TECHNICAL MEMORANDUM

JR ENGINEERING

To: **Jeff Rice, PE, El Paso County**

From: **Mike Bramlett, PE, JR Engineering**

Date: **April 13, 2021**

Subject: Sterling Ranch MDDP – Hydrology Alternatives

Mr. Rice,

JR Engineering is preparing an updated MDDP for the Sterling Ranch Development, revising the approved *Master Development Drainage Plan for Sterling Ranch* prepared by M&S Civil Consultants, dated October 2018. JR is presenting two alternatives for how the hydrology for the MDDP along Sand Creek could be analyzed. Initially, JR was provided with a HEC-HMS model previously done by M&S for the current MDDP. Due in part to skepticism over the validity of the model, as well as the desire to incorporate all the proposed offline storage into the model, it was decided that rather than revising the existing model in HEC-HMS, it would be preferable to use EPA SWMM for the hydrologic modeling. Unfortunately, there is no clean, easy way to directly convert a HEC-HMS model to SWMM. The HEC-HMS model uses SCS Curve Number for its infiltration calculations. Colorado Springs criteria explicitly states that Curve Number cannot be used in SWMM because it doesn't accurately model infiltration with Curve Number. Unable to directly use Curve Number, it is proposed instead to use Horton's Equation for infiltration.
The two modeling methods presented both use SWMM. One model uses CUHP to generate sub-basin hydrology, while the other uses the internal hydrologic parameters in SWMM. Rather than modeling all the design storms at this time, we decided to use just the Existing Conditions 100-year storm for this comparison, since the model is simpler and where the differences between models would be at their most extreme . Both models use the 24-hour Type II Storm, simulating a frontal storm typically seen along the Front Range.

Alternative 1: This evaluation uses the Colorado Urban Hydrograph Procedure (CUHP) to develop sub-basin hydrographs for use in SWMM. To get as close of a comparison as possible, we tried to use as much original sub-basin information as possible from the 2018 MDDP. From the MDDP Appendices we were able to determine basin area and imperviousness. Basin length and distance to centroid were determined by re-creating the Existing Conditions Map. Basin slope was determined based on the Lag Time tables in the appendices and then adjusted based Colorado Springs criteria for slopes in SWMM models. Horton parameters were determined based on the soil group composition of each basin. The rain gauge for the 24-hr storm was made by converting the cumulative hydrograph into an incremental one, so as to better model the peaks.

All basins were defined as junction nodes. Any nodes that had a defined channel connecting them were used based on parameters taken from the HEC-HMS model. When a channel wasn't defined in the HEC-HMS model, it was assumed that one wasn't present and a dummy conduit of minimal length was used to connect the node to its nearest downstream junction. Results from both alternatives can be seen in the table below.

Alternative 2: This alternative calculates the sub-basin hydrology based on the internal hydrology parameters within SWMM. Basin area, imperviousness, and slope were all the same as those used in alternative 1. Horton parameters were also taken directly from alternative 1. All defined channels were also taken directly from alternative 1. One of the biggest differences between the two is how is calculates basin width. Colorado Springs provides an excel spreadsheet to convert an irregular shaped basin into a uniform width rectangle. The other big difference between the two models is how routing is done. To simulate runoff from single family houses and local roads in the mostly large, undeveloped basins, pervious routing was used. Depression storage depths were the same assumptions used in alternative 1, and it was assumed that zero percent of all the basins had no depression storage available. The rain gauge was identical to the cumulative hydrograph in the HEC-HMS model.

The basins were laid out in a similar fashion as the HEC-HMS model. If a basin doesn't drain directly to a defined channel, then the basin drains to a dummy node at the top of the channel, which then conveys it downstream to the next node. Channel parameters were taken directly from the HEC-HMS model. Results from both alternatives can be seen in the table below.

Basin Summary					
Basin	MDDP (HEC-HMS)	CUHP		SWMM	
	24-hr Type II Storm Q100 (cfs)	CUHP Q100 (cfs)	Percent Difference	Internal Hydrology Q100 (cfs)	Percent Difference
EX-0	32.2	31.5	2%	67.7	210%
EX-1	30.9	27.9	10%	73.3	237%
EX-2	7.1	4.5	36%	58.9	830%
EX-3	143.1	149.6	5%	640.5	448%
EX-3A	192.6	223.4	16%	556.7	289%
EX-4	197.3	221.2	12%	542.5	275%
EX-4A	160.1	104.8	35%	378.6	236%
EX-5	158.2	150.4	5%	786.7	497%
EX-6	100.5	95.3	5%	387.6	386%
EX-7	107.4	147.0	37%	484.5	451%
EX-8	20.5	50.9	248%	151.4	738%
EX-9	125.2	106.6	15%	222.9	178%
EX-10	236.1	247.9	5%	786.5	333%
EX-10A	43.1	121.6	282%	338.2	785%
EX-11	126.1	213.9	170%	365.1	290%
EX-12	33.3	63.4	90%	98.8	297%
EX-13	78.4	70.5	10%	327.7	418%
EX-20	166.2	215.0	29%	453.7	273%
EX-20A	194.6	171.9	12%	235.3	121%
EX-21	49	41.9	14%	259.6	530%
EX-24	73	60.4	17%	148.0	203%
EX-25	25.1	38.2	52%	72.2	287%
EX-73	102	102.0	0%	262.2	257%
EX-74	140.7	197.9	41%	349.0	248%
EX-75	82.8	85.8	4%	330.7	399%
EX-76	89.6	86.2	4%	330.5	369%
EX-77	227.7	190.5	16%	704.5	309%
EX-78	174.5	245.4	41%	318.9	183%
EX-79	220.1	299.7	36%	348.6	158%
EX-80	171.4	181.7	6%	373.6	218%
EX-81	275.7	267.2	3%	349.1	127%
EX-82	132.3	186.8	41%	243.3	184%
EX-88	144.4	156.6	8%	410.1	284%

Results: As seen in the above table, almost across the board, the CUHP model was closer to MDDP results than the SWMM Internal Geometry. There are basins where the CUHP is within a few percent of the MDDP, while the Internal Hydrology is several times higher. A few basins are over double compared to the MDDP in both models, but for the most part the Internal Hydrology model is substantially higher. The discrepancy appears to be mainly in the hydrology itself. The values at the design points of the model are overall closer to the MDDP values. Peak values at design points for the CUHP model are within 40% with one exception, while there are 8 nodes in the Internal Hydrology model that are at least double that of the MDDP. Curiously, volumes across the board show a lower percent difference than peak flows. The CUHP volumes all stay below 50% of the MDDP model, while the highest difference in the Internal Hydrology model is 76%.

Conclusions: As expected, converting a HEC-HMS model to a SWMM model creates differences in results, regardless of how you choose to model it. Due to SWMM's inability to properly model SCS Curve Number, neither of these models is a perfect comparison to the 2018 MDDP's HEC-HMS models. Using as many parameters provided from the MDDP model as possible, we were able to create two functioning SWMM models. Using CUHP to calculate basin hydrology proved to be across the board more similar to the MDDP results than by calculating basin hydrology with SWMM's internal parameters.

It is our recommendation that CUHP and SWMM be used for all further hydrologic modeling involved with this MDDP revision.