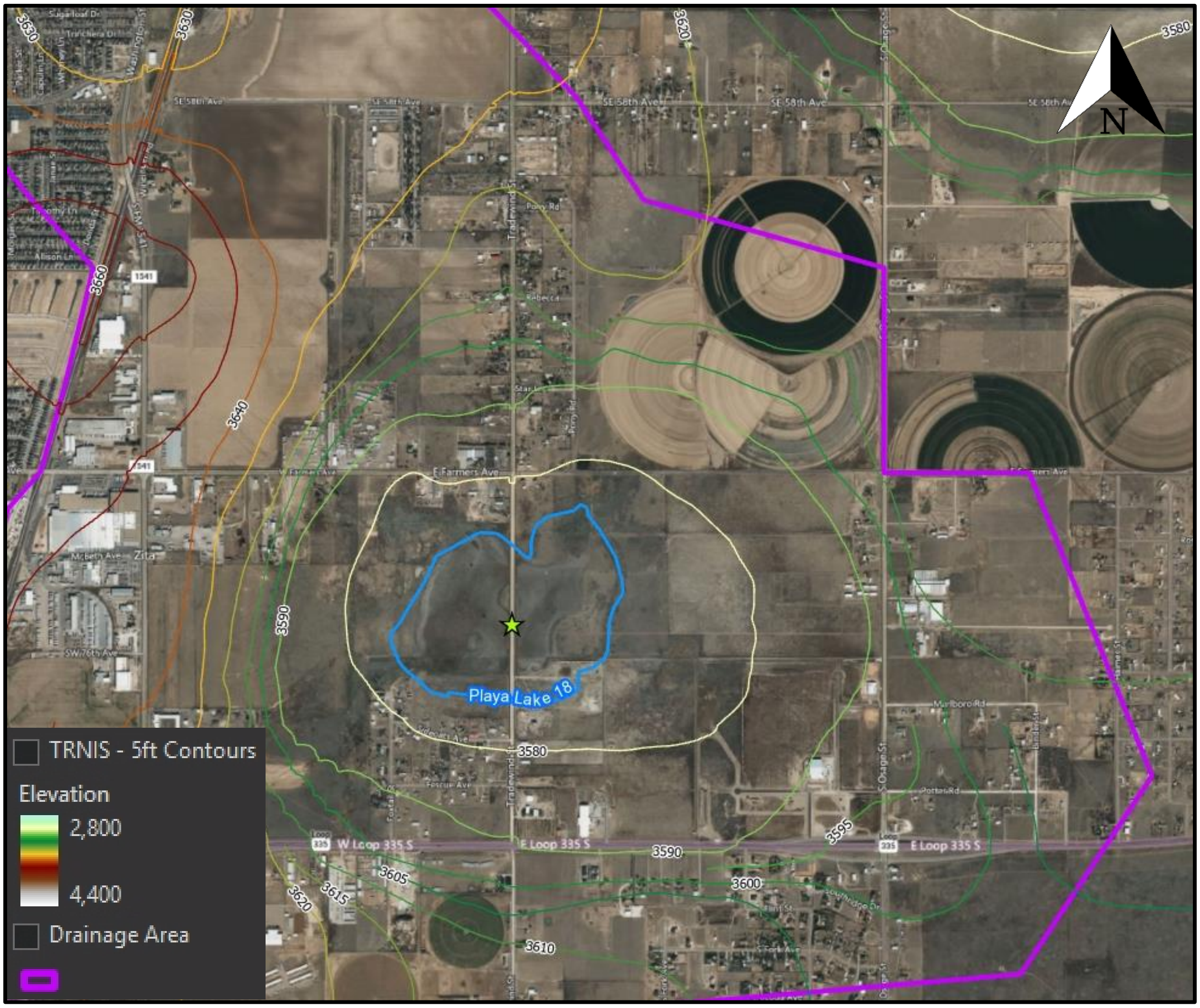

Figure 24: Location of Tradewinds and Farmers crossing.

This crossing is not serviceable for any ACE studied. The following proposed hydraulic improvements are for the 20% ACE and the 1% ACE.

20% ACE Proposed Hydraulic Improvements

Table 18 summarizes the proposed improvements to provide a 20% LOS.

Table 18: 20% LOS improvements proposed for Tradewinds & Farmers.

20% LOS Improvements - Tradewinds & Farmers	
20% ACE Flow (cfs)	4,689
Functional Class	Local Road (dirt)
Approximate AADT (veh/day)	1,500
Existing Crossing	24" RCP
List of Improvements	Raise Road
Road Rise (ft)	3.7
Approx. Length of Roadway (ft)	3,150
1% Inundation with 20% LOS	2.1

The proposed crossing to provide a 20% LOS is shown in Figure 25.

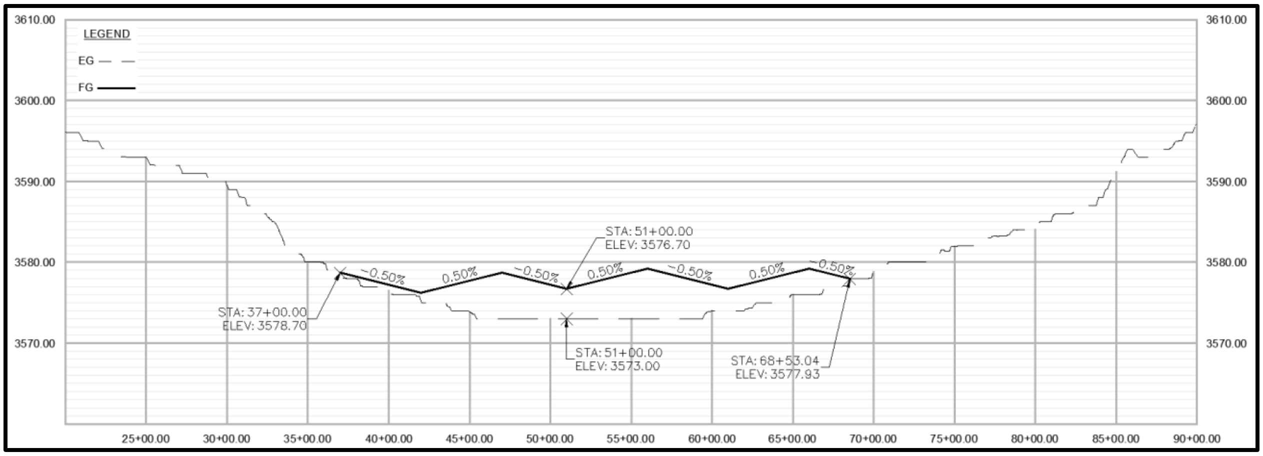

Figure 25: Proposed 20% LOS upstream cross section at Tradewinds and Farmers at Playa Lake 18.

1% ACE Proposed Hydraulic Improvements

Table 19 summarizes the proposed improvements to provide a 1% LOS.

Table 19: 1% LOS improvements proposed for Tradewinds & Farmers.

1% LOS Improvements - Tradewinds & Farmers	
1% ACE Flow (cfs)	11,035
Functional Class	Local Road (dirt)
Approximate AADT (veh/day)	1,500
Existing Crossing	24" RCP
List of Improvements	Raise Road
Road Rise (ft)	6.8
Approx. Length of Roadway (ft)	3,600

The proposed crossing to provide a 1% LOS is shown in Figure 26.

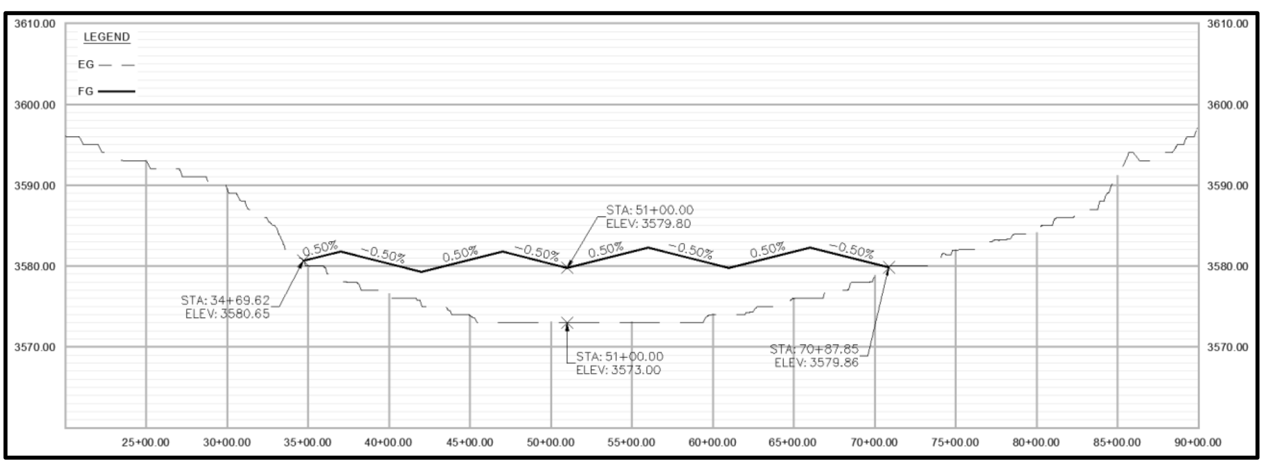

Figure 26: Proposed 1% LOS upstream cross section at Tradewinds and Farmers at Playa Lake 18.

The County requested the 20% Level of Service be pursued as an FMP.

Site 14. Whitaker and FM 1511 at Playa Lake 64

Randall County has identified a clogged equalizer pipe that connects the north and south sides of Playa Lake 64 across FM 1151, as shown in Figure 27. However, FNI was unable to find the equalizer pipe when collecting field data for this crossing. The hydrologic and hydraulic analysis for this site assumes that if there is an equalizer that currently exists, it is completely clogged and not functioning.

Figure 27: Location of Whitaker and FM 1511 crossing.

This crossing is not serviceable for the 1% ACE and larger events. The following proposed hydraulic improvements are for the 1% ACE, since the existing crossing provides a 20% LOS.

1% ACE Proposed Hydraulic Improvements

Table 20 summarizes the proposed improvements to provide a 1% LOS.

Table 20: 1% LOS improvements proposed for Whitaker & FM 1511.

1% LOS Improvements - Whitaker & FM 1511	
1% ACE Flow (cfs)	2,086
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	2,500
Existing Crossing	N/A
List of Improvements	Install Playa Equalizer
Proposed Crossing	42" RCP

The County requested the 1% Level of Service be pursued as an FMP.

Additional Considerations

Depending on the needs of the County and feasibility of the proposed improvements, there are additional solutions that can be implemented at crossings to address safety and maintenance issues. To provide traffic safety at the numerous crossings, design and safety measures such as conventional guardrails can be placed at most crossings except low-water crossings. Guard rails at low-water crossings can accumulate debris during overtopping rain events, so low curbs or borders to define edge of roadway are more appropriate. Other appropriate traffic safety measures include implementing warning signs along the road where the crossing is located. Various signage such as flood gauges, high water sensors with flashing lights, and signs with wording such as “FLOOD AREA AHEAD” or “DO NOT ENTER WHEN FLOODED” are all examples of additional measures that can be taken to address safety concerns.

Many crossings service unpaved roads, which can lead to various maintenance problems during overtopping rain events. Soil from unpaved roads can accumulate dirt and block the inlet and/or outlet of a culvert crossing, as observed in FNI’s field site visits. By paving the road sections at the location of the crossing, the culvert crossings can function at the expected capacity and require less maintenance over time. Other maintenance solutions include clearing and grubbing of the channel upstream and downstream of the crossing to avoid blockage and facilitate runoff traveling through the crossing.

Summary and Next Steps

Proposed improvements have been evaluated for the crossings to achieve both a 20% LOS and a 1% LOS. The solutions implemented include a combination of raising the road, upsizing the existing crossing, and modifying the channel. Technical Memo 4 will follow this memo, which will provide opinions of probable construction cost, document Benefit/Cost Analyses for each FMP, and confirm which proposed improvements will be pursued as FMPs. Table 21 summarizes the proposed improvements for each site.

Table 21: Site Summary of Proposed Improvements.

Site Summary of Proposed Improvements				
Rank	**Site**	**Type of Flooding**	**LOS Pursued**	**Proposed Improvements**
1	**West Rockwell Road and Soncy Road**	Riverine Flooding	20% ACE	*Additional culverts, raise road, modify channel*
2	**Happy West Road and Bell Street**	Riverine Flooding	20% ACE	*Additional culverts, raise road, modify channel*
3	**Hix Drive and FM 217**	Riverine Flooding	1% ACE	*Additional culverts, raise road, modify channel*
4	**Country Club Road**	Riverine Flooding	1% ACE	*Additional culverts, raise road, modify channel*
6	**Westline Road**	Riverine Flooding	None	*Traffic safety alternatives*
8	**Running Water Road and FM 1714**	Riverine Flooding	20% ACE	*Replace bridge opening with culverts, raise road*
9	**Hill Road and 46th**	Playa Flooding	20% ACE	*Raise road*
11	**Gordon-Cummings Road Low Water Crossing**	Riverine Flooding	20% ACE	*Increase bridge opening/raise low chord, raise road*
12	**Tradewinds and Farmers**	Playa Flooding	20% ACE	*Raise road*
14	**Whitaker and FM 1511**	Playa Flooding	1% ACE	*Install playa equalizer pipe*

Memo

Date:	Friday, June 09, 2023
Project:	Region 1 (Canadian – Upper Red) Regional Flood Plan
To:	Scott Hubley, PE Chris Johnson, PE
From:	Emily Daniel, PE David Dunn, PE Ronaldo Rodriquez, EIT
Subject:	Technical Memo 4 – Benefit-Cost Analyses for Proposed Randall County Crossings FMPs

Technical Memo 4

In Technical Memo 1 (TM1) (March 22, 2023), the Region 1 consultant team proposed analysis methodologies for 15 culvert crossings requested by Randall County to be evaluated for potential Flood Mitigation Project (FMP) status. In Technical Memo 2 (TM2) (May 18, 2023) the results of the hydrologic and hydraulic analysis of the existing conditions of the various culvert crossings were presented. The analyses were based in part on field data collected by Freese and Nichols, Inc (FNI) at each site.

On April 26, 2023, the Region 1 consultant team presented initial recommendations to representatives from Randall County and received feedback as to the County's preferred FMP at each site. In Technical Memorandum 3 (TM3) (May 26, 2023) the results of the proposed conditions of the various culvert crossing improvements were presented reflecting the County's preferences expressed during the April meeting.

This memorandum (TM4) presents an Opinion of Probable Construction Costs and a Benefit-Cost Analysis (BCA) for each of the FMPs. Table 1 summarizes the potential FMP's to be considered by the Region 1 (Canadian-Upper Red) Flood Planning Group (FPG).

Table 1: Summary of potential projects to be pursued as FMPs.

Summary of FMPs for Region 1 FPG Consideration				
Site		Type of Flooding	LOS Pursued	Proposed Improvements
1	**West Rockwell Road and Soncy Road**	Riverine Flooding	20% ACE	*Additional culverts, raise road, modify channel*
2	**Happy West Road and Bell Street**	Riverine Flooding	20% ACE	*Additional culverts, raise road, modify channel*
3	**Hix Drive and FM 217**	Riverine Flooding	1% ACE	*Additional culverts, raise road, modify channel*
4	**Country Club Road**	Riverine Flooding	1% ACE	*Additional culverts, raise road, modify channel*
6	**Westline Road**	Riverine Flooding	None	*Traffic safety alternatives*
8	**Running Water Road and FM 1714**	Riverine Flooding	20% ACE	*Replace bridge opening with culverts, raise road*
9	**Hill Road and 46th**	Playa Flooding	20% ACE	*Raise road*
11	**Gordon-Cummings Road LWC**	Riverine Flooding	20% ACE	*Increase bridge opening/raise low chord, raise road*
12	**Tradewinds and Farmers**	Playa Flooding	20% ACE	*Raise road*
14	**Whitaker and FM 1511**	Playa Flooding	None	*Install playa equalizer pipe*

Benefit-Cost Analysis Methodology

The BCA is to compute a benefit-cost ratio (BCR) using the Texas Water Development Board's (TWDB) BCA Input Tool. This tool creates a spreadsheet that estimates flood impacts for "Baseline" (existing) and "Project" (proposed) conditions for up to three Annual Chance Events (ACE). The impacts of Flooded Streets and Low Water Crossing are evaluated in the BCAs.

The individual spreadsheets for the BCA Tool used for these analyses are:

- Project Information
- Project Costs
- Flooded Streets
- Low Water Crossing
- Results

The following methodologies and assumptions were made for the BCAs:

Project Information

Each BCA assumed a construction start in 2025 and one year to complete construction.

Since TWDB's BCA Input Tool spreadsheet is limited to three recurrence intervals, two spreadsheets were made for each site to incorporate six ACE's: 50%, 20%, 10%, 4%, 2%, and 1%.

Project Costs
Opinions of Probable Construction Costs (OPCCs) were developed for each potential FMP for use in the BCA. The TxDOT Online Workbook for Bid Item Averages, and bid tabs and cost estimates from similar infrastructure projects designed by HDR were used as references for determining appropriate unit costs for each item.[1]

The quantities developed for excavation and embankment were determined by comparing the proposed terrain modifications in the hydraulic model with the existing terrain. The total costs associated with each site are based on design at a conceptual level, and are not intended for permitting, bidding, or construction purposes. Contingencies of 30% were applied to each cost estimate to account for the conceptual design stage of each project, as well as 20% for design fees and contract overhead, profit, and insurance.

Flooded Streets
According to the BCA Input Tool, streets are considered impassable when the inundation depths reach six inches or deeper. The miles of flooded roadway were approximated using the recorded depths at each ACE and measured across the roadway profiles for each site. The time roadways are impassable due to riverine flooding was calculated by determining the flood discharge needed to overtop the road and measuring the duration of the hydrograph with discharges exceeding this value. Figure 1 shows an example of this calculation if the roadway is overtopped with discharges exceeding 500 cubic feet per second (cfs).

For the riverine flooding sites that used the FIS discharges and have no hydrographs available, the inundated times from Site 2 – Happy West and Bell were used because the drainage areas are similar in size.

For the playa flooding sites, the inundation durations were calculated by multiplying the depths of the playa flooding above the road by a uniform infiltration rate of 0.428 inches per day. TWDB Report 386, Playa Lakes in the Southern High Plains: Runoff, Infiltration, and Recharge (April 2021) reports average infiltration rates of 0.204 inches per day, with rates as high as 0.839 inches per day. An infiltration rate of 0.428 inches per day was used to apply a uniform assumption that a playa takes approximately four weeks to drop 12 inches. It should be noted that some of the playa sites could be inundated for much longer based on anecdotal evidence from Randall County, but for the purposes of these BCA analyses, the uniform infiltration rate was applied.

[1] Any opinions of probable construction cost provided by HDR are made based on information available to HDR and based on the cost estimator's experience and qualifications and represents its judgment as an experienced and qualified professional engineer. HDR has no control over the cost of labor, materials, equipment, or services furnished by others, or over methods of determining prices, or over competitive bidding or market conditions. HDR does not guarantee that proposals, bids, or actual project or construction cost will not vary from opinions of probable cost prepared by HDR.

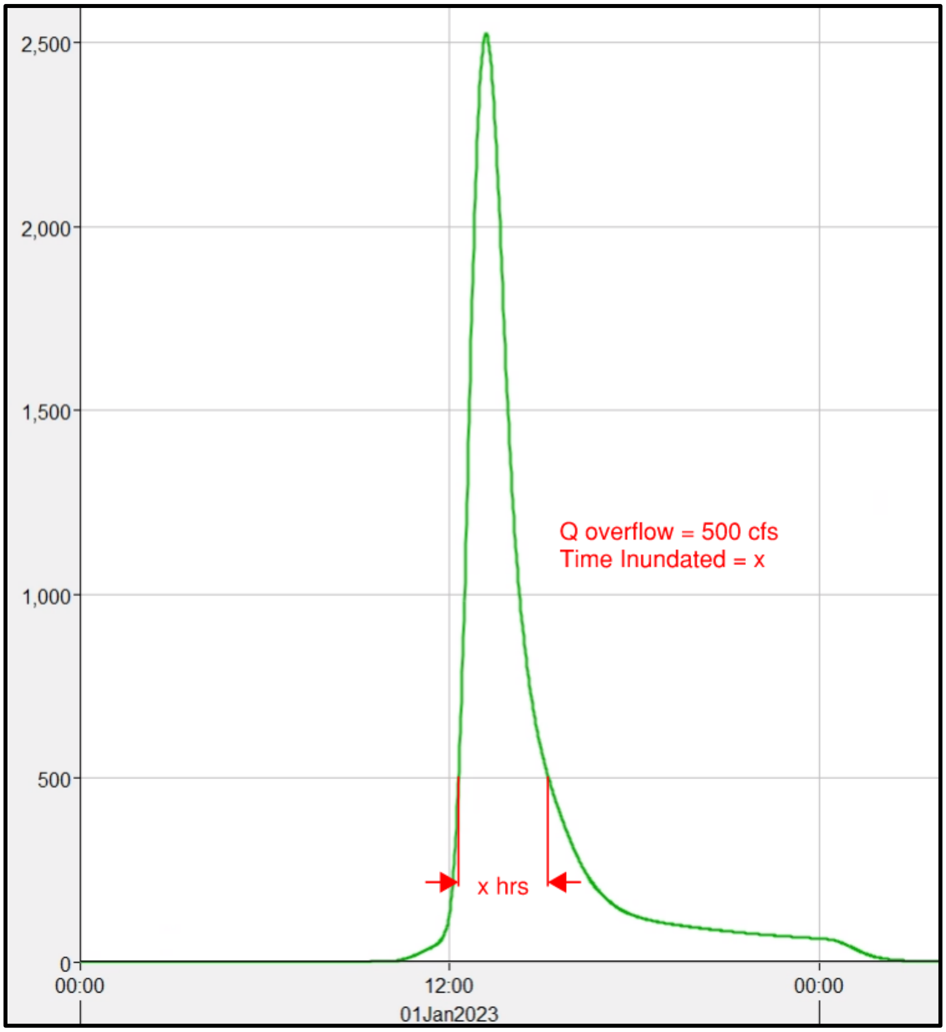

Figure 1: Example of using an inflow hydrograph to calculate inundation times.

The daily traffic count for each BCA was recorded from TxDOT's Traffic Count Database System (TCDS) (https://txdot.public.ms2soft.com/tcds). When calculating additional time for detours, Google Maps was used to approximate the nearest detour route. The Normal Emergency Services response time was assumed to be 14.5 minutes based on the rural mean value from Table 2 of the National Institutes of Health Journal of the American Medical Association Surgery study (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5831456/). For EMS response time during a storm event, the time was increased to 19 minutes and included any additional time for detours. The TNRIS Land Parcels (Various Appraisal Districts (Various Appraisal Districts). Land Parcels, 2022-07-01) was used to estimate the number of residential and commercial structures impacted by the EMS delay.

Low Water Crossing

The depths of flooding at the low water crossings were calculated using the hydraulic models. Like the Flooded Streets section of the BCA Input Tool spreadsheet, inputs for duration of flooding, daily traffic count, and detour times were calculated as noted above.

Calculation of BCRs

The damages calculated by the BCA Input Tool for each recurrence interval were then used in the Federal Emergency Management Agency (FEMA) BCA Toolkit 6.0 to calculate the project benefits at each site. The benefits generated by the FEMA BCA Toolkit were then input back into TWDB's BCA Input Tool to calculate a BCR for each site. The following sections summarize each potential FMP's cost and BCR, grouped by the three hydrologic and hydraulic methodologies. For more information regarding the hydrologic and hydraulic methodologies, consult TM2 and TM3.

Methodology 1: FIS Flows for Studied Streams

SITE 1: WEST ROCKWELL ROAD AND SONCY ROAD AT SPRING DRAW

Randall County expressed support for the 20% Level of Service (LOS) improvements to be pursued for FMP status. Table 2 summarizes the proposed improvements to provide a 20% LOS.

Table 2: 20% LOS improvements proposed for West Rockwell & Soncy.

20% LOS Improvements - West Rockwell & Soncy	
20% ACE Flow (cfs)	1,523
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	1,850
Existing Crossing	2 - 36" RCPs
List of Improvements	Raise Road, Upsize Culvert, Channel Mod.
Channel Modifications	Widen channel opening: 55' bottom, 4:1 SS
Proposed Crossing	3 - 12'x5' RCBs
Road Rise (ft)	0.5
Approx. Length of Roadway (ft)	280
1% Inundation with 20% LOS	3.0

The OPCC for the 20% LOS improvements is shown in the Appendix. The cost of the FMP to provide 20% LOS is $712,776. The BCR output calculated by TWDB's BCA Input Tool is shown in Figure 2. [2]The BCR for the proposed FMP is 0.1.

[2] Note that the "Total Costs" displayed in the BCR output are different from the OPCC shown in the appendix due to adjustment of costs during the BCA process.

Texas Water Development Board

Input Into BCA Toolkit		
Project Useful Life	30	
Event Damages	**Baseline**	**Project**
25 - year storm	$2,138	$668
50 - year storm	$2,138	$1,016
100 - year storm	$2,138	$1,283

Total Benefits from BCA Toolkit	$32,834
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs	$602,202
Net Benefits	-$569,368
Net Benefits with Recreation	-$569,368
Final BCR	**0.1**
Final BCR with Recreation	**0.1**

Figure 2: TWDB BCA Input Tool Results for West Rockwell & Soncy.

SITE 6: WESTLINE ROAD AT PALO DURO CREEK

The Westline Road bridge currently provides a 4% LOS and the bridge is inspected every year by TxDOT; thus the County does not desire to pursue a large-scale redesign of this bridge and prefers to pursue roadway safety measures.

Some examples of appropriate safety measures include installing conventional guardrails and implementing warning signs along the road where the crossing is located. Various signage such as flood gauges, high water sensors with flashing lights, and signs with wording such as "FLOOD AREA AHEAD" or "DO NOT ENTER WHEN FLOODED". All traffic safety measures to be considered for this site should be discussed and approved by Randall County.

No FMP has been developed for this site and no BCA was performed.

SITE 11: GORDON-CUMMINGS ROAD LOW WATER CROSSING AT TIERRA BLANCA CREEK

Randall County expressed support for the 20% LOS improvements to be pursued for FMP status. Traffic is expected to increase in the future at this location. Table 3 summarizes the proposed improvements to provide a 20% LOS.

Table 3: 20% LOS improvements proposed for Gordon-Cummings LWC.

20% LOS Improvements - Gordon-Cummings LWC	
20% ACE Flow (cfs)	3,139
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	150
Existing Crossing	24" CMP
List of Improvements	Raise Road, Replace Culvert with Bridge
Proposed Crossing	140-ft long, 6-ft tall bridge opening
Road Rise (ft)	6.1
Approx. Length of Roadway (ft)	670
1% Inundation with 20% LOS	3.7

The OPCC for the 20% LOS improvements is shown in the Appendix. The cost of the FMP to provide 20% LOS is $1,181,269. The BCR output calculated by TWDB's BCA Input Tool is shown in Figure 3. The BCR for the proposed FMP is 1.3.

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
25 - year storm	**$220,513**	**$30,416**
50 - year storm	**$231,919**	**$51,920**
100 - year storm	**$243,325**	**$45,167**

Total Benefits from BCA Toolkit	$1,335,002
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs	$1,067,878
Net Benefits	$267,124
Net Benefits with Recreation	$267,124
Final BCR	**1.3**
Final BCR with Recreation	**1.3**

Figure 3: TWDB BCA Input Tool Results for Gordon-Cummings LWC.

Methodology 2: Storm Event Modeling

SITE 2: HAPPY WEST ROAD AND BELL STREET AT HAPPY DRAW

Randall County expressed support for the 20% LOS improvements to be pursued for FMP status. Table 4 summarizes the proposed improvements to provide a 20% LOS.

Table 4: 20% LOS improvements proposed for Happy West & Bell.

20% LOS Improvements - Happy West & Bell	
20% ACE Flow (cfs)	2,198
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	250
Existing Crossing	2 - 8'x3.5' RCBs & 2 - 30" RCPs
List of Improvements	Raise Road, Upsize Culvert, Channel Mod.
Channel Modifications	Widen channel opening: 20' bottom, 4:1 SS
Proposed Crossing	4 - 8'x7' RCBs
Road Rise (ft)	4.0
Approx. Length of Roadway (ft)	760
1% Inundation with 20% LOS	1.4

The OPCC for the 20% LOS improvements is shown in the Appendix. The cost of the FMP to provide 20% LOS is $1,225,428 The BCR output calculated by TWDB's BCA Input Tool is shown in Figure 4. The BCR for the proposed FMP is < 0.05.[3]

Texas Water Development Board

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
25 - year storm	**$2,257**	**$78**
50 - year storm	**$2,374**	**$195**
100 - year storm	**$2,491**	**$233**

Total Benefits from BCA Toolkit	$10,337
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs	$1,107,798
Net Benefits	-$1,097,461
Net Benefits with Recreation	-$1,097,461
Final BCR	**0.0**
Final BCR with Recreation	**0.0**

Figure 4: TWDB BCA Input Tool Results for Happy West & Bell.

[3] The BCR displayed by the tool is rounded to the nearest tenth, so any BCR less than 0.05 will display as "0.0".

SITE 3: HIX DRIVE AND FM 217 AT UNNAMED STREAM

The County has requested the 1% LOS improvements be pursued as an FMP. Table 5 summarizes the proposed improvements to provide a 1% LOS.

Table 5: 1% LOS improvements proposed for Hix & FM 217.

1% LOS Improvements - Hix Drive & FM 217	
1% ACE Flow (cfs)	2,302
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	480
Existing Crossing	2 - 30" RCPs
List of Improvements	Raise Road, Upsize Culvert, Channel Mod.
Channel Modifications	Widen channel opening: 40' bottom, 4:1 SS
Proposed Crossing	4 - 10'x7' RCBs
Road Rise (ft)	2.5
Approx. Length of Roadway (ft)	760

The OPCC for the 1% LOS improvements is shown in the Appendix. The cost of the FMP to provide 1% LOS is $1,216,248. The BCR output calculated by TWDB's BCA Input Tool is shown in Figure 5. The BCR for the proposed FMP is < 0.05.

Texas Water Development Board

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	**Baseline**	**Project**
25 - year storm	**$2,060**	**$0**
50 - year storm	**$2,317**	**$0**
100 - year storm	**$2,961**	**$0**

Total Benefits from BCA Toolkit	$10,324
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs	$1,099,499
Net Benefits	-$1,089,175
Net Benefits with Recreation	-$1,089,175
Final BCR	**0.0**
Final BCR with Recreation	**0.0**

Figure 5: TWDB BCA Input Tool Results for Hix & FM 217.

SITE 4: COUNTRY CLUB ROAD AT UNNAMED STREAM EAST OF IH-27

The County has requested the 1% LOS improvements be pursued as an FMP. Table 6 summarizes the proposed improvements to provide a 1% LOS.

Table 6: 1% LOS improvements proposed for Country Club Road.

1% LOS Improvements - Country Club Road	
1% ACE Flow (cfs)	2,524
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	680
Existing Crossing	2 - 36" RCP EQV Arch Pipes
List of Improvements	Raise Road, Upsize Culvert, Channel Mod.
Channel Modifications	20' shelf left overbank, 4:1 SS
Proposed Crossing	6 - 10'x5' RCBs
Road Rise (ft)	5.0
Approx. Length of Roadway (ft)	380

The OPCC for the 1% LOS improvements is shown in the Appendix. The cost of the FMP to provide 1% LOS is $1,243,026 The BCR output calculated by TWDB's BCA Input Tool is shown in Figure 6. The BCR for the proposed FMP is < 0.05.

Texas Water Development Board

Input Into BCA Toolkit

Project Useful Life	**30**

Event Damages	Baseline	Project
25 - year storm	$1,955	$0
50 - year storm	$2,053	$0
100 - year storm	$2,346	$0

Total Benefits from BCA Toolkit	$11,218
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs	$1,123,707
Net Benefits	-$1,112,489
Net Benefits with Recreation	-$1,112,489
Final BCR	**0.0**
Final BCR with Recreation	**0.0**

Figure 6: TWDB BCA Input Tool Results for Country Club Road.

SITE 8: RUNNING WATER ROAD AND FM 1714 AT UNNAMED TRIBUTARY TO HACKBERRY CREEK

The County stated that there has not been much reported flooding across this road. The County requested the 20% Level of Service be pursued as an FMP, with box culverts preferred over an increased bridge opening. The box culverts have been sized to provide an equivalent function as the bridge opening described in TM3. Table 7 summarizes the proposed improvements to provide a 20% LOS.

Table 7: 20% LOS improvements proposed for Running Water & FM 1714.

20% LOS Improvements - Running Water & FM 1714	
20% ACE Flow (cfs)	638
Functional Class	Local Road (dirt)
Approximate AADT (veh/day)	25
Existing Crossing	12-ft long, 1.8-ft tall bridge opening
List of Improvements	Raise Road, Upsize Culvert
Proposed Crossing	2 - 8'x5' RCBs
Road Rise (ft)	1.6
Approx. Length of Roadway (ft)	290
1% Inundation with 20% LOS	0.9

The OPCC for the 20% LOS improvements is shown in the Appendix. The cost of the FMP to provide 20% LOS is $471,257 The BCR output calculated by TWDB's BCA Input Tool is shown in Figure 7. The BCR for the proposed FMP is 0.5.

Texas Water Development Board

Input Into BCA Toolkit		
Project Useful Life	30	
Event Damages	**Baseline**	**Project**
25 - year storm	$39,920	$1,980
50 - year storm	$56,776	$11,881
100 - year storm	$60,831	$13,861
Total Benefits from BCA Toolkit	$210,979	
Other Benefits (Not Recreation)	$0	
Recreation Benefits	-	
Total Costs	$426,021	
Net Benefits	-$215,042	
Net Benefits with Recreation	-$215,042	
Final BCR	**0.5**	
Final BCR with Recreation	**0.5**	

Figure 7: TWDB BCA Input Tool Results for Running Water & FM 1714.

Methodology 3: Playa Lake Flooding

SITE 9. HILL ROAD AND 46TH AT PLAYA LAKE 53

The County reported that when the playa floods, it is inundated for 8-9 months following a significant storm event, which exceeds the standard assumption for inundation time used in the BCA . The 20% Level of Service will be pursued as an FMP. Table 8 summarizes the proposed improvements to provide a 20% LOS.

Table 8: 20% LOS improvements proposed for Hill & 46th.

20% LOS Improvements - Hill & 46th	
20% ACE Flow (cfs)	1,074
Functional Class	Local Road (dirt)
Approximate AADT (veh/day)	50
Existing Crossing	24" RCP & 30" CMP
List of Improvements	Raise Road
Road Rise (ft)	2.3
Approx. Length of Roadway (ft)	2,100
1% Inundation with 20% LOS	2.2

The OPCC for the 20% LOS improvements is shown in the Appendix. The cost of the FMP to provide 20% LOS is $2,373,370 The BCR output calculated by TWDB's BCA Input Tool is shown in Figure 8. The BCR for the proposed FMP is < 0.05.

Texas Water Development Board

Input Into BCA Toolkit		
Project Useful Life	30	
Event Damages	**Baseline**	**Project**
25 - year storm	$33,846	$7,003
50 - year storm	$45,517	$18,674
100 - year storm	$53,686	$26,843
Total Benefits from BCA Toolkit	$58,955	
Other Benefits (Not Recreation)	$0	
Recreation Benefits	-	
Total Costs	$2,143,858	
Net Benefits	-$2,084,903	
Net Benefits with Recreation	-$2,084,903	
Final BCR	**0.0**	
Final BCR with Recreation	**0.0**	

Figure 8: TWDB BCA Input Tool Results for Hill & 46th.

SITE 12. TRADEWINDS AND FARMERS AT PLAYA LAKE 18

The County requested the 20% Level of Service be pursued as an FMP. Table 9 summarizes the proposed improvements to provide a 20% LOS.

Table 9: 20% LOS improvements proposed for Tradewinds & Farmers.

20% LOS Improvements - Tradewinds & Farmers	
20% ACE Flow (cfs)	4,689
Functional Class	Local Road (dirt)
Approximate AADT (veh/day)	1,500
Existing Crossing	24" RCP
List of Improvements	Raise Road
Road Rise (ft)	3.7
Approx. Length of Roadway (ft)	3,150
1% Inundation with 20% LOS	2.1

The OPCC for the 20% LOS improvements is shown in the Appendix. The cost of the FMP to provide 20% LOS is $3,885,180 The BCR output calculated by TWDB's BCA Input Tool is shown in Figure 9. The BCR for the proposed FMP is 1.3.

Texas Water Development Board

Input Into BCA Toolkit

Project Useful Life	30	

Event Damages	Baseline	Project
25 - year storm	$1,214,810	$173,544
50 - year storm	$1,475,127	$433,861
100 - year storm	$1,677,595	$636,329

Total Benefits from BCA Toolkit	$4,458,606
Other Benefits (Not Recreation)	$0
Recreation Benefits	-
Total Costs	$3,512,238
Net Benefits	$946,368
Net Benefits with Recreation	$946,368
Final BCR	**1.3**
Final BCR with Recreation	**1.3**

Figure 9: TWDB BCA Input Tool Results for Tradewinds & Farmers.

SITE 14. WHITAKER AND FM 1511 AT PLAYA LAKE 64

The County reported that fill at this site has blocked the culvert crossing. The County expressed that coordination should be done with TxDOT prior to starting construction of hydraulic improvements. Table 10 summarizes the proposed improvements to provide a 1% LOS.

Table 10: 1% LOS improvements proposed for Whitaker & FM 1511.

1% LOS Improvements - Whitaker & FM 1511	
1% ACE Flow (cfs)	2,086
Functional Class	Local Road (pvmt.)
Approximate AADT (veh/day)	2,500
Existing Crossing	N/A
List of Improvements	Install Playa Equalizer
Proposed Crossing	42" RCP

The existing conditions analysis concluded that the crossing at Whitaker and FM 1511 inundates the road approximately 0.1 feet. TWDB's BCA Input Tool only calculates damages at a flooded street for depths of 6-inches or more. Because this crossing does not meet that criterion, and damages cannot be assessed, a BCR cannot be calculated. TWDB's Exhibit C: Technical Guidelines for Regional Flood Planning states that evaluations of potentially feasible FMPs require calculated benefit-cost ratios. It is recommended that this site be evaluated as an FME to further assess the conditions and if hydraulic improvements for the crossing are desired.

No BCA was performed for this site.

Summary

This technical memo (TM4) outlines the BCA methodology, provides opinions of probable construction costs, and documents the BCRs for each FMP to be considered by the Region 1 Flood Planning Group. Table 11 summarizes the costs and BCRs for each site for which a BCA was performed.

Table 11: Summary of Benefit-Cost Ratios for each crossing.

Benefit-Cost Ratio Summary				
Site		Cost	Benefits	BCR
1	**Rockwell & Soncy**	$712,776	$32,834	**0.1**
2	**Happy West & Bell**	$1,225,428	$10,337	**< 0.05**
3	**Hix & FM 217**	$1,216,248	$10,324	**< 0.05**
4	**Country Club Rd**	$1,243,026	$11,218	**< 0.05**
8	**Running Water**	$471,257	$210,979	**0.5**
9	**Hill & 46th**	$2,373,370	$58,955	**< 0.05**
11	**Gordon-Cummings LWC**	$1,181,269	$1,335,002	**1.3**
12	**Tradewinds & Farmers**	$3,885,180	$4,458,606	**1.3**

As seen in Table 11, most of the BCRs are much less than 1.0 based on the costs and benefits calculated. Each potential FMP is located in a rural area and does not involve removing residential or commercial structures from flooding, but only reduces roadway flooding. The BCA process to be utilized by the regional flood planning groups heavily favors projects that remove structures from the floodplain over other considerations. These proposed FMPs are intended to improve traffic safety and accessibility, and those benefits do not factor strongly in the BCRs. It is up to the discretion of the regional flood planning group and the FMP sponsor (Randall County) to decide which projects are feasible and beneficial to pursue, considering the BCR as only one factor in the decision.

Appendix – Opinions of Probable Construction Costs for the Randall County Crossings FMPs

Firm No. F-754

Client:	**Randall County**
Project Name:	**Region 1 (Canadian - Upper Red) Regional Flood Plan**
Project Manager:	**David Dunn, PE**
HDR Project Number:	**10306671**
Project Location	**Site 01: Rockwell & Soncy**
Date Prepared:	**6/9/2023**

THIS DOCUMENT IS FOR INTERIM REVIEW AND IS NOT INTENDED FOR PERMITTING, BIDDING, OR CONSTRUCTION PURPOSES.

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

Description	Units	Quantity	Unit Price	Total
General Conditions				
Mobilization and Demobilization	LS	1	$20,000	$20,000
Clearing and Grubbing	AC	1.1	$1,000	$1,100
Traffic Control	LS	1	$8,500	$8,500
Construction Survey Services	LS	1	$15,000	$15,000
Utility Location Services	LS	1	$2,000	$2,000
Erosion Control				
Silt Fencing	LF	560	$3	$1,680
Stablized Construction Entrance	EA	1	$7,500	$7,500
Demolition				
Remove and Dispose Existing 2-36" RCPs	LF	60	$25	$1,500
Channel Excavation (channel regrading)	CY	740	$40	$29,600
Installation				
Reinforced Concrete Box (3-12'x5')	LF	90	$1,300	$117,000
Earthwork (Embankment)	CY	470	$60	$28,200
Install Guard Rail	LF	80	$120	$9,600
Flexamat Slope Protection	SF	3,750	$10	$37,500
Bermuda / St. Augustine Block Sodding	SY	420	$10	$4,200
Sheeting, Shoring and Bracing	SF	900	$40	$36,000
Roadway				
Reconstruction of Road (includes pavement, subgrade, flex base)	SY	620	$145	$89,900
Other				
TxDOT Coordination	LS	1	$10,000	$10,000
			Subtotal	**$419,280**
			Consultant Design Fee and Profit (20%)	**$83,856**
			Contractor OH&P and Insurance (20%)	**$83,856**
			Contingency (30%)	**$125,784**
			Total	**$712,776**

Notes:

All prices, costs and quantities are preliminary and should not be used for permitting, bidding, or construction purposes.

Unit costs sources include TxDOT Bid Item Averages Workbook and similar drainage infrastructure projects by HDR that have gone to bid.

HDR

Firm No. F-754

Client:	**Randall County**
Project Name:	**Region 1 (Canadian - Upper Red) Regional Flood Plan**
Project Manager:	**David Dunn, PE**
HDR Project Number:	**10306671**
Project Location	**Site 02: Happy West & Bell**
Date Prepared:	**6/9/2023**

THIS DOCUMENT IS FOR INTERIM REVIEW AND IS NOT INTENDED FOR PERMITTING, BIDDING, OR CONSTRUCTION PURPOSES.

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

Description	Units	Quantity	Unit Price	Total
General Conditions				
Mobilization and Demobilization	LS	1	$20,000	$20,000
Clearing and Grubbing	AC	1.0	$1,000	$1,000
Traffic Control	LS	1	$8,500	$8,500
Construction Survey Services	LS	1	$15,000	$15,000
Utility Location Services	LS	1	$2,000	$2,000
Erosion Control				
Silt Fencing	LF	1,520	$3	$4,560
Stablized Construction Entrance	EA	1	$7,500	$7,500
Demolition				
Remove and Dispose Existing 2-30" RCPs & 2 8'x4' RCBs	LF	96	$25	$2,400
Remove Guard Rail	LF	80	$50	$4,000
Channel Excavation (channel regrading)	CY	230	$20	$4,600
Installation				
Reinforced Concrete Box (4-8'x7')	LF	96	$1,230	$118,080
Earthwork (Embankment)	CY	3,680	$60	$220,800
Install Guard Rail	LF	80	$120	$9,600
Flexamat Slope Protection	SF	3,060	$10	$30,600
Bermuda / St. Augustine Block Sodding	SY	340	$10	$3,400
Sheeting, Shoring and Bracing	SF	960	$40	$38,400
Roadway				
Reconstruction of Road (includes pavement, subgrade, flex base)	SY	1,520	$145	$220,400
Other				
TxDOT Coordination	LS	1	$10,000	$10,000
			Subtotal	**$720,840**
			Consultant Design Fee and Profit (20%)	**$144,168**
			Contractor OH&P and Insurance (20%)	**$144,168**
			Contingency (30%)	**$216,252**
			Total	**$1,225,428**

Notes:

All prices, costs and quantities are preliminary and should not be used for permitting, bidding, or construction purposes.

Unit costs sources include TxDOT Bid Item Averages Workbook and similar drainage infrastructure projects by HDR that have gone to bid.

Firm No. F-754

Client:	**Randall County**
Project Name:	**Region 1 (Canadian - Upper Red) Regional Flood Plan**
Project Manager:	**David Dunn, PE**
HDR Project Number:	**10306671**
Project Location	**Site 03: Hix & FM 217**
Date Prepared:	**6/9/2023**

THIS DOCUMENT IS FOR INTERIM REVIEW AND IS NOT INTENDED FOR PERMITTING, BIDDING, OR CONSTRUCTION PURPOSES.

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

Description	Units	Quantity	Unit Price	Total
General Conditions				
Mobilization and Demobilization	LS	1	$20,000	$20,000
Clearing and Grubbing	AC	0.8	$1,000	$800
Traffic Control	LS	1	$8,500	$8,500
Construction Survey Services	LS	1	$15,000	$15,000
Utility Location Services	LS	1	$2,000	$2,000
Erosion Control				
Silt Fencing	LF	1,520	$3	$4,560
Stablized Construction Entrance	EA	1	$7,500	$7,500
Demolition				
Remove and Dispose Existing 2-30" RCPs	LF	72	$25	$1,800
Remove Guard Rail	LF	100	$50	$5,000
Channel Excavation (channel regrading)	CY	880	$20	$17,600
Installation				
Reinforced Concrete Box (4-10'x7')	LF	144	$1,700	$244,800
Earthwork (Embankment)	CY	700	$60	$0
Install Guard Rail	LF	100	$120	$12,000
Flexamat Slope Protection	SF	4,785	$10	$47,850
Bermuda / St. Augustine Block Sodding	SY	530	$10	$5,300
Sheeting, Shoring and Bracing	SF	1,692	$40	$67,680
Roadway				
Reconstruction of Road (includes pavement, subgrade, flex base)	SY	1,690	$145	$245,050
Other				
TxDOT Coordination	LS	1	$10,000	$10,000
			Subtotal	**$715,440**
			Consultant Design Fee and Profit (20%)	**$143,088**
			Contractor OH&P and Insurance (20%)	**$143,088**
			Contingency (30%)	**$214,632**
			Total	**$1,216,248**

Notes:

All prices, costs and quantities are preliminary and should not be used for permitting, bidding, or construction purposes.

Unit costs sources include TxDOT Bid Item Averages Workbook and similar drainage infrastructure projects by HDR that have gone to bid.

Firm No. F-754

Client:	**Randall County**
Project Name:	**Region 1 (Canadian - Upper Red) Regional Flood Plan**
Project Manager:	**David Dunn, PE**
HDR Project Number:	**10306671**
Project Location	**Site 04: Country Club Road**
Date Prepared:	**6/9/2023**

THIS DOCUMENT IS FOR INTERIM REVIEW AND IS NOT INTENDED FOR PERMITTING, BIDDING, OR CONSTRUCTION PURPOSES.

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

Description	Units	Quantity	Unit Price	Total
General Conditions				
Mobilization and Demobilization	LS	1	$20,000	$20,000
Clearing and Grubbing	AC	0.5	$1,000	$500
Traffic Control	LS	1	$8,500	$8,500
Construction Survey Services	LS	1	$15,000	$15,000
Utility Location Services	LS	1	$2,000	$2,000
Erosion Control				
Silt Fencing	LF	780	$3	$2,340
Stablized Construction Entrance	EA	1	$7,500	$7,500
Demolition				
Remove and Dispose Existing 2-36" RCP EQV Arch Pipes	LF	48	$25	$1,200
Remove Guard Rail	LF	320	$50	$16,000
Channel Excavation (channel regrading)	CY	600	$20	$12,000
Installation				
Reinforced Concrete Box (6-10'x5')	LF	144	$1,590	$228,960
Earthwork (Embankment)	CY	2,830	$60	$169,800
Install Guard Rail	LF	320	$120	$38,400
Flexamat Slope Protection	SF	1,957	$10	$19,570
Bermuda / St. Augustine Block Sodding	SY	220	$10	$2,200
Sheeting, Shoring and Bracing	SF	1,277	$40	$51,072
Roadway				
Reconstruction of Road (includes pavement, subgrade, flex base)	SY	870	$145	$126,150
Other				
TxDOT Coordination	LS	1	$10,000	$10,000
			Subtotal	**$731,192**
			Consultant Design Fee and Profit (20%)	**$146,238**
			Contractor OH&P and Insurance (20%)	**$146,238**
			Contingency (30%)	**$219,358**
			Total	**$1,243,026**

Notes:

All prices, costs and quantities are preliminary and should not be used for permitting, bidding, or construction purposes.

Unit costs sources include TxDOT Bid Item Averages Workbook and similar drainage infrastructure projects by HDR that have gone to bid.

HDR

Firm No. F-754

Client:	**Randall County**
Project Name:	**Region 1 (Canadian - Upper Red) Regional Flood Plan**
Project Manager:	**David Dunn, PE**
HDR Project Number:	**10306671**
Project Location	**Site 08: Running Water & FM 1714**
Date Prepared:	**6/9/2023**

THIS DOCUMENT IS FOR INTERIM REVIEW AND IS NOT INTENDED FOR PERMITTING, BIDDING, OR CONSTRUCTION PURPOSES.

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

Description	Units	Quantity	Unit Price	Total
General Conditions				
Mobilization and Demobilization	LS	1	$20,000	$20,000
Clearing and Grubbing	AC	0.2	$1,000	$200
Traffic Control	LS	1	$8,500	$8,500
Construction Survey Services	LS	1	$15,000	$15,000
Utility Location Services	LS	1	$2,000	$2,000
Erosion Control				
Silt Fencing	LF	580	$3	$1,740
Stablized Construction Entrance	EA	1	$7,500	$7,500
Demolition				
Remove Guard Rail	LF	90	$50	$4,500
Installation				
Reinforced Concrete Box (2-8'x5')	LF	48	$1,050	$50,400
Earthwork (Embankment)	CY	270	$60	$16,200
Install Guard Rail	LF	90	$120	$10,800
Sheeting, Shoring and Bracing	SF	468	$40	$18,720
Roadway				
Reconstruction of Road (includes pavement, subgrade, flex base)	SY	770	$145	$111,650
Other				
TxDOT Coordination	LS	1	$10,000	$10,000
			Subtotal	**$277,210**
			Consultant Design Fee and Profit (20%)	**$55,442**
			Contractor OH&P and Insurance (20%)	**$55,442**
			Contingency (30%)	**$83,163**
			Total	**$471,257**

Notes:

All prices, costs and quantities are preliminary and should not be used for permitting, bidding, or construction purposes.

Unit costs sources include TxDOT Bid Item Averages Workbook and similar drainage infrastructure projects by HDR that have gone to bid.

Firm No. F-754

Client:	**Randall County**	
Project Name:	**Region 1 (Canadian - Upper Red) Regional Flood Plan**	
Project Manager:	**David Dunn, PE**	
HDR Project Number:	**10306671**	
Project Location	**Site 09: Hill & 46th**	
Date Prepared:	**6/9/2023**	

THIS DOCUMENT IS FOR INTERIM REVIEW AND IS NOT INTENDED FOR PERMITTING, BIDDING, OR CONSTRUCTION PURPOSES.

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

Description	Units	Quantity	Unit Price	Total
General Conditions				
Mobilization and Demobilization	LS	1	$20,000	$20,000
Clearing and Grubbing	AC	1.3	$1,000	$1,300
Traffic Control	LS	1	$8,500	$8,500
Construction Survey Services	LS	1	$15,000	$15,000
Utility Location Services	LS	1	$2,000	$2,000
Erosion Control				
Silt Fencing	LF	4,200	$3	$12,600
Stablized Construction Entrance	EA	1	$7,500	$7,500
Installation				
Earthwork (Embankment)	CY	5,070	$60	$304,200
Roadway				
Reconstruction of Road (includes pavement, subgrade, flex base)	SY	7,000	$145	$1,015,000
Other				
TxDOT Coordination	LS	1	$10,000	$10,000
			Subtotal	**$1,396,100**
			Consultant Design Fee and Profit (20%)	**$279,220**
			Contractor OH&P and Insurance (20%)	**$279,220**
			Contingency (30%)	**$418,830**
			Total	**$2,373,370**

Notes:

All prices, costs and quantities are preliminary and should not be used for permitting, bidding, or construction purposes.

Unit costs sources include TxDOT Bid Item Averages Workbook and similar drainage infrastructure projects by HDR that have gone to bid.

Firm No. F-754

Client:	**Randall County**
Project Name:	**Region 1 (Canadian - Upper Red) Regional Flood Plan**
Project Manager:	**David Dunn, PE**
HDR Project Number:	**10306671**
Project Location	**Site 11: Gordon-Cummings LWC**
Date Prepared:	**6/9/2023**

THIS DOCUMENT IS FOR INTERIM REVIEW AND IS NOT INTENDED FOR PERMITTING, BIDDING, OR CONSTRUCTION PURPOSES.

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

Description	Units	Quantity	Unit Price	Total
General Conditions				
Mobilization and Demobilization	LS	1	$20,000	$20,000
Clearing and Grubbing	AC	0.7	$1,000	$700
Traffic Control	LS	1	$8,500	$8,500
Construction Survey Services	LS	1	$15,000	$15,000
Utility Location Services	LS	1	$2,000	$2,000
Erosion Control				
Silt Fencing	LF	1,168	$3	$3,504
Stablized Construction Entrance	EA	1	$7,500	$7,500
Demolition				
Remove and Dispose Existing 24" CMP	LF	24	$25	$600
Installation				
Reinforced Concrete Bridge	SF	2800	$95	$266,000
Earthwork (Embankment)	CY	2,360	$60	$141,600
Install Guard Rail	LF	258	$120	$30,960
Roadway				
Reconstruction of Road (includes pavement, subgrade, flex base)	SY	1,300	$145	$188,500
Other				
TxDOT Coordination	LS	1	$10,000	$10,000
			Subtotal	**$694,864**
			Consultant Design Fee and Profit (20%)	**$138,973**
			Contractor OH&P and Insurance (20%)	**$138,973**
			Contingency (30%)	**$208,459**
			Total	**$1,181,269**

Notes:

All prices, costs and quantities are preliminary and should not be used for permitting, bidding, or construction purposes.

Unit costs sources include TxDOT Bid Item Averages Workbook and similar drainage infrastructure projects by HDR that have gone to bid.

Firm No. F-754

Client:	**Randall County**	THIS DOCUMENT IS FOR INTERIM REVIEW AND IS NOT INTENDED FOR PERMITTING, BIDDING, OR CONSTRUCTION PURPOSES.
Project Name:	**Region 1 (Canadian - Upper Red) Regional Flood Plan**	
Project Manager:	**David Dunn, PE**	
HDR Project Number:	**10306671**	
Project Location	**Site 12: Tradewinds & Farmers**	
Date Prepared:	**6/9/2023**	

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

Description	Units	Quantity	Unit Price	Total
General Conditions				
Mobilization and Demobilization	LS	1	$20,000	$20,000
Clearing and Grubbing	AC	2.0	$1,000	$2,000
Traffic Control	LS	1	$8,500	$8,500
Construction Survey Services	LS	1	$15,000	$15,000
Utility Location Services	LS	1	$2,000	$2,000
Erosion Control				
Silt Fencing	LF	6,300	$3	$18,900
Stablized Construction Entrance	EA	1	$7,500	$7,500
Installation				
Earthwork (Embankment)	CY	14,700	$60	$882,000
Roadway				
Reconstruction of Road (includes pavement, subgrade, flex base)	SY	9,100	$145	$1,319,500
Other				
TxDOT Coordination	LS	1	$10,000	$10,000
			Subtotal	**$2,285,400**
			Consultant Design Fee and Profit (20%)	**$457,080**
			Contractor OH&P and Insurance (20%)	**$457,080**
			Contingency (30%)	**$685,620**
			Total	**$3,885,180**

Notes:

All prices, costs and quantities are preliminary and should not be used for permitting, bidding, or construction purposes.

Unit costs sources include TxDOT Bid Item Averages Workbook and similar drainage infrastructure projects by HDR that have gone to bid.

Appendix E-4 | E-4.1

FMP Project Details Spreadsheet

Texas Water Development Board

General Project Data															Score 1: Severity - Pre-Project Average Depth of Flooding (100-year)				Score 2: Severity - Community Need (% Population)					
Project Name	FMP	Project Description:	Flood Region	Project Type	FIUP Project Category	Project Watershed	Rural Applicant	Project Cost	Benefit Cost Ratio	Cost per Structure Removed	Pre-Project Level-of-Service	Post-Project Level-of-Service	# of Structures in 1% Annual Chance FP (Pre-Project)	Project Status	Average Flood Depth (100yr)	Notes	Severity Ranking: Pre-Project Average Depth of Flooding (100-year)	Score 1	Communities Served by Project	Community Population Served	Flood Plain Population	Notes 2	Severity Ranking: Community Need (% Population)	Score 2
T-Anchor Lake Watershed Drainage Improvements	013000001	Four phase playa excavation project, pump station relocation and construction of storm sewer improvements along Ross-Osage Street and Southeast 10th Street to provide 100-year flood protection	Canadian-Upper Red	Infrastructure	Category 2	T-Anchor Lake	N	$31,300,000	1.7	$78,816	10% annual	1% annual	407	Planning	1.0	Average flood depth assumed; modeling data not available	Baseline average flood depth > 0.5ft	4	1	200393	1743	1%	<25% of project community affected	1
Rhea Road Drainage Project	013000002	The proposed improvements include the installation of a storm drain system north along Rhea Road that would eliminate structure flooding in the 100-year storm event.	Canadian-Upper Red	Storm Drain	Category 2	Holliday Creek	N	$2,995,000	1.1	$110,929	<50% annual	1% annual	27	Planning	0.26	From Wichita Falls Drainage Master Plan	Baseline average flood depth < 0.5ft	2	1	102316	9	0.0%	<25% of project community affected	1
Brenda Hursh Drainage Improvement Project	013000003	Install a bypass system that will intercept flow from Brenda Hursh Creek and Brenda Hursh Channel at their respective Weeks Street Road crossings and convey the runoff to the west through a proposed pipe system	Canadian-Upper Red	Infrastructure	Category 2	Wichita	N	$4,151,000	1.1	$64,865	50% annual	2% annual	114	Planning	0.8	Used model results for inundation at structures	Baseline average flood depth > 0.5ft	4	1	102316	417	0.4%	<25% of project community affected	1
City of Canyon Flood Mitigation Project	013000012	The proposed improvements include upstream and midstream detention ponds, channel enlargements and low water crossings improvements to reduce flooding in the residential area near Palo Duro Creek Golf Course.	Canadian-Upper Red	Other	Category 2	Lower Palo Duro Creek	N	$37,238,000	0.5	$1,379,176	<50% annual	50% annual	106	Planning	1.89	From modeled results from USACE study	Baseline average flood depth > 1ft	6	1	14836	318	2%	<25% of project community affected	1
Wichita Gardens Drainage Improvements	013000013	The proposed improvements include for the installation of concrete curb and gutter throughout entire development in order to install a storm drain system with curb inlets and a trunk line that runs to an outfall at the Wichita River.	Canadian-Upper Red	Storm Drain	Category 2	Buffalo Creek-Wichita River	N	$10,008,000	3.1	$100,082	<50% annual	0.2% annual	100	Planning	0.96	From Wichita Falls Drainage Master Plan	Baseline average flood depth > 0.5ft	4	1	102316	13	0.0%	<25% of project community affected	1
Echo/Neta Lane Drainage Project	013000015	Install a storm drain system with curb and gutter along Jacksboro Highway beginning south of Echo Lane and reaching north to Norman Street.	Canadian-Upper Red	Storm Drain	Category 2	Holliday Creek	N	$2,853,000	3.7	$203,779	<50% annual	50% annual	18	Planning	1.12	From Wichita Falls Drainage Master Plan	Baseline average flood depth > 1ft	6	1	102316	0	0.0%	<25% of project community affected	1
Hirschi - Huskie	013000016	Extend the existing storm drain system on Huskie Drive to reach to the north and south on Hirschi Lane. Additionally, acquire properties along the north side of Iowa Park Road between Hirschi Lane and Ridgeway Drive.	Canadian-Upper Red	Storm Drain	Category 2	Buffalo Creek-Wichita River	N	$632,000	0.8	$18,071	<50% annual	1% annual	35	Planning	0.28	From Wichita Falls Drainage Master Plan	Baseline average flood depth < 0.5ft	2	1	102316	186	0.2%	<25% of project community affected	1
Landon, Duty and Sunset St Drainage Project	013000017	The proposed solution is be a combination of curb and gutter street improvements for Duty Lane, Landon Road, and Sunset Lane south of Duty Lane.	Canadian-Upper Red	Storm Drain	Category 2	Buffalo Creek-Wichita River	N	$2,120,000	10.6	$51,707	<50% annual	10% annual	43	Planning	1.89	From Wichita Falls Drainage Master Plan	Baseline average flood depth > 1ft	6	1	102316	157	0.2%	<25% of project community affected	1
Spanish Trace Drainage Project	013000018	The proposed improvements include re-grading of an abandoned irrigation canal to convey flow north towards Johnson Road, connecting to the existing storm sewer system.	Canadian-Upper Red	Storm Drain	Category 2	Holliday Creek	N	$1,043,000	1.2	$130,322	<50% annual	1% annual	8	Planning	0.62	From Wichita Falls Drainage Master Plan	Baseline average flood depth > 0.5ft	4	1	102316	24	0.02%	<25% of project community affected	1
China Creek	013000019	Installing staff gauges, flashers, and flood hazard signs to warn drivers of flooding, as well as guardrails and roadway lighting for drivers to be able to see better	Canadian-Upper Red	Preparedness	Category 4	Blue-China, Southern Beaver	Y	$455,000	0.0	N/A	<50% annual	<50% annual	18	Planning	3.49	From the China Creek Existing Conditions Model	Baseline average flood depth > 2ft	8	1	133205	1	0.001%	<25% of project community affected	1
Wild Horse Creek	013000020	Replaces existing culvert with a bridge and grading to increase road level of service.	Canadian-Upper Red	Infrastructure	Category 2	Blue-China	Y	$3,411,000	2.9	$1,705,452	<50% annual	1% annual	4	Planning	2.31	From the White Horse Creek Existing Conditions Model	Baseline average flood depth > 2ft	8	1	10894	6	0.06%	<25% of project community affected	1
Buffalo Creek	013000021	Minor channel grading to reduce structure flooding in neighborhood.	Canadian-Upper Red	Infrastructure	Category 2	Wichita	Y	$686,000	0.3	$228,819	50% annual	50% annual	39	Planning	0.64	From the Buffalo Creek Existing Conditions Model	Baseline average flood depth > 0.5ft	4	1	6499	118	1.82%	<25% of project community affected	1
Gilbert Creek	013000022	Raises road and replaces existing culverts with larger culverts and a bridge with grading to increase road level of service.	Canadian-Upper Red	Infrastructure	Category 2	Blue-China	Y	$11,783,000	2.3	N/A	<10% annual	10% annual	2	Planning	2.82	From the Gilbert Creek Existing Conditions Model	Baseline average flood depth > 2ft	8	1	10894	0	0.00%	<25% of project community affected	1
West Rockwell & Soncy	013000023	Upsize the culvert crossing, raise the road, modify channel.	Canadian-Upper Red	LWC Upgrade	Category 2	Lower Palo Duro Creek	N	$713,000	0.1	N/A	< 50% ACE	20% ACE	0	Planning	4.8	Average flood depth taken at road cross-section	Baseline average flood depth > 3.5ft	10	1	15,556	0	0.00%	<25% of project community affected	1
Happy West & Bell	013000024	Upsize the culvert crossing, raise the road, modify channel.	Canadian-Upper Red	LWC Upgrade	Category 2	Happy Draw-Prarie Dog Town Fork Red River	N	$1,225,000	0.0	N/A	< 50% ACE	20% ACE	0	Planning	2.7	Average flood depth taken at road cross-section	Baseline average flood depth > 2ft	8	1	614	0	0.00%	<25% of project community affected	1
Hix & FM 217	013000025	Upsize the culvert crossing, raise the road, modify channel.	Canadian-Upper Red	LWC Upgrade	Category 2	Buffalo Lake-Tierra Blanca Creek	N	$1,216,000	0.0	N/A	< 50% ACE	1% ACE	0	Planning	3.3	Average flood depth taken at road cross-section	Baseline average flood depth > 2ft	8	1	15,556	0	0.00%	<25% of project community affected	1
Country Club Road	013000026	Upsize the culvert crossing, raise the road, modify channel.	Canadian-Upper Red	LWC Upgrade	Category 2	Headwaters Prarie Dog Town Fork Red River	N	$1,243,000	0.0	N/A	< 50% ACE	1% ACE	0	Planning	3	Average flood depth taken at road cross-section	Baseline average flood depth > 2ft	8	1	15,556	0	0.00%	<25% of project community affected	1
Running Water & FM 1714	013000027	Replace the bridge crossing with culverts, raise the road.	Canadian-Upper Red	LWC Upgrade	Category 2	Buffalo Lake-Tierra Blanca Creek	N	$471,000	0.5	N/A	< 50% ACE	20% ACE	0	Planning	3.5	Average flood depth taken at road cross-section	Baseline average flood depth > 2ft	8	1	15,556	0	0.00%	<25% of project community affected	1
Hill & 46th	013000028	Raise the road.	Canadian-Upper Red	LWC Upgrade	Category 2	Lower Palo Duro Creek	N	$2,373,000	0.0	N/A	50% ACE	20% ACE	0	Planning	4.5	Average flood depth taken at road cross-section	Baseline average flood depth > 3.5ft	10	1	199,138	0	0.00%	<25% of project community affected	1
Gordon-Cummings LWC	013000029	Increase the bridge opening ^& raise the low chord, raise the road.	Canadian-Upper Red	LWC Upgrade	Category 2	Buffalo Lake-Tierra Blanca Creek	N	$1,181,000	1.3	N/A	< 50% ACE	20% ACE	0	Planning	7.4	Average flood depth taken at road cross-section	Baseline average flood depth > 3.5ft	10	1	15,556	0	0.00%	<25% of project community affected	1
Tradewinds & Farmers	13000030	Raise the road.	Canadian-Upper Red	LWC Upgrade	Category 2	Headwaters Prarie Dog Town Fork Red River	N	$3,885,000	1.3	N/A	< 50% ACE	1% ACE	0	Planning	5.8	Average flood depth taken at road cross-section	Baseline average flood depth > 3.5ft	10	1	199,138	0	0.00%	<25% of project community affected	1

Texas Water Development Board

		Score 3: Flood Risk Reduction				Score 4: Flood Damage Reduction					
Project Name	**FMP**	**# of Structures Removed from 1% Annual Chance FP**	**Notes 3**	**Flood Risk Reduction**	**Score 3**	**# of Structures with Reduced 1% Annual Chance Flood Risk**	**Pre-Project Damage $**	**Post-Project Damage $**	**Notes 4**	**Flood Damage Reduction**	**Score 4**
T-Anchor Lake Watershed Drainage Improvements	013000001	397	98%	Reduced risk to >75% of structures in floodplain	10	10	$ 57,200,000	$ 3,600,000	94%	Flood damage reduction > 75%	8
Rhea Road Drainage Project	013000002	26	96%	Reduced risk to >75% of structures in floodplain	10	0	$ 270,921	$ -	100%	Flood damage reduction >95%	10
Brenda Hursh Drainage Improvement Project	013000003	64	56%	Reduced risk to <75% of structures in floodplain	7	7	$ 6,278,218	$ 2,949,638	53%	Flood damage reduction >95%	10
City of Canyon Flood Mitigation Project	013000012	27	25%	Reduced risk to <50% of structures in floodplain	4	79	$ 2,889,929	$ 1,351,802	53%	Flood damage reduction >95%	6
Wichita Gardens Drainage Improvements	013000013	100	100%	Reduced risk to >75% of structures in floodplain	10	0	$ 3,440,091	$ 899,813	74%	Flood damage reduction >95%	6
Echo/Neta Lane Drainage Project	013000015	14	78%	Reduced risk to >75% of structures in floodplain	10	4	$ 892,686	$ 36,706	96%	Flood damage reduction >95%	10
Hirschi - Huskie	013000016	35	100%	Reduced risk to >75% of structures in floodplain	10	0	$ 39,621	$ -	100%	Flood damage reduction >95%	10
Landon, Duty and Sunset St Drainage Project	013000017	41	95%	Reduced risk to >75% of structures in floodplain	10	2	$ 1,820,345	$ 4,085	100%	Flood damage reduction >95%	10
Spanish Trace Drainage Project	013000018	8	100%	Reduced risk to >75% of structures in floodplain	10	0	$ 99,703	$ -	100%	Flood damage reduction >95%	10
China Creek	013000019	0	0%	Reduced risk to 0 structures in floodplain	0	0	$ -	$ -	0%	Flood damage reduction < 25%	2
Wild Horse Creek	013000020	2	50%	Reduced risk to <75% of structures in floodplain	7	1	$ 6,310,935	$ 109,229	98%	Flood damage reduction >95%	10
Buffalo Creek	013000021	3	8%	Reduced risk to <10% of structures in floodplain	1	24	$ 4,201,447	$ 3,914,900	7%	Flood damage reduction < 25%	2
Gilbert Creek	013000022	0	0%	Reduced risk to 0 structures in floodplain	0	0	$ 28,310,577	$ 56,209,586	-99%	Flood damage reduction < 25%	2
West Rockwell & Soncy	013000023	0	No Structures	Reduced risk to 0 structures in floodplain	0	0	$ 41,692	$ 12,507	70%	Flood damage reduction > 50%	6
Happy West & Bell	013000024	0	No Structures	Reduced risk to 0 structures in floodplain	0	0	$ 12,142	$ 603	95%	Flood damage reduction > 75%	8
Hix & FM 217	013000025	0	No Structures	Reduced risk to 0 structures in floodplain	0	0	$ 12,166	$ -	100%	Flood damage reduction >95%	10
Country Club Road	013000026	0	No Structures	Reduced risk to 0 structures in floodplain	0	0	$ 11,731	$ -	100%	Flood damage reduction >95%	10
Running Water & FM 1714	013000027	0	No Structures	Reduced risk to 0 structures in floodplain	0	0	$ 218,992	$ 27,722	87%	Flood damage reduction > 75%	8
Hill & 46th	013000028	0	No Structures	Reduced risk to 0 structures in floodplain	0	0	$ 172,730	$ 52,520	70%	Flood damage reduction > 50%	6
Gordon-Cummings LWC	013000029	0	No Structures	Reduced risk to 0 structures in floodplain	0	0	$ 1,363,926	$ 127,503	91%	Flood damage reduction > 75%	8
Tradewinds & Farmers	13000030	0	No Structures	Reduced risk to 0 structures in floodplain	0	0	$ 6,507,911	$ 1,243,734	81%	Flood damage reduction > 75%	8

	Score 5: Critical Facilities Damage Reduction				Score 6: Life and Safety				Score 7: Water Supply					
Project Name	**# of Critical Faciliites Removed from 1% Annual Chance FP**	**Notes 5**	**Reduction in Critical Facilities Flood Risk**	**Score 5**	**Adjusted Injury Risk (%)**	**Notes 6**	**Life and Safety Ranking (Injury/Loss of Life)**	**Score 6**	**Water Supply Benefit in Acre-Feet**	**SourceID**	**WMS_ID**	**Notes 7**	**Water Supply Yield Ranking**	**Score 7**
T-Anchor Lake Watershed Drainage Improvements	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	18.00	Using assumed depth of 1 ft and velocity of 0 fps (playa is standing water); Road storm drain model does not provide velocity, only have historical depth of flooding at historical HWR locations	Life/injury risk percentage <20%	2	0	N/A	N/A		No impact on water supply	0
Rhea Road Drainage Project	1	One critical facility in floodplain is removed	Reduced risk for >75% of critical facilities in floodplain	10	15.28	Refer to Life and Safety Calculation	Life/injury risk percentage <20%	2	0	N/A	N/A		No impact on water supply	0
Brenda Hursh Drainage Improvement Project	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	40.60	Refer to Life and Safety Calculation	Life/injury risk percentage >40%	8	0	N/A	N/A		No impact on water supply	0
City of Canyon Flood Mitigation Project	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	79.96	Refer to Life and Safety Calculation	Life/injury risk percentage >50%	10	0	N/A	N/A		No impact on water supply	0
Wichita Gardens Drainage Improvements	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	34.88	Refer to Life and Safety Calculation	Life/injury risk percentage >30%	6	0	N/A	N/A		No impact on water supply	0
Echo/Neta Lane Drainage Project	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	39.36	Refer to Life and Safety Calculation	Life/injury risk percentage <20%	2	0	N/A	N/A		No impact on water supply	0
Hirschi - Huskie	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	15.84	Refer to Life and Safety Calculation	Life/injury risk percentage >50%	10	0	N/A	N/A		No impact on water supply	0
Landon, Duty and Sunset St Drainage Project	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	60.92	Refer to Life and Safety Calculation	Life/injury risk percentage >30%	6	0	N/A	N/A		No impact on water supply	0
Spanish Trace Drainage Project	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	25.36	Refer to Life and Safety Calculation	Life/injury risk percentage >20%	4	0	N/A	N/A		No impact on water supply	0
China Creek	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	105.71	Refer to Life and Safety Calculation	Life/injury risk percentage >50%	10	0	N/A	N/A		No impact on water supply	0
Wild Horse Creek	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	364.66	Refer to Life and Safety Calculation	Life/injury risk percentage >50%	10	0	N/A	N/A		No impact on water supply	0
Buffalo Creek	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	61.03	Refer to Life and Safety Calculation	Life/injury risk percentage >50%	10	0	N/A	N/A		No impact on water supply	0
Gilbert Creek	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	279.17	Refer to Life and Safety Calculation	Life/injury risk percentage >50%	10	0	N/A	N/A		No impact on water supply	0
West Rockwell & Soncy	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	124.90	Refer to Life and Safety Calculation	Life/injury risk percentage >50%	10	0				No impact on water supply	0
Happy West & Bell	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	61.90	Refer to Life and Safety Calculation	Life/injury risk percentage >50%	10	0				No impact on water supply	0
Hix & FM 217	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	73.45	Refer to Life and Safety Calculation	Life/injury risk percentage >50%	10	0				No impact on water supply	0
Country Club Road	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	70.00	Refer to Life and Safety Calculation	Life/injury risk percentage >50%	10	0				No impact on water supply	0
Running Water & FM 1714	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	86.50	Refer to Life and Safety Calculation	Life/injury risk percentage >50%	10	0				No impact on water supply	0
Hill & 46th	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	13.75	Refer to Life and Safety Calculation	Life/injury risk percentage <20%	2	0				No impact on water supply	0
Gordon-Cummings LWC	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	126.32	Refer to Life and Safety Calculation	Life/injury risk percentage >50%	10	0				No impact on water supply	0
Tradewinds & Farmers	0	No critical facilities in floodplain	Reduced risk for 0 structures in floodplain	0	17.00	Refer to Life and Safety Calculation	Life/injury risk percentage <20%	2	0				No impact on water supply	0

Texas Water Development Board

		Score 8: Social Vulnerability				Score 9: Nature-Based Solution				Score 10: Multiple Benefits				Score 11: O&M				Score 12: Admin, Regulatory Obstacles			Score 13: Enviromental Benefit		
Project Name	FMP	SVI Score	Notes 8	Social Vulnerability Ranking	Score 8	% Nature Based Solution by Cost	Notes 9	Nature-Based Solutions Ranking	Score 9	Multiple Benefits Description	Notes 10	Multiple Benefit Ranking	Score 10	O&M Cost (Annual)	Notes 11	Operations and Maintenance Ranking	Score 11	Notes 12	Administrative, Regulatory and Other Obstacle Ranking	Score 12	Notes 13	Environmental Benefit Ranking	Score 13
T-Anchor Lake Watershed Drainage Improvements	013000001	0.90		SVI between 0.75-1.00 (high vulnerability)	10	0%		<25% of the project cost is nature-based	1	Recreation benefits, Transportation benefits	Improved roadway accessibility on principle arterials during high-frequency storm events; some recreation benefits may be realized if park space can be preserved	Project delivers benefits in 2 wider benefit categories	4	$ -	Will be a part of the City's existing O&M	Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7	Coordination with THC on Cultural Resource permitting; Potential coordination with USACE on Section 404/wetlands permitting after JD. See *Tee Anchor Lake Drainage Master Plan* (Halff Associates, 2014)	Project has a typical number of administrative, regulatory and limitations / requirements	6	Creates open space through property acquisition	Project will deliver a low level of environmental benefits (1 category)	3
Rhea Road Drainage Project	013000002	0.60		SVI between 0.5-0.75 (moderate to high vulnerability)	7	0%		<25% of the project cost is nature-based	1	No wider benefits		Project does not deliver any wider benefits	0	$ 26,645		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Brenda Hursh Drainage Improvement Project	013000003	0.17		SVI between 0.01-0.25 (low vulnerability)	1	9%		<25% of the project cost is nature-based	1	Recreation benefits	Enhanced use of golf course amenity	Project delivers benefits in only 1 wider benefit category	1	$ -	Will be a part of the City's existing O&M	Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7	Coordinate easement through golf course, check environmental permitting requirements (potentially in the Waters of the United States, but could probably use Nation Wide Permit and not go through USACE)	Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
City of Canyon Flood Mitigation Project	013000012	0.53		SVI between 0.5-0.75 (moderate to high vulnerability)	7	0%		<25% of the project cost is nature-based	1	No wider benefits		Project does not deliver any wider benefits	0	$ 100,000		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7	Due to construction in channel of Palo Duro Creek, likely long lead time for USACE 404 permitting	Project has a high number of administrative, regulatory and limitations / requirements	2		Project does not provide any environmental benefits	0
Wichita Gardens Drainage Improvements	013000013	0.63		SVI between 0.5-0.75 (moderate to high vulnerability)	7	0%		<25% of the project cost is nature-based	1	No wider benefits		Project does not deliver any wider benefits	0	$ 78,331		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Echo/Neta Lane Drainage Project	013000015	0.24		SVI between 0.01-0.25 (low vulnerability)	1	0%		<25% of the project cost is nature-based	1	No wider benefits		Project does not deliver any wider benefits	0	$ 25,380		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Hirschi - Huskie	013000016	0.76		SVI between 0.75-1.00 (high vulnerability)	10	0%		<25% of the project cost is nature-based	1	No wider benefits		Project does not deliver any wider benefits	0	$ 5,627		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Landon, Duty and Sunset St Drainage Project	013000017	0.76		SVI between 0.75-1.00 (high vulnerability)	10	0%		<25% of the project cost is nature-based	1	No wider benefits		Project does not deliver any wider benefits	0	$ 18,860		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Spanish Trace Drainage Project	013000018	0.51		SVI between 0.5-0.75 (moderate to high vulnerability)	7	0%		<25% of the project cost is nature-based	1	No wider benefits		Project does not deliver any wider benefits	0	$ 9,275		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
China Creek	013000019	0.21		SVI between 0.01-0.25 (low vulnerability)	1	0%		<25% of the project cost is nature-based	1	No wider benefits		Project does not deliver any wider benefits	0	$ 455		Project will not require any ongoing operation and maintenance (low);	10		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Wild Horse Creek	013000020	0.50		SVI between 0.25-0.5 (low to moderate vulnerability)	4	0%		<25% of the project cost is nature-based	1	No wider benefits		Project does not deliver any wider benefits	0	$ 3,411		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Buffalo Creek	013000021	0.33		SVI between 0.25-0.5 (low to moderate vulnerability)	4	0%		<25% of the project cost is nature-based	1	No wider benefits		Project does not deliver any wider benefits	0	$ 686		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Gilbert Creek	013000022	0.48		SVI between 0.25-0.5 (low to moderate vulnerability)	4	0%		<25% of the project cost is nature-based	1	No wider benefits		Project does not deliver any wider benefits	0	$ 11,783		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
West Rockwell & Soncy	013000023	0.07		SVI between 0.01-0.25 (low vulnerability)	1	0		<25% of the project cost is nature-based	1	Improved road		Project delivers benefits in only 1 wider benefit category	1	$ 1,000		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Happy West & Bell	013000024	0.07		SVI between 0.01-0.25 (low vulnerability)	1	0		<25% of the project cost is nature-based	1	Improved road		Project delivers benefits in only 1 wider benefit category	1	$ 1,000		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Hix & FM 217	013000025	0.07		SVI between 0.01-0.25 (low vulnerability)	1	0		<25% of the project cost is nature-based	1	Improved road		Project delivers benefits in only 1 wider benefit category	1	$ 1,000		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Country Club Road	013000026	0.55		SVI between 0.5-0.75 (moderate to high vulnerability)	7	0		<25% of the project cost is nature-based	1	Improved road, development occuring in nearby areas		Project delivers benefits in 2 wider benefit categories	4	$ 1,000		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Running Water & FM 1714	013000027	0.07		SVI between 0.01-0.25 (low vulnerability)	1	0		<25% of the project cost is nature-based	1	Improved road		Project delivers benefits in only 1 wider benefit category	1	$ 1,000		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Hill & 46th	013000028	0.07		SVI between 0.01-0.25 (low vulnerability)	1	0		<25% of the project cost is nature-based	1	Improved road		Project delivers benefits in only 1 wider benefit category	1	$ 1,000		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Gordon-Cummings LWC	013000029	0.07		SVI between 0.01-0.25 (low vulnerability)	1	0		<25% of the project cost is nature-based	1	Improved road, development occuring in nearby areas		Project delivers benefits in 2 wider benefit categories	4	$ 1,000		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0
Tradewinds & Farmers	13000030	0.41		SVI between 0.25-0.5 (low to moderate vulnerability)	4	0		<25% of the project cost is nature-based	1	Improved road		Project delivers benefits in only 1 wider benefit category	1	$ 1,000		Project requires regular, ongoing operation and maintenance; and/or O&M requirements are well defined (Regular);	7		Project has a typical number of administrative, regulatory and limitations / requirements	6		Project does not provide any environmental benefits	0

		Score 14: Environmental Impact			Score 15: Mobility				Score 16: Regional		
Project Name	**FMP**	**Notes 14**	**Environmental Impact Ranking**	**Score 14**	**Traffic Count for LWC Project**	**Notes 15**	**Mobility Ranking**	**Score 15**	**Project Count**	**Regional Ranking**	**Score 16**
T-Anchor Lake Watershed Drainage Improvements	**013000001**	None currently identified; subject to coordination with THC and USACE Tulsa	Project has no adverse environmental impacts	10	0	Increased accessibility along Ross-Osage St and T Anchor Blvd including at two points of historical HWR	Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
Rhea Road Drainage Project	**013000002**	Project does not provide any environmental benefits	Project has no adverse environmental impacts	10	0		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
Brenda Hursh Drainage Improvement Project	**013000003**	Project does not provide any environmental benefits	Project has no adverse environmental impacts	10	0		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
City of Canyon Flood Mitigation Project	**013000012**	Project does not provide any environmental benefits	Project has no adverse environmental impacts	10	1232	Improve LWC at two locations	Project will protect all major access routes in floodplain and all emergency service access. Minor access routes are still flooded or have restricted access in local areas.	7			
Wichita Gardens Drainage Improvements	**013000013**	Project does not provide any environmental benefits	Project has no adverse environmental impacts	10	0		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
Echo/Neta Lane Drainage Project	**013000015**	Project does not provide any environmental benefits	Project has no adverse environmental impacts	10	0		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
Hirschi - Huskie	**013000016**	Project does not provide any environmental benefits	Project has no adverse environmental impacts	10	0		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
Landon, Duty and Sunset St Drainage Project	**013000017**	Project does not provide any environmental benefits	Project has no adverse environmental impacts	10	0		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
Spanish Trace Drainage Project	**013000018**	Project does not provide any environmental benefits	Project has no adverse environmental impacts	10	0		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
China Creek	**013000019**	Project does not provide any environmental benefits	Project has no adverse environmental impacts	10	0		Project provides no change to major, minor, or emergency access routes in the project area.	0			
Wild Horse Creek	**013000020**	Project does not provide any environmental benefits	Project has no adverse environmental impacts	10	0		Project will protect all major access routes in floodplain and all emergency service access. Minor access routes are still flooded or have restricted access in local areas.	7			
Buffalo Creek	**013000021**	Project does not provide any environmental benefits	Project has no adverse environmental impacts	10	0		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
Gilbert Creek	**013000022**	Project does not provide any environmental benefits	Project has no adverse environmental impacts	10	0		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
West Rockwell & Soncy	**013000023**		Project has no adverse environmental impacts	10	1850		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
Happy West & Bell	**013000024**		Project has no adverse environmental impacts	10	250		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
Hix & FM 217	**013000025**		Project has no adverse environmental impacts	10	480		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
Country Club Road	**013000026**		Project has no adverse environmental impacts	10	680		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
Running Water & FM 1714	**013000027**		Project has no adverse environmental impacts	10	25		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
Hill & 46th	**013000028**		Project has no adverse environmental impacts	10	50		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
Gordon-Cummings LWC	**013000029**		Project has no adverse environmental impacts	10	150		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			
Tradewinds & Farmers	**13000030**		Project has no adverse environmental impacts	10	1500		Project will protect some major access routes in floodplain and the majority (>50%) of emergency service access. Some major and many minor access routes will remain flooded, and emergency services access may be restricted in some areas	4			