(DRAFT) CLOMR APPLICATION

FOR THE

PROPOSED PAINTED HILLS DEVELOPMENT

CITY OF SPOKANE VALLEY & SPOKANE COUNTY, WASHINGTON

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INTRODUCTION

A 91 acre mixed use development is proposed for the former Painted Hills Golf Course property located in Spokane Valley, Washington. The development includes both residential and commercial property, and open space. Construction of flood control facilities as well as grading and fill are proposed to address floodplain requirements. The property is located within the area known as Storage Area 1 (SA1) in the effective FEMA Flood Insurance Study (FIS). SA1 is designated as a compensatory storage area. Within a compensatory storage area loss of flood storage capacity due to placement of fill must be mitigated with an equivalent compensatory volume of storage or through a reduction in flows such that the net condition causes no adverse impact to the base flood or floodway elevations within the storage area. In addition, loss of infiltration capacity due to placement of fill or impervious surfaces must be mitigated such that the decrease in infiltration capacity will causes no adverse impact to the base flood or floodway elevations within the storage area. The overall purpose of the "compensatory" requirement is to ensure that development activities do not cause an adverse impact on flood elevations within the storage area, or downstream of the development (e.g. increasing downstream flows due to reduced infiltration capacity within the storage area.)

Whipple Consulting Engineers, Inc., (WCE) proposes to address the compensatory storage and infiltration requirements by intercepting floodwaters entering the storage area and then storing and infiltrating flood flows and local storm water through the use of a series of infiltration and storage facilities. The infiltration facilities will make use of dry wells and gravel infiltration galleries. Due to the presence of glacially deposited sands and gravels with high infiltration capacities, drywells are currently in wide use throughout the Chester Creek floodplain and are included in the effective FIS hydrologic model and have the effect of reducing flood elevations and volumes. The inclusion of infiltration facilities within the proposed development plan will create a net benefit by significantly reducing flood elevations within and nearby the subject property. The infiltration facilities and proposed changes will result in approximately 126 acres being removed from the 1% annual chance floodplain, and the removal of 0.7 river miles of floodway.

Geotechnical analysis was conducted by Inland Pacific Engineering Company (IPEC). Design of infiltration and storage facilities was conducted by Whipple Consulting Engineers. WEST Consultants, Inc, conducted the hydraulic analyses to evaluate the effects the proposed development would have on base flood elevations (BFEs – water surface elevations associated with the 1% annual chance event), floodway elevations, floodplain boundaries, and floodway limits of Chester Creek. This report, along with supporting documentation, will be submitted to the Federal Emergency Management Agency (FEMA) through the local communities (City of Spokane Valley, WA, and Spokane County, WA) as a Conditional Letter of Map Revision (CLOMR).

Pertinent information about the request is provided as follows:

Identifier:	Painted Hills Development
Flooding Source:	Chester Creek and Unnamed Tributary
Community:	Spokane Valley, WA, Spokane County, WA

Community Number:	530342, 430174
FIRM Panels Affected:	0751D

Unless otherwise stated, all elevations within this report are referenced to the North American Vertical Datum of 1988 (NAVD88).

BACKGROUND & RESEARCH

General

The Chester Creek watershed is located in Spokane County and the City of Spokane Valley. A location map of the watershed is shown in Figure 1. A map of the effective stream reaches, storage areas, and CLOMR boundary is shown in Figure 2.

The watershed varies in elevation from 1,984 feet at 2nd Avenue (the downstream extent of the effective study) to a high point of approximately 3,680 feet along the western watershed boundary. The lower portions of the watershed are underlain by deep glacial outwash deposits of high infiltration capacity. The upper basin is much steeper and relatively undeveloped. Due to the high infiltration rates in the lower watershed, the Chester Creek channel is distinct only in the upper reaches of the basin. Chester Creek and its unnamed tributary have no outlet. Historically, both channels transitioned from channel to pastures where no distinct channel is evident.

An FIS restudy for Chester Creek and its unnamed tributary was conducted in 2005. Due to the unique infiltration characteristics of the Chester Creek watershed, it was recognized that the prior effective FIS did not consider the effects of infiltration or available storage in the watershed. The restudy included an extensive HSPF hydrologic modeling effort that considered the effects of infiltration and several storage areas that would serve to attenuate flood flows. The study resulted in significantly reduced flood discharges. Nine storage areas were identified, several of which were designated by FEMA as 'compensatory storage areas' within which development must compensate equally for reductions in storage and infiltration capacity. The hydrology went through multiple rounds of peer review and revision which included FEMA, FEMA's review consultant Baker, and the USGS. Details of the original hydrologic analysis can be found in the original FIS hydrology report.

The main channel of Chester Creek currently terminates at a large borrow pit (Storage Area 4) which was developed as part of improvements to Dishman-Mica Road (D-M Road) in 1998 and is intended to act as a storm water retention and infiltration facility. The FEMA regulatory floodplain continues north for approximately 1.5 miles beyond the physical end of the channel.

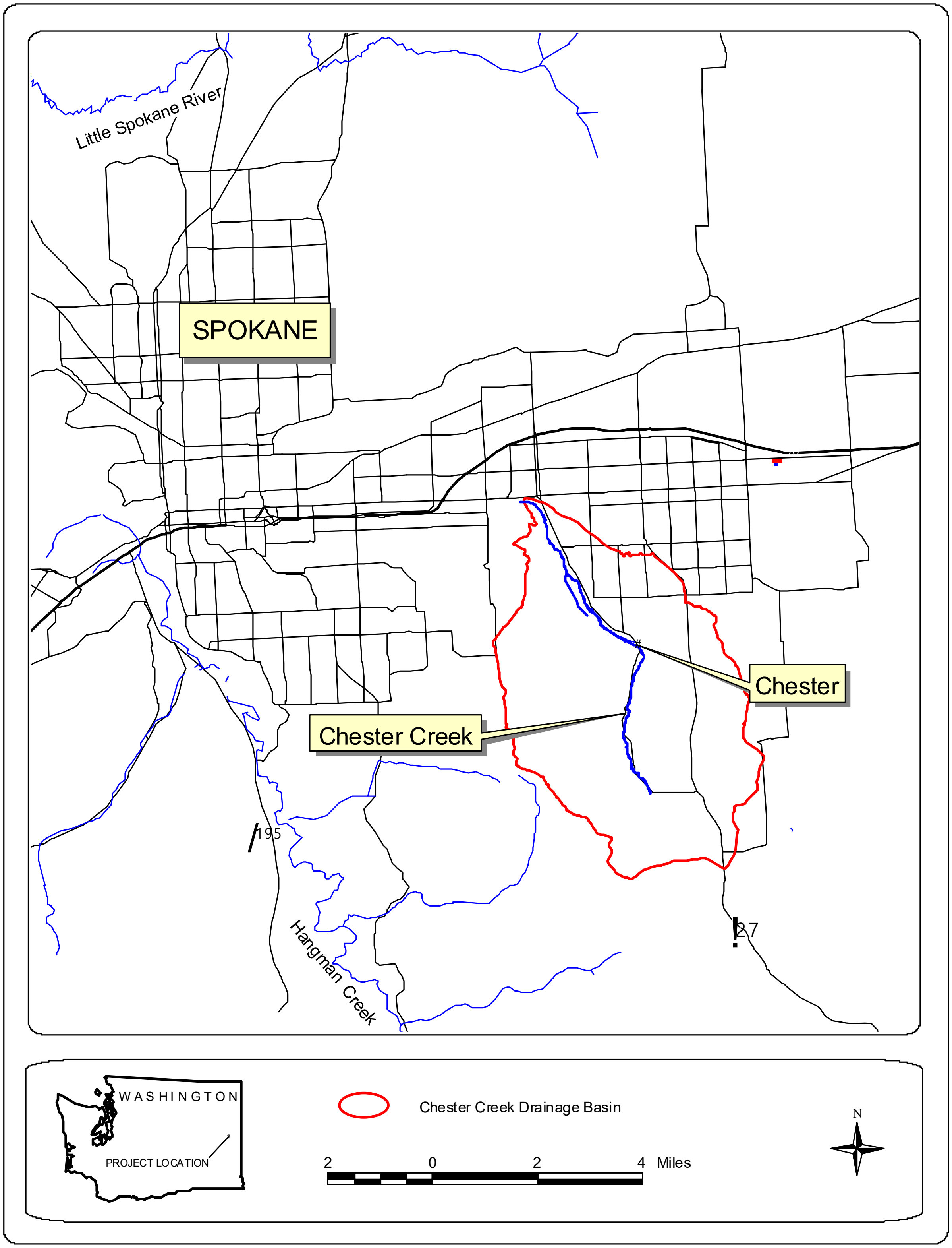

Figure 1. Chester Creek Location Map

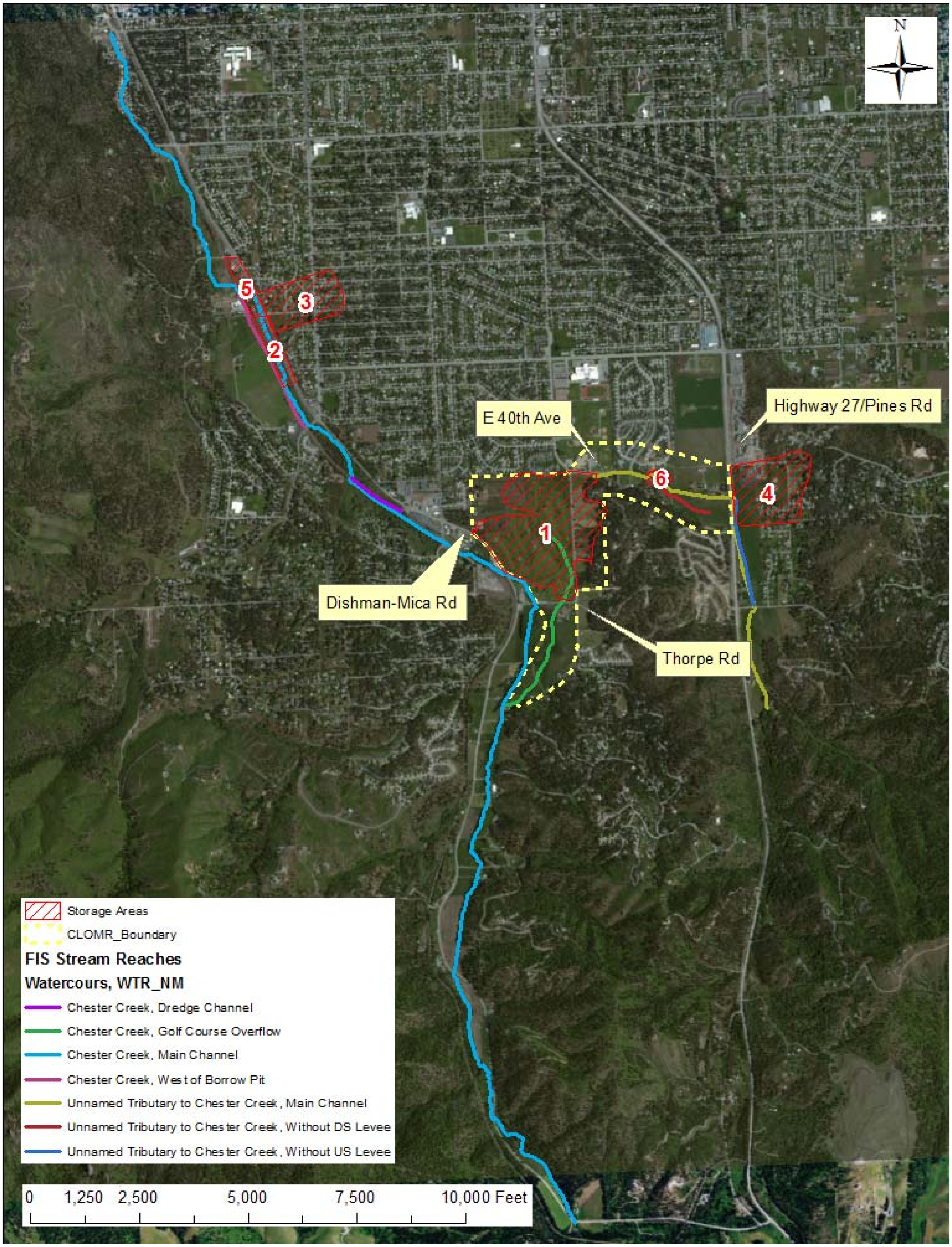

Figure 2. Effective FIS stream reaches and storage areas

The Unnamed Tributary channel does not physically connect to the main channel of Chester Creek. The lower portion of the Unnamed Tributary was historically rerouted to higher ground and currently terminates in a large pit (Storage Area 6 per the effective FIS) that is east of the proposed project site. Based on the effective FIS, the floodplain of the Unnamed Tributary continues west from the Storage Area 6 (SA6) until it reaches SA1, the site of the former Painted Hills Golf Course. A small levee is located along the left bank between Highway 27 and SA6. For the with-levee condition, the 1% annual chance flow downstream of SA6 that continues to SA1 (project site) is 4 cfs. For the without downstream levee condition in which the levee between Highway 27 and SA6 is removed, the floodplain bypasses SA6 and the 1% annual chance flow that could continue to SA1 is 16 cfs.

The proposed development project area is located within SA1 in the right overbank of Chester Creek. SA1 is physically separated from the main channel of Chester Creek by a levee along the right bank of the main channel between Thorpe Rd and Dishman-Mica Road. Figure 3 shows the location of reaches and levees within and near the CLOMR project area.. Flood flows can enter the project site from two sources: The Golf Course Overflow Reach, and the Unnamed Tributary. Due to the natural topography, the Golf Course Levee, and D-M Road, there is no downstream exit for flows that enter SA1 and flood flows that enter the storage area pond until they infiltrate. Descriptions of the two primary flow paths affected by this CLOMR are below.

Golf Course Overflow Reach - Flow escapes the Chester Creek channel approximately 3,000 ft upstream of the golf course due to limited channel capacity, and follows the right overbank until it crosses Thorpe Road and enters the golf course (SA1). The flow entering the golf course does not rejoin the main channel due to the topography of the area, a small levee system along the right bank of the main channel, and the raised embankment of Dishman-Mica Road. As the golf course has no outlet, floodwaters up to the 0.2% annual chance flood (500-yr flood) are stored until they infiltrate. This flow path generally does not contain a physical channel.

Unnamed Tributary – Based on the effective FIS, flows from the Unnamed Tributary can reach the project site via two paths. First, though SA6 has a noticeable impact on peak discharge and serves to attenuate flood flows, flow from the 1%-annual-chance-flood event will fill SA6 and then overflow (4 cfs) and continue to flow west via low ground, overtopping driveways, and eventually Madison Road, at which point it would enter the project site. Second, a levee is present along the left bank of the Unnamed Tributary between SA6 and Highway 27. As this levee is not certified, a without levee analysis was conducted in the effective FIS. Since the channel is perched at this location, failure of the levee assumed all floodwaters (1% annual chance flow of 16 cfs) potentially leave the channel. Flood waters would then flow along the low ground of the left overbank, bypassing SA6 and continue until reaching SA1.

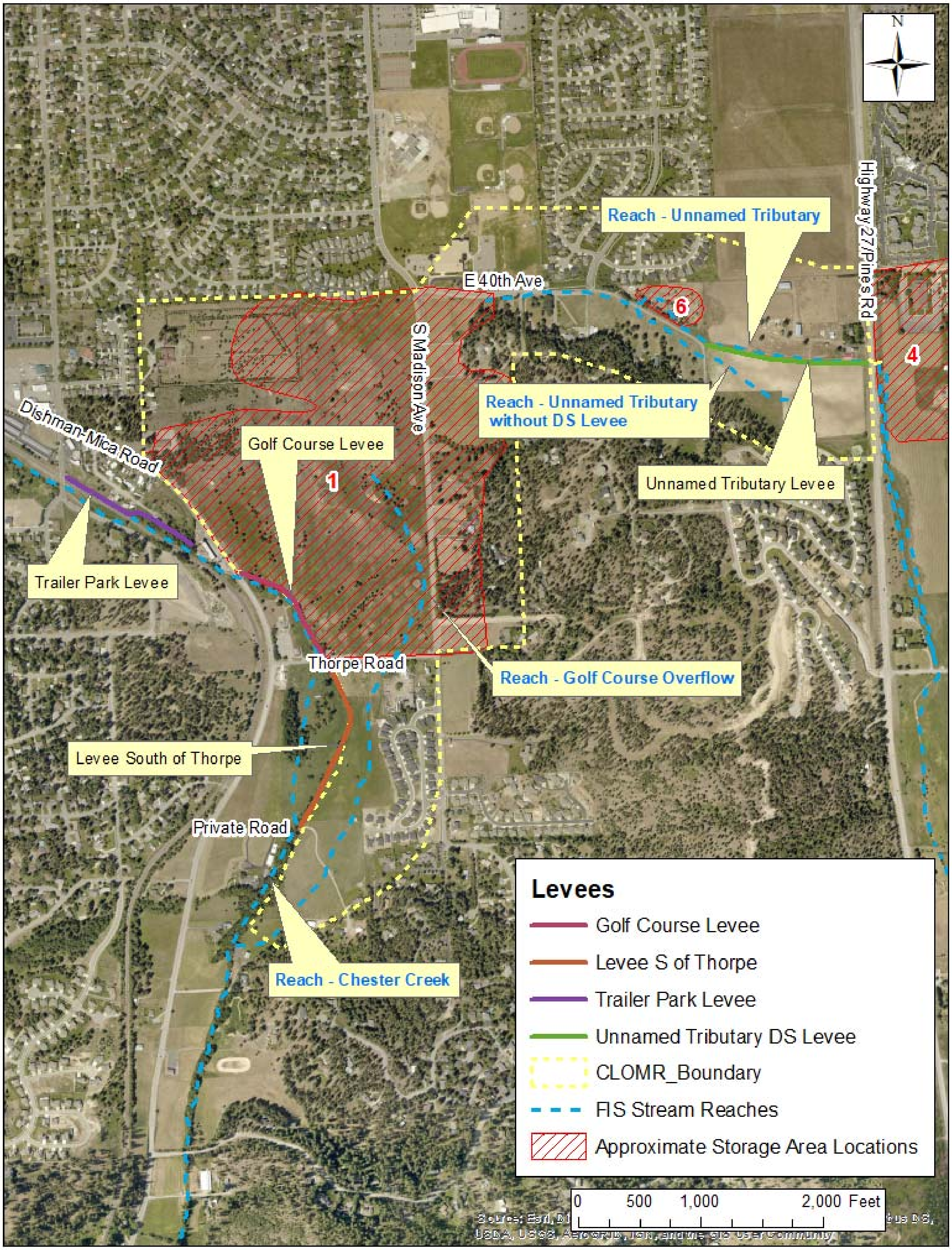

Figure 3. Detail of project area and levees

Levees

Three non-certified levees are present near the project area based on the effective FIS, that are of concern to the project site. They are described below from south to north. A map denoting the levees is provided as Figure 3.

A non-certified levee, referred to in this report as the “levee south of Thorpe”, is located along the right bank and overbank of Chester Creek between Thorpe Road and a private road approximately 1550 feet south of Thorpe Road. The levee is located along the right bank of the original channel; however, based on the 2005 FIS, the channel was diverted to the left overbank and into a pond. Water exits the pond via a rock spillway and returns to the original channel immediately south of Thorpe Road. Due to the diversion, a large portion of the floodplain no longer abuts the levee (Figure 4).

A non-certified levee, referred to in this report as the “golf course levee”, is located along the east bank of Chester Creek between Thorpe Road and D-M Road. This levee is approximately 1,000 feet in length and protects the project site. A without levee analysis for this levee was not conducted as part of the original FIS since floodwaters of similar elevation are mapped on both sides of the levee (the floodwaters on the landward side of the levee originating from the Golf Course Overflow Reach).

A third non-certified levee, referred to as the “Gustin Ditch levee”, is located along the left bank of the Unnamed Tributary between SA6 and Highway 27. In this area, the man-made channel is perched and the levee protects the low ground to the south, in the left overbank. A without levee analysis was conducted in the 2005 FIS.

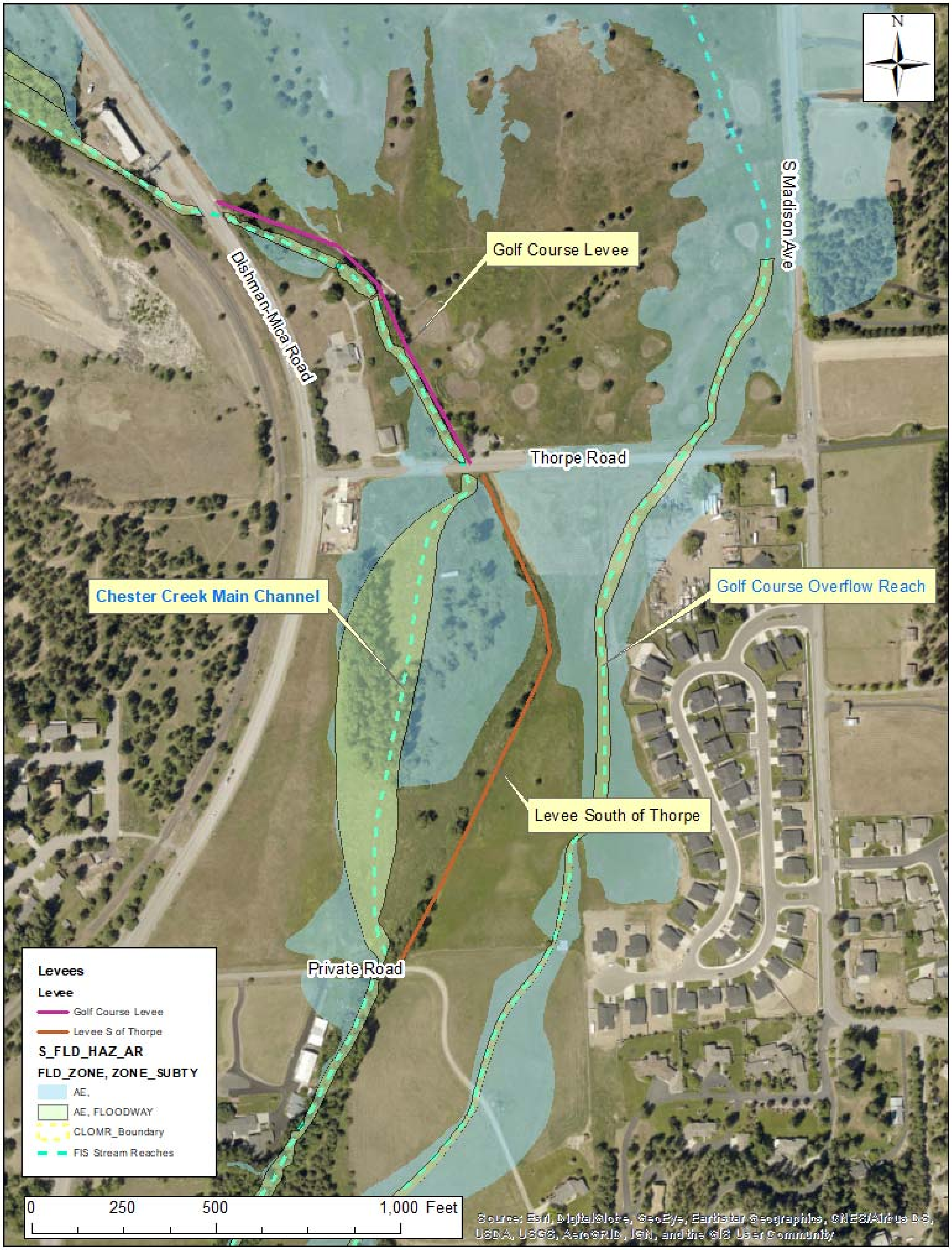

Figure 4. Effective FEMA Floodplain and levee south of Thorpe Road

A review of the effective FIS HEC-RAS model and additional RAS modeling were conducted by WEST, for the levee South of Thorpe Road. The conclusions of that analysis are as follows:

- Based on the effective FIS. much of the 1% annual chance floodplain no longer abuts the levee due to historic rerouting of the channel to the nearby pond, in the west overbank of Chester Creek Based on the effective FIS, the base flood floodplain does not touch the levee along the southern 1,100 feet of its 1,500 foot overall length (Figure 4).
- In the areas where floodwaters do abut the levee, flood velocities are low; approximately 0.5ft/s – 2.2 ft/s for the 1% annual chance flood. Velocities are likely higher immediately downstream of the rock spillway from the pond and it is recommended the levee bank across from the spillway be protected by rock, if possible. Additionally, where floodwaters do abut the levee the 1% annual chance flood generally averages 1 foot or less in depth between the base flood elevation and the toe of the levee.

Although the flood depths and velocities adjacent to the levee are relatively small, it is recognized that a failure of this levee could cause some additional floodwaters to leave the main channel of Chester Creek and join the Golf Couse Overflow channel and hence the proposed infiltration facility. Accordingly, a without-levee scenario was modeled in HEC-RAS to determine the amount of additional flow that could join the Golf Course Overflow Reach in the event of a levee failure so that the infiltration facility could be designed to accommodate this scenario. In this scenario, the approximately 400-feet long section of the levee that abuts the effective floodplain is removed (to the levee toe) in the hydraulic model and flow is allowed to move between the main channel and the Golf Course Overflow Reach. Under this scenario, an additional 27 cfs and 35 cfs can join the Golf Course Oveflow Reach for the 100-yr and 500-yr events, respectively (increases of 42% and 40%) (Table 1). Accordingly, the infiltration facility being used to intercept the Golf Course Overflow Reach has been designed by WCE with an ultimate infiltration outflow of 162 cfs, which exceeds the 500-year without-levee scenario. Per FEMA guidelines, the revised CLOMR mapping shown in the work maps and annotated FIRM reflect the without-levee scenario. The FDT includes both with- and without-levee data and the flood profiles include a fifth profile indicating the 1% annual chance without-levee water surface elevations for the Golf Course Overflow Reach.

Table 1. Thorpe Levee Breach Discharges

Event	With Levee	Without Levee	Difference (cfs)	Difference (%)
100-yr	64	91	27	0.42
500-yr	88	123	35	0.40

Infiltration Facilities

The effective FIS included an extensive hydrologic modeling effort that considered the effects of infiltration and several storage areas that would serve to attenuate flood flows. Nine storage areas were identified and considered in the hydrologic analysis, six of which have been designated by FEMA as compensatory storage areas within which development must compensate equally for reductions in storage and infiltration such that there is no adverse impact on water surface elevations within and downstream of the storage areas. The proposed development is to occupy a large portion of Storage Area 1.

To mitigate for fill and reduced infiltration WCE proposes to construct two infiltration facilities designed to intercept and infiltrate the flows from the Golf Course Overflow and the Unnamed Tributary before they enter the project site. This will result in the entire storage area (and areas outside SA1) being removed from the 1% and 0.2% annual chance floodplains. The infiltration facilities, designed and analyzed by WCE, have several components described below. Further details regarding the facility design beyond the general description below can be found in the technical memo, *Painted Hills Flood Control Development Narrative (Storage Area 1, SA1)*, by WCE (WCE, 2018). The design narrative and full design plans are provided in Appendix J. A geotechnical investigation was conducted by IPEC in order to help WCE determine the design infiltration capacity of the proposed drywells and gravel gallery. More information can be found in the two reports, *Preliminary Geotechnical Evaluation Phase I* and *Full-Scale Drywell Testing,* located in Appendix I.

The largest of the two flood sources contributing to SA1 is the Golf Course Overflow Reach. The peak 1%-annual-chance-flood discharge entering SA1 via this reach is 64 cfs based on the effective FIS. Flood flows for the 10-year and greater events overtop the right bank of Chester Creek approximately 3,000 feet upstream of Thorpe Road, and flow along low ground in the right overbank before entering the property through three 15” culverts under Thorpe Road, and via overtopping of the roadway when flows exceed the capacity of the culverts. The proposed facility that will intercept this flow path includes a replacement box culvert under Thorpe Road, a short section of open concrete channel, a series of culverts, a bioswale, a settling pond, weir, and a series of gravel infiltration trenches containing 48 drywells (Figure 5).

The roadside ditch along the south side of Thorpe will be regraded to drain flows to a 3-foot-tall by 30-foot-wide box culvert under Thorpe Road which will replace the three existing 15” culverts. On the north side of Thorpe Road, a short section of 24-foot-wide rectangular concrete channel will transition flows to a set of two 48” RCP culverts that will convey flow north along the west side of S Madison Road to the northeast corner of the project site where flow exits the pipe into a prismatic open bioswale which will be planted to help filter sediment. At the downstream end of the bioswale, flows will enter a bio-infiltration settling pond. Once flows exceed 1’ in depth they will overtop a rock lined weir and flow into a second bio-infiltration pond which contains the gravel gallery infiltration system. Once flood waters reach a depth of 1’ water will crest over the rims of the drywell and enter into the gravel gallery infiltration system. Based on the design report from WCE the infiltration system has a design infiltration rate capacity of approximately 162 cfs, which is 56 cfs greater than the 0.2% annual chance flow of 88 cfs (or 106 cfs when including local drainage from the hills to the east of Madison St), and 98 cfs greater than the 1% annual chance flow of 64 cfs (or 79 cfs including local drainage) for the Golf Course Overflow Reach. It is recognized however, that the twin 48” RCPs, while having the capacity to convey the 0.2% without-levee flows of 123 cfs, would surcharge and overtop before reaching the 162 cfs capacity of the downstream infiltration gallery. Although that scenario is outside the scope of this analysis, topography indicates that overtopping flows would likely first enter a detention facility located immediately north of Thorpe Road, which contains an outflow pipe into the western RCP. If overflows were to fill the detention facility, water would likely discharge northeast along local low ground, flow across a walking path, and then north along proposed roadside swales, eventually discharging into catch basins which lead to the Madison culverts and the bio infiltration facility. A more complete description of the facilities is available in the WCE design report and plan sheets provided in Appendix J.

The Unnamed Tributary (locally known as Gustin Ditch) currently terminates in SA6, a large pit. Although no channel exists downstream of SA6, the FEMA floodplain extends downstream of the pit and connects to SA1. Based on the effective FIS, the 1% annual chance flow entering and leaving the pit is 16 cfs and 4 cfs, respectively. The privately owned pit has a County easement and is currently used for flood control and storage. Proposed changes to the existing pit include regrading to increase overall storage capacity, moving the channel entrance from the south side to the southeast corner of the pit, and construction of 18 double depth drywells (Figure 6). The ditch between Highway 27 and SA6 will be replaced with a 3' diameter pipe which has the capacity to convey the 0.2% annual chance flood per the effective FIS. Based on the effective FIS, SA6 attenuates the 1% peak flow exiting the pit by 75%, (16 cfs to 4 cfs) and the 0.2% peak flow by 65% (20 cfs to 7 cfs). The 18 proposed drywells have a capacity of 18 cfs, which exceeds the 1% peak discharge of 16 cfs entering the pit. Further, the storage volume of the pit provides an additional factor of safety and can storage up to the 0.2% flood. The effective FIS includes an overflow path in the left overbank of the unnamed tributary downstream of Highway 27 which is based on a levee failure scenario assuming the levee on the left bank of the channel will fail. Since this potion of the watercourse will be piped from the highway to SA6 under the proposed design, there is no longer a need for a without levee scenario. This As proposed, the modification to the channel and pit will provide capacity to store and infiltrate events up to the 0.2% annual chance event, and the proposed FEMA floodplain for this reach will terminate at SA6.

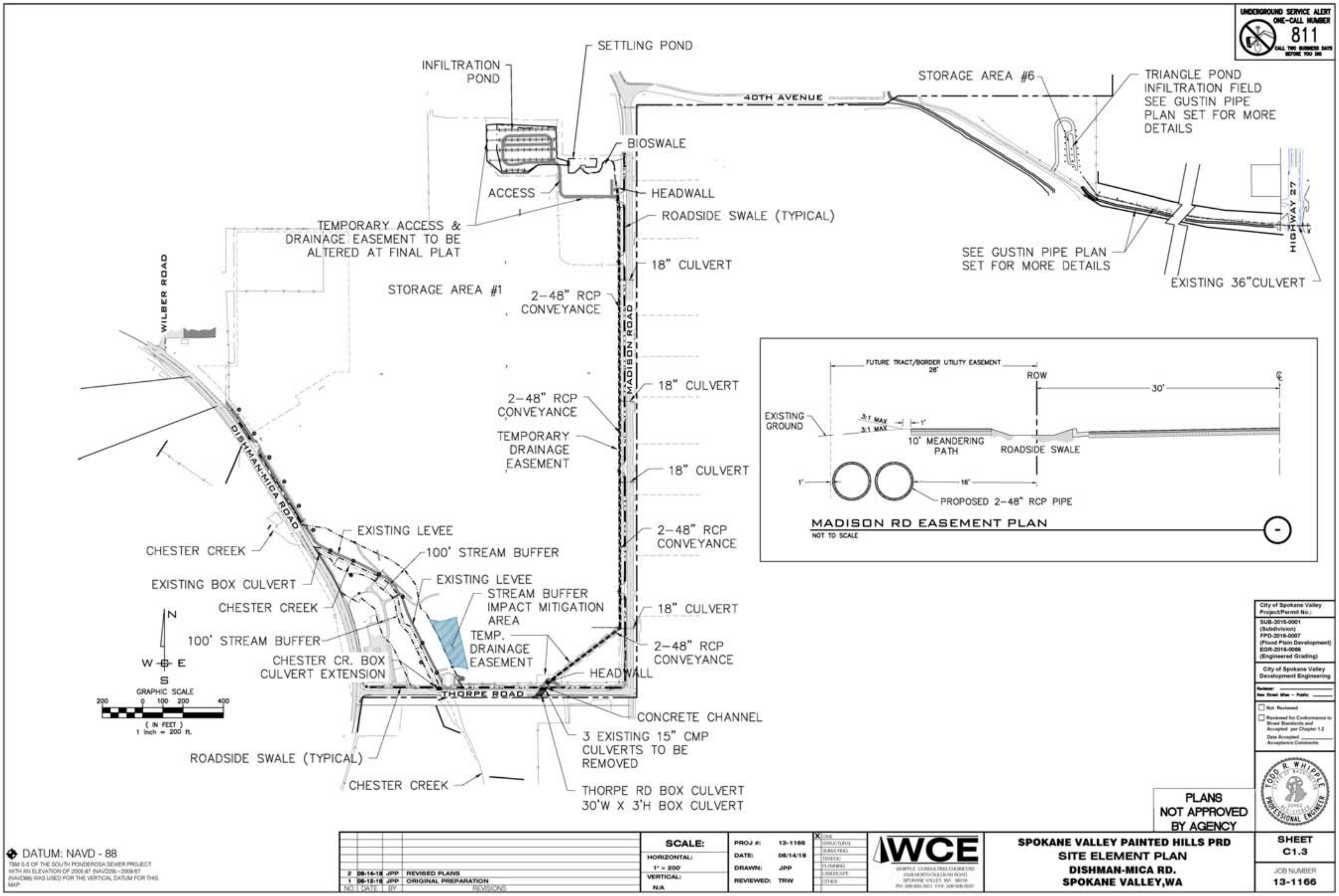

Figure 5. Golf Course Overflow facilities overview. (Full plan set located in Appendix J)

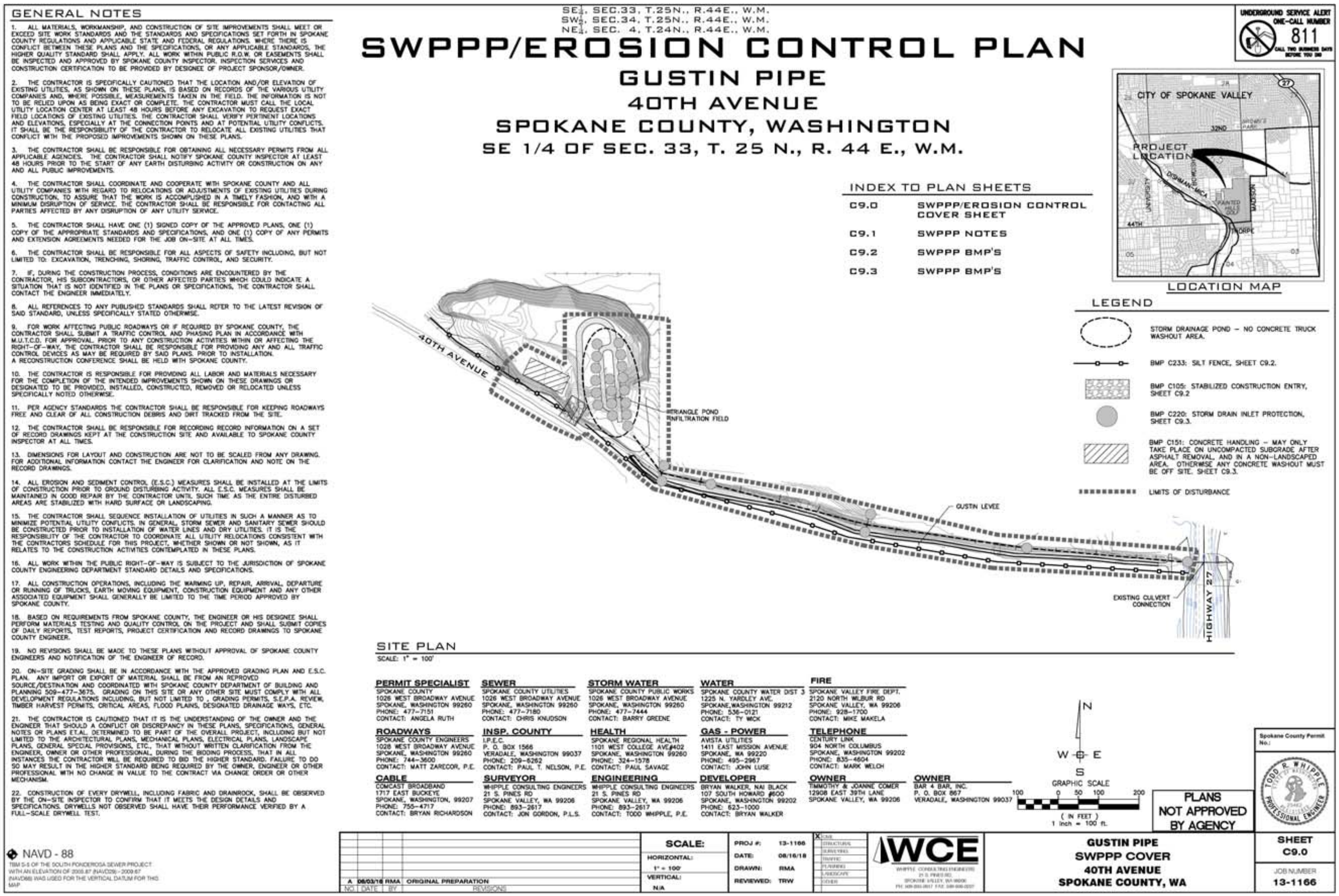

Figure 6. Unnamed Tributary facility overview. (Full plan set located in Appendix J)

Interior Drainage

It is recognized that there are additional local drainage areas that can also contribute flows to the project (Figure 7). This basin area of 0.6 square miles is well under the 1 square mile threshold that FEMA requires for flood inundation analysis; however, the area was considered in order to make sure the proposed infiltration and storm drain facilities can accommodate nearby storm runoff that naturally drains to the project site. The pink and yellow areas in Figure 9 currently drain to the lower portion of the Unnamed Tributary Without Downstream Levee flow path. These areas could potentially contribute flow to the project site that would not be intercepted by the SA6 infiltration facility. Runoff from the largely undeveloped 0.34 square mile area east of Madison Road (shown in pink) will be conveyed to the SA1 infiltration facility via the four existing culverts under S Madison Rd. The four culverts are to be connected to the eastern of the two proposed north/south trending RCP culverts immediately west of S Madison Rd which conveys flood flows to the infiltration facility. Discharges were calculated based the unit discharge and drainage area ratios from similar watersheds reported by the HSPF hydrologic model in the existing FIS (Table 2). The small portion of the school property (in yellow) identified as 'school west' has a calculated runoff of 3 cfs; however, five drywells are located at the lower end of the basin which would reduce flow downstream. Single depth drywells in the area typically have a design flow of 0.3 cfs; therefore, it is expected that less than 2 cfs would flow downstream of this portion of the basin.

Table 2. Assumed runoff for Adjacent Subbasins Draining to Project Site.

Subbasin	Assumed 1% annual chance event discharge (cfs/sq mi)	Calculated runoff from unit discharge
Painted Hills	150	21
School West	100	3
Madison East	44	15

The remaining 0.22 square mile area west of Madison Road (purple) will be addressed by the approximately 103 additional drywells being proposed as part of the project storm water design. These drywells are not part of the proposed infiltration facilities meant to address the Golf Course Overflow and the Unnamed Tributary. As part of the effective FIS, a drywell analysis was conducted on several highly developed subbasins within the Chester Creek watershed in order to determine if the existing drywell system in highly developed portions of the basin have capacity to infiltrate the 1%, and 0.2% annual chance flood events (i.e. do these subbasins contribute to flood flows in Chester Creek?) (WEST 2008). Based on HSPF hydrologic model analysis, the highly developed subbasins had a unit discharge of approximately 150, and 180 cfs/sq mi for the 1% and 0.2% annual chance events, respectively. The existing drywell network density was found to have capacity to address large storm events, and the basins were assumed to contribute no flow to Chester Creek. Using the 1% annual chance flood unit discharge of 150 cfs/sq mi (reasonable since much of this basin will be developed for this project) and a basin area west of Madison Road of 0.22 sq mi, a peak discharge of 33 cfs was estimated. At 0.3 cfs per drywell (conservatively assuming all single depth), the total of 103 proposed drywells would have approximately the same capacity needed to address the peak runoff, assuming no detention facilities were present. The WCE development plan does however contain several large detention facilities as well as pervious open space.

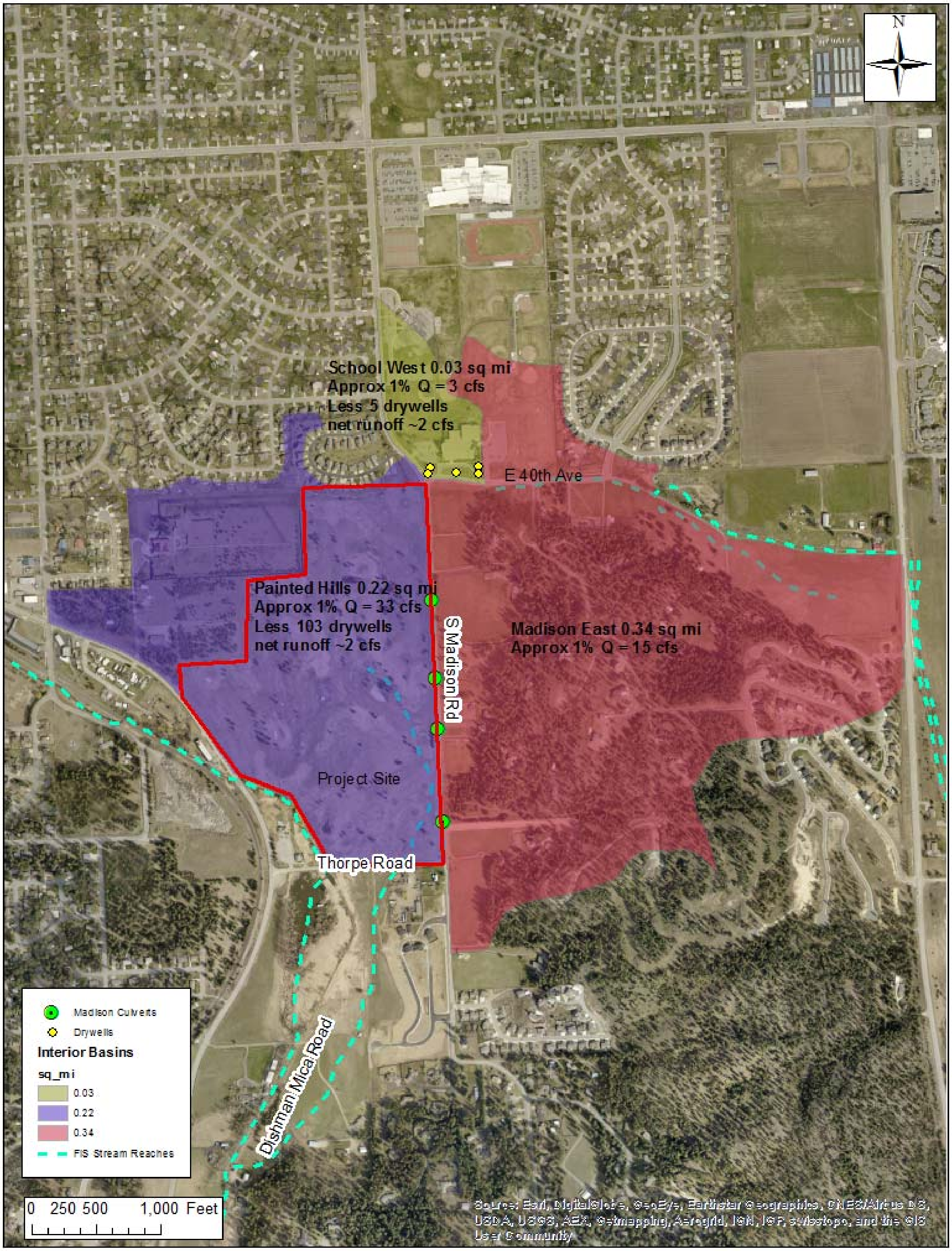

Figure 7. Interior drainage basins

SITE INVESTIGATION

A site visit was conducted on 12/18/2014 by Ken Puhn of WEST Consultants, Inc. (WEST) in order to determine site conditions and observe any changes that may have occurred since the effective FIS was conducted.

Survey data for the site was provided in a xyz format by WCE. Survey data were supplemented by 2003 LiDAR data collected for the effective FIS. The 2003 LiDAR data is considered sufficient since areas where it is used have not been modified or changed since the effective FIS. Plan views showing the location of the cross sections in the hydraulic models are shown in Figure 8 and Figure 9.

HYDROLOGY

Hydrology for the effective FIS is based on a detailed hydrologic analysis using the Hydrologic Simulation Program Fortran (HSPF). Design flows for the proposed infiltration facility are based on the effective FEMA discharges. The 100-year and 500-year discharges were obtained directly from the effective FIS hydraulic model. No modifications were made to the HSPF model for this CLOMR.

Table 3. Discharges Used in HEC-RAS Models

Location	1% Annual Chance Peak Flow (cfs)	0.2% Annual Chance Peak Flow (cfs)
Golf Course Overflow Channel	64	88
Unnamed Tributary	16/4 (upstream/downstream of SA6)	20/7 (upstream/downstream of SA6)

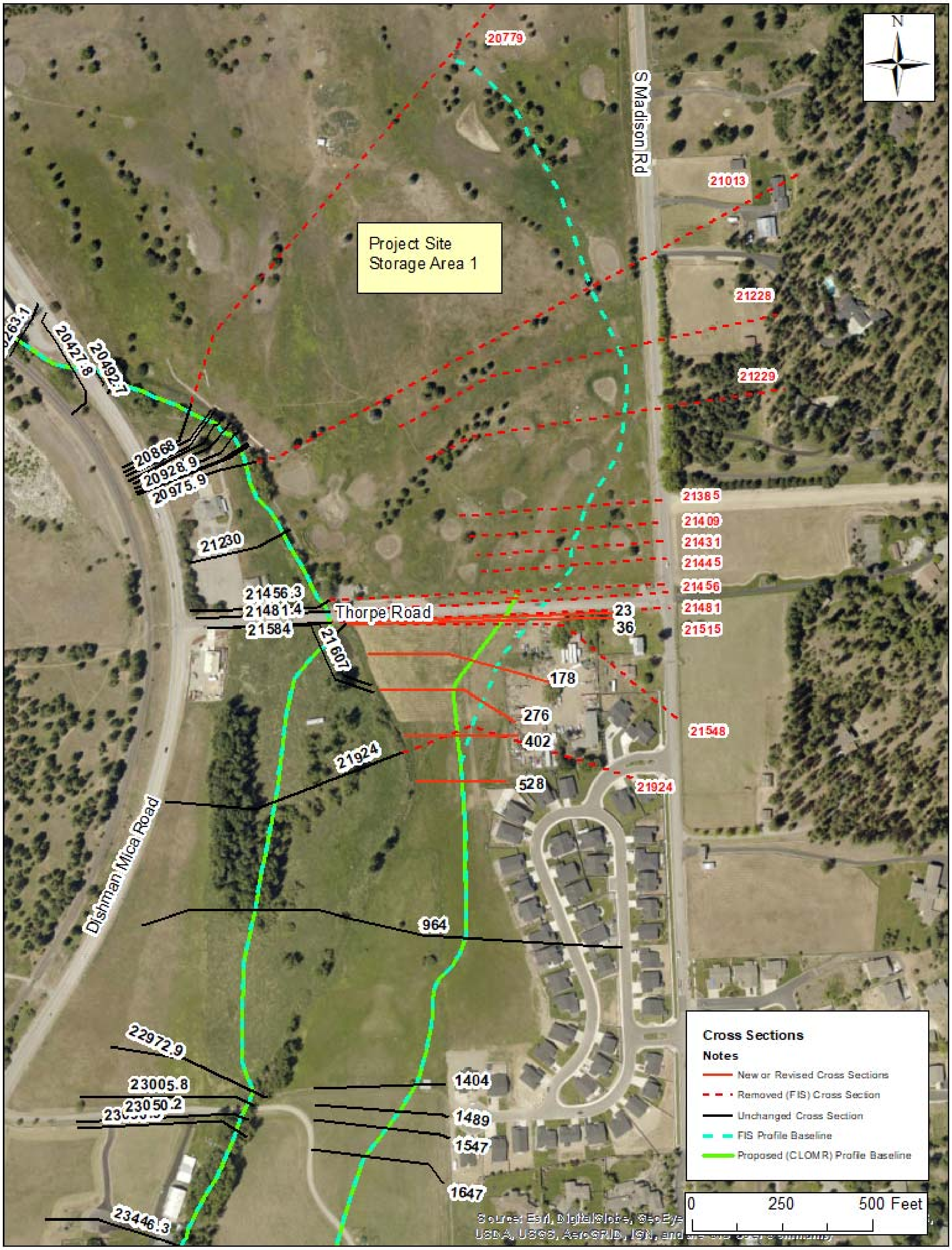

Figure 8. Layout of HEC-RAS Cross Sections for Chester Creek Golf Course Overflow

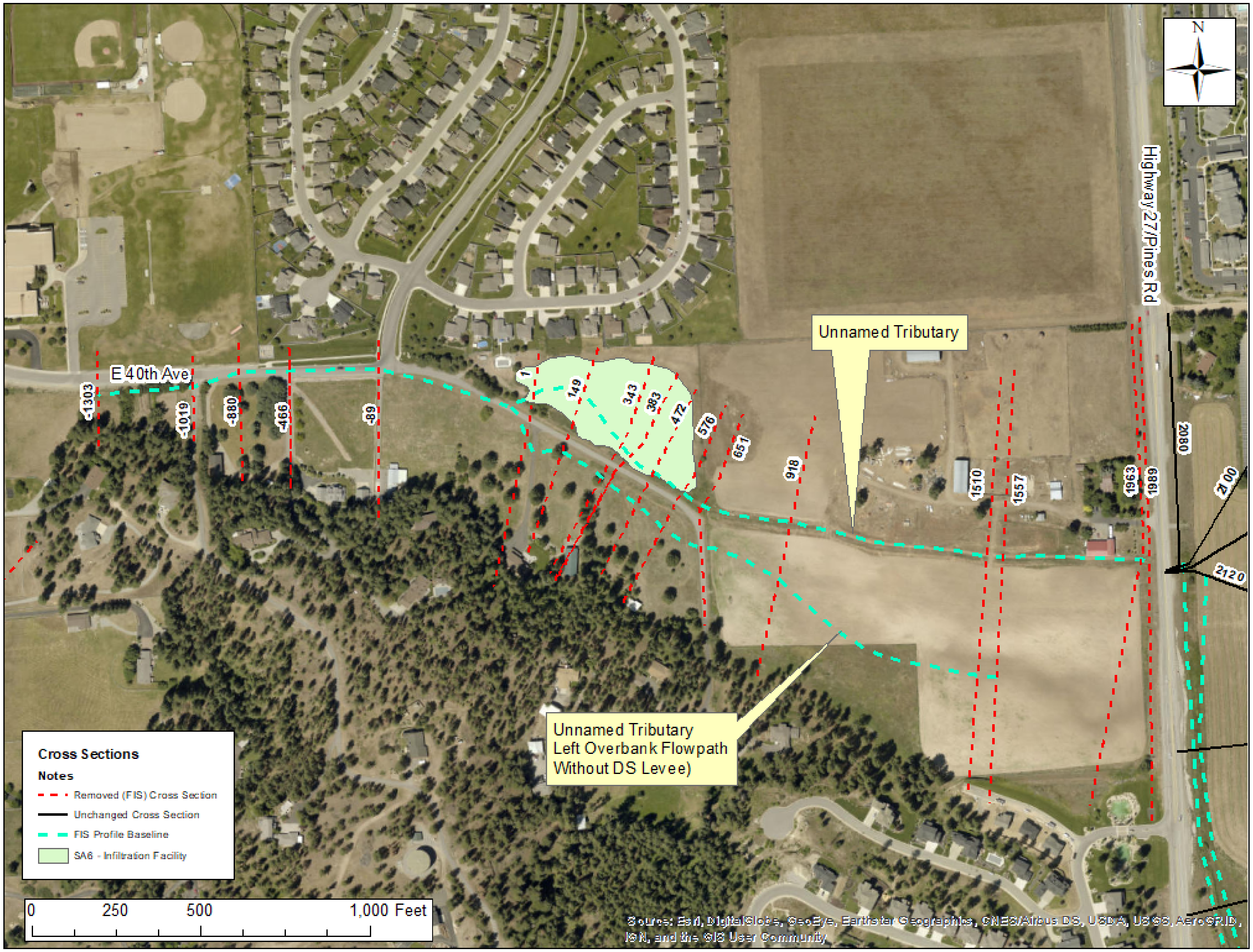

Figure 9. Layout of HEC-RAS Cross Sections for the Unnamed Tributary

HYDRAULICS

Information related to the development of the various hydraulic models required for the CLOMR application is provided in the following paragraphs. In the effective FIS, Chester Creek (which includes the Golf Course Overflow Reach) and the Unnamed Tributary, were modeled separately. The CLOMR follows this preexisting methodology. The RAS models for the Golf Course Overflow and the Unnamed Tributary are provided in separate folders within the digital submittal materials (Exhibit M) and are named CCMain.prj and CCTrib.prj, respectively. A summary list of model plans is provided in Table 4. A summary of model reaches is provided in Table 5. A summary of modeled existing and proposed conditions 1% annual-chance flood flows within the CLOMR reaches is provided in Table 6.

Table 4. Summary of HEC-RAS Model Plans

Model	Plan	Flow File	Geometry File	Description
CCMain.prj	DEM	Upper Reach	US reach w/levee (DEM)	Duplicate Effective Model - Upper Reach of Chester Creek (above SA 5 Borrow Pit), and Golf Course Overflow
CCMain.prj	DEM FW	Upper Reach, floodway	US reach w/levee (DEM)	Duplicate Effective Model for Enchroachment Analysis - Upper Reach of Chester Creek (above SA 5 Borrow Pit), and Golf Course Overflow
CCMain.prj	CEM	Upper Reach	US reach w/levee (CEM)	Corrected Effective Model - Upper Reach of Chester Creek (above SA 5 Borrow Pit), and Golf Course Overflow
CCMain.prj	CEM FW	Upper Reach, floodway	US reach w/levee (CEM)	Corrected Effective Model for Enchroachment Analysis - Upper Reach of Chester Creek (above SA 5 Borrow Pit), and Golf Course Overflow
CCMain.prj	ECM	Upper Reach	US reach w/levee (ECM)	Existing Conditions Model - Upper Reach of Chester Creek (above SA 5 Borrow Pit), and Golf Course Overflow
CCMain.prj	ECM FW	Upper Reach, floodway	US reach w/levee (ECM)	Existing Conditions Model for Enchroachment Analysis - Upper Reach of Chester Creek (above SA 5 Borrow Pit), and Golf Course Overflow
CCMain.prj	PCM	Upper Reach Proposed	US reach w/levee (PCM)	Proposed Conditions Model - Upper Reach of Chester Creek (above SA 5 Borrow Pit), and Golf Course Overflow
CCMain.prj	PCM FW	Upper Reach Proposed, Floodway	US reach w/levee (PCM)	Proposed Conditions Model for Enchroachment Analysis - Upper Reach of Chester Creek (above SA 5 Borrow Pit), and Golf Course Overflow
CCMain.prj	PCM w/breach	Upper Reach Proposed, without Thorpe Levee	US reach wo/Thorpe levee (PCM)	Proposed Conditions Model - Upper Reach of Chester Creek (above SA 5 Borrow Pit), and Golf Course Overflow, without Thorpe levee

CCTrib.prj	DEM	With levee (DEM)	With levee flows and boundary	Duplicate Effective Model - Unnamed Tributary with levee conditions (with both levees US and DS of Hwy 27)
CCTrib.prj	DEM FW	With levee (DEM)	With levee flows, floodway	Duplicate Effective Model for Encroachment Analysis - Unnamed Tributary with levee conditions (with both levees US and DS of Hwy 27)
CCTrib.prj	DEM w/o DS lev	Without DS levee (DEM)	Without ds levee flows and boundary	Duplicate Effective Model - Unnamed Tributary without downstream levee conditions (with levee US of Hwy 27 and without levee DS of Hwy 27)
CCTrib.prj	DEM w/o DS lev FW	Without DS levee (DEM)	Without ds levee flows and boundary, fw	Duplicate Effective Model for Encroachment Analysis - Unnamed Tributary with levee conditions(with levee US of Hwy 27 and without levee DS of Hwy 27)
CCTrib.prj	CEM	With levee (CEM)	With levee flows and boundary	Corrected Effective Model - Unnamed Tributary with levee conditions (with both levees US and DS of Hwy 27)
CCTrib.prj	CEM FW	With levee (CEM)	With levee flows, floodway	Corrected Effective Model for Encroachment Analysis - Unnamed Tributary with levee conditions (with both levees US and DS of Hwy 27)
CCTrib.prj	CEM w/o DS lev	Without DS levee (CEM)	Without ds levee flows and boundary	Corrected Effective Model - Unnamed Tributary without downstream levee conditions (with levee US of Hwy 27 and without levee DS of Hwy 27)
CCTrib.prj	CEM w/o DS lev FW	Without DS levee (CEM)	Without ds levee flows and boundary, fw	Corrected Effective Model for Encroachment Analysis - Unnamed Tributary with levee conditions(with levee US of Hwy 27 and without levee DS of Hwy 27)
CCTrib.prj	ECM	With levee (ECM)	With levee flows and boundary	Existing Conditions Model - Unnamed Tributary with levee conditions (with both levees US and DS of Hwy 27)
CCTrib.prj	ECM FW	With levee (ECM)	With levee flows, floodway	Existing Conditions Model for Encroachment Analysis - Unnamed Tributary with levee conditions (with both levees US and DS of Hwy 27)
CCTrib.prj	ECM w/o DS lev	Without DS levee (ECM)	Without ds levee flows and boundary	Existing Conditions Model - Unnamed Tributary without downstream levee conditions (with levee US of Hwy 27 and without levee DS of Hwy 27)
CCTrib.prj	ECM w/o DS lev FW	Without DS levee (ECM)	Without ds levee flows and boundary, fw	Existing Conditions Model for Encroachment Analysis - Unnamed Tributary with levee conditions(with levee US of Hwy 27 and without levee DS of Hwy 27)
CCTrib.prj	PCM	With levee (PCM)	With levee flows and boundary (proposed)	Proposed Conditions Model - Unnamed Tributary with levee conditions (with both levees US and DS of Hwy 27)
CCTrib.prj	PCM FW	With levee (PCM)	With levee flows, floodway (proposed)	Proposed Conditions Model for Encroachment Analysis - Unnamed Tributary with levee conditions (with both levees US and DS of Hwy 27)

Table 5. Summary of Model Reaches

Model	Reach	Description	Part of CLOMR
CCMain.prj	Upper	Chester Creek from upstream end of FIS to FEMA XS AO (culvert under RR tracks between Bowdish Road and Schafer Rd)	No
CCMain.prj	Dredge Channel	Parallel channel of Chester Creek on east side of RR tracks between Bowdish Road and Schafer	No
CCMain.prj	DS Dredge Channel	Chester Creek from FEMA XS AO to FEMA XS AD (upstream end of SA 5, Dishman-Mica Rd Borrow Pit)	No
CCMain.prj	Golf Course	Golf Course Overflow reach of Chester Creek	Yes
CCTrib.prj	Trib	Main channel of unnamed tributary	Yes
CCTrib.prj	LOB Overflow	Left overbank flowpath; flowpath is modeled only for without DS levee conditions	Yes

Table 6. Summary of 1% Annual Chance Flood Flows for CLOMR Reaches

Watercourse	Location	RAS Station (Existing FIS)	RAS Station (Revised CLOMR)	1% Annual Chance Flood (cfs)	
				Effective Model (DEM, CEM, ECM)	Revised Model (PCM)
Unnamed Tributary	Highway 27 to SA6	2080 - 149	2080 - 548	16	16
Unnamed Tributary	Outflow from SA6	1 - (-1303)	n/a	4	0
Unnamed Tributary	Left Overbank Flowpath (without levee scenario	1989 - (-1303)	n/a	16	0
Chester Creek	Golf Course Overflow Reach	23887 - 20779	2863 - (-2737)	64	64

Duplicate Effective Model (DEM)

The Duplicate Effective Model (DEM) is a copy of the hydraulic model used to create the effective FIS. Creation of the DEM is required to ensure proper transfer of data from the effective FIS. As the effective FIS model was developed by WEST, the model was obtained from WEST archives. The hydraulic analysis for the effective FIS had been completed using the

Corps of Engineers River Analysis System (HEC-RAS) standard-step backwater computer program version 3.1.3.

The DEM model was run using HEC-RAS Version 4.1.0. and model output compared to the effective Floodway Data Tables (FDT). A comparison of water surface elevations (WSEs) for the 1% annual chance flood (100-year flood) event and the floodway for the FIS and DEM model output is provided in Table 7 and Table 8. As shown in Table 7 and Table 8, the water surface elevations computed using the DEM model are nearly identical to elevations published in the effective FISs. For the golf course overflow reach the model reports water surface elevations at RAS cross section 21,013 and 21,128 that differ from the published FIS elevations. This is due to computational changes between RAS version 3.1.3 and 4.1. The water surface elevation at cross section 21,013 is fixed in the RAS model based on the static water elevation reported by the HSPF hydrologic model for SA1. RAS 4.1 has difficulty converging on a subcritical solution at this cross section and defaults to a critical depth solution, ignoring the fixed elevation. In this case, since the floodplain at this location would reflect the ponded conditions expected within the storage area, the reported critical depth solution is erroneous and the fixed elevation of 2008.05 (rounded to 2008.1) is the correct elevation. The erroneous solution at cross section 21,013 results in a slight calculated increase of 0.1 feet at cross section 21,128.

For the Unnamed Tributary, RAS cross sections 1,472 and 1,963 are 0.1 foot lower than the FIS. This again is likely due to small computational differences between RAS 3.1.3 and 4.1. No modifications were made to the DEM because the noted differences were within the ±0.50 ft tolerance required by FEMA Guidelines and Specification for Flood Mapping Partners (G&S) (FEMA). HEC-RAS DEM model output data are provided in Exhibit C.

Table 7. Comparison of FIS and DEM model results for Golf Course Overflow Reach

RAS Station	FEMA Station	XS Letter	1% Annual Chance Flood Event			Floodway		
			Effective FIS (FT NAVD)	DEM (FT NAVD)	Difference (FT)	Effective FIS (FT NAVD)	DEM (FT NAVD)	Difference (FT)
20779	0	A	2008.1	2008.1	0.0	--	2009.1	--
21013	773	B	2008.1	2007.8	-0.3	--	2009.1	--
21128	961	C	2008.5	2008.6	0.1	--	2009.1	--
21229	1145	D	2008.9	2008.9	0.0	2009.6	2009.6	0.0
21385	1425	E	2009.1	2009.1	0.0	2010.0	2010.0	0.0
21445	1600	F	2009.3	2009.3	0.0	2010.3	2010.3	0.0
21548	1800	G	2013.3	2013.3	0.0	2014.1	2014.1	0.0
21924	2123	H	2013.3	2013.3	0.0	2014.2	2014.2	0.0
22423	2704	I	2013.5	2013.5	0.0	2014.5	2014.5	0.0
22972	3144	J	2014.8	2014.8	0.0	2015.3	2015.3	0.0
23050	3287	K	2015.4	2015.4	0.0	2016.2	2016.2	0.0
23090	3387	L	2015.7	2015.7	0.0	2016.6	2016.6	0.0
23446	3721	M	2018.1	2018.1	0.0	2019.0	2019.0	0.0
23887	4318	N	2023.0	2023.0	0.0	2023.8	2023.8	0.0

Table 8. Comparison of FIS and DEM model results for Unnamed Tributary

RAS Station	FEMA Station	XS Letter	1% Annual Chance Flood Event			Floodway		
			Effective FIS (FT NAVD)	DEM (FT NAVD)	Difference (FT)	Effective FIS (FT NAVD)	DEM (FT NAVD)	Difference (FT)
-1303	0	A	2008.1	2008.1	0.0	2009.1	2009.1	0.0
-1019	283	B	2008.4	2008.4	0.0	2009.1	2009.1	0.0
-880	422	C	2008.4	2008.4	0.0	2009.1	2009.1	0.0
-466	836	D	2008.4	2008.4	0.0	2009.1	2009.1	0.0
-89	910	E	2008.4	2008.4	0.0	2009.1	2009.1	0.0
1	1,378	F	2009.7	2009.7	0.0	2010.7	2010.7	0.0
149	1,525	G	2009.7	2009.7	0.0	2010.7	2010.7	0.0
343	1,720	H	2009.7	2009.7	0.0	2010.7	2010.7	0.0
383	1,760	I	2009.7	2009.7	0.0	2010.7	2010.7	0.0
472	1,849	J	2009.7	2009.7	0.0	2010.7	2010.7	0.0
576	1,952	K	2010.0	2010.0	0.0	2010.7	2010.7	0.0
651	2,028	L	2011.0	2011.0	0.0	2011.1	2011.1	0.0
918	2,295	M	2011.5	2011.5	0.0	2011.6	2011.6	0.0
1472	2,849	N	2012.8	2012.8	0.0	2012.8	2012.7	-0.1
1528	2,905	O	2014.3	2014.3	0.0	2014.3	2014.3	0.0
1557	2,933	P	2014.3	2014.3	0.0	2014.3	2014.3	0.0
1963	3,339	Q	2019.7	2019.7	0.0	2019.7	2019.6	-0.1
2100	3,485	R	2020.8	2020.8	0.0	2020.8	2020.8	0.0

Corrected Effective Model (CEM)

The Corrected Effective Model (CEM) is the model that corrects any errors that occur in the DEM, adds any additional cross sections needed, and/or incorporates more detailed topographic information than that used in the DEM. The DEM model review for both the Unnamed Tributary and the Golf Course Overflow Reach found that the models have reasonable cross section spacing and contain detailed topographic data based on channel survey and LiDAR capable of supporting 2-foot contours. Further, the floodplain areas within the CLOMR boundary have remained essentially unchanged since the effective FIS and the effective model topography is representative of current conditions.

For the Unnamed Tributary, the topography and ‘n’ values within the effective models are considered to be reasonable and representative of site conditions based on engineering judgement and guidance provided in the HEC-RAS Hydraulic Reference Manual; therefore, no changes were made. The CEM model is identical to the DEM except for the following two changes. First, ineffective flow stations which were added to RAS cross sections 651 and 1,742 to better reflect local topography. Second, new survey collected by WCE shows that the downstream invert of the Highway 27 culvert is at elevation 2017.4, rather than elevation 2017.83 as shown in the effective model. The change in the culvert invert results in very minor changes to water surface elevations, (ranging from -0.02 to 0.04 feet) at the next five cross sections upstream of the culvert.

For the Golf Course Overflow, in order to more accurately assess the impacts of the proposed project, cross sections 22,423, 21,924, and 21,548 were removed and replaced with five new cross-sections (21,525, 21,609, 21,726, 21,857, and 21,983), the spacing and alignment of which better represent the area immediately upstream of Thorpe Road. Cross section 21,498 was also added to better define the influence of Thorpe Road. Mannings ‘n’ values for the new cross sections are identical to the ‘n’ values for the cross sections they were replacing, and were considered reasonable based on engineering judgement and the RAS Hydraulic Reference Manual. Mannings ‘n’ values and topographic data in other portions of the model were considered reasonable; therefore, no other changes were made. A comparison of DEM and CEM results are provided in Table 9 and Table 10.

Table 9. DEM and CEM model results for the Golf Course Overflow

RAS Station	FEMA Station	XS Letter	1% Annual Chance Flood Event			Floodway		
			DEM (FT NAVD)	CEM (FT NAVD)	Difference (FT)	DEM (FT NAVD)	CEM (FT NAVD)	Difference (FT)
20779	0	A	2008.05	2008.05	0.00	2009.05	2009.05	0.00
21013	773	B	2007.79	2007.79	0.00	2009.05	2009.05	0.00
21128	961	C	2008.60	2008.60	0.00	2009.05	2009.05	0.00
21229	1145	D	2008.87	2008.87	0.00	2009.59	2009.59	0.00
21385	1425	E	2009.12	2009.12	0.00	2010.03	2010.03	0.00
21409	--	--	2009.17	2009.17	0.00	2010.12	2010.12	0.00
21431	--	--	2009.23	2009.23	0.00	2010.23	2010.23	0.00
21445	1600	F	2009.31	2009.31	0.00	2010.29	2010.29	0.00
21456	--	--	2013.13	2013.13	0.00	2013.79	2013.79	0.00
21481	--	--	2013.25	2013.25	0.00	2014.10	2014.10	0.00
21485 [1]	--	--	--	2013.25	--	--	2014.10	--
21515	--	--	2013.25	2013.26	0.01	2014.11	2014.11	0.00
21525 [1]	--	--	--	2013.26	--	--	2014.12	--
21548 [2]	1800	G	2013.26	--	--	2014.13		--
21609 [1]	--	--	--	2013.26	--	--	2014.14	--
21726 [1]	--	--	--	2013.26	--	--	2014.16	--
21924 [3]	2123	H	2013.27	2013.27	0.00	2014.23	2014.24	0.01
21983 [1]	--	n/a	--	2013.31	--	--	2014.28	--
22423	2704	I	2013.51	2013.64	0.13	2014.48	2014.45	-0.03
22972	3144	J	2014.82	2014.60	-0.22	2015.26	2015.26	0.00
23005	--	--	2015.25	2015.28	0.03	2016.10	2016.10	0.00
23050	3287	K	2015.38	2015.39	0.01	2016.21	2016.21	0.00
23090	3387	L	2015.65	2015.65	0.00	2016.61	2016.61	0.00
23446	3721	M	2018.10	2018.10	0.00	2019.02	2019.02	0.00
23887	4318	N	2022.99	2022.99	0.00	2023.79	2023.79	0.00
24430	--	--	2029.56	2029.56	0.00	2029.72	2029.72	0.00

Table 10. DEM and CEM model results for the Unnamed Tributary

RAS Station	FEMA Station	XS Letter	1% Annual Chance Flood Event			Floodway		
			DEM (FT NAVD)	CEM (FT NAVD)	Difference (FT)	DEM (FT NAVD)	CEM (FT NAVD)	Difference (FT)
-1303	0	A	2008.05	2008.05	0.00	2009.05	2009.05	0.00
-1019	283	B	2008.36	2008.36	0.00	2009.05	2009.05	0.00
-880	422	C	2008.42	2008.42	0.00	2009.05	2009.05	0.00
-466	836	D	2008.42	2008.42	0.00	2009.05	2009.05	0.00
-89	910	E	2008.42	2008.42	0.00	2009.05	2009.05	0.00
1	1,378	F	2009.70	2009.70	0.00	2010.70	2010.70	0.00
149	1,525	G	2009.70	2009.70	0.00	2010.70	2010.70	0.00
343	1,720	H	2009.70	2009.70	0.00	2010.70	2010.70	0.00
383	1,760	I	2009.70	2009.70	0.00	2010.70	2010.70	0.00
472	1,849	J	2009.70	2009.70	0.00	2010.70	2010.70	0.00
576	1,952	K	2009.95	2009.95	0.00	2010.67	2010.67	0.00
651	2,028	L	2010.95	2011.13	0.18	2011.07	2011.07	0.00
918	2,295	M	2011.45	2011.63	0.18	2011.63	2011.63	0.00
1472	2,849	N	2012.83	2012.72	-0.11	2012.71	2012.71	0.00
1510	--	--	2013.26	2013.26	0.00	2013.26	2013.26	0.00
1528	2,905	O	2014.30	2014.30	0.00	2014.31	2014.31	0.00
1557	2,933	P	2014.32	2014.32	0.00	2014.32	2014.32	0.00
1963	3,339	Q	2019.66	2019.66	0.00	2019.63	2019.63	0.00
1989	--	--	2020.06	2020.06	0.00	2020.08	2020.08	0.00
2080	--	--	2020.61	2020.65	0.04	2020.61	2020.65	0.04
2100	3,485	R	2020.83	2020.86	0.03	2020.83	2020.86	0.03
2110	--	--	2020.88	2020.90	0.02	2020.88	2020.90	0.02
2120	3,509	S	2020.91	2020.93	0.02	2020.92	2020.93	0.01
2651	4,040	T	2023.40	2023.37	-0.03	2023.40	2023.38	-0.02
3126	4,515	U	2026.19	2026.19	0.00	2026.18	2026.19	0.01

Existing (Pre-Project) Conditions Model

The Existing or Pre-Project Conditions Model is a modification of the CEM to reflect any modifications that have occurred within the floodplain since the date of the effective model but prior to the construction of the project for which the revision is being requested. For the Unnamed Tributary, no significant changes have occurred to the channel or existing floodplain since the time of the effective study; therefore, the Existing Conditions model (ECM) is a duplicate of the CEM.

For the Golf Course Overflow Reach, the only significant modifications known to have occurred are the addition of three, 15” corrugated metal culverts under Thorpe Road. The Existing Conditions model was modified to include the culverts. Comparisons of CEM and ECM model results are summarized in Table 11 and Table 12.

Table 11. CEM and ECM model results for the Golf Course Overflow

RAS Station	FEMA Station	XS Letter	1% Annual Chance Flood Event			Floodway		
			CEM (FT NAVD)	ECM (FT NAVD)	Difference (FT)	CEM (FT NAVD)	ECM (FT NAVD)	Difference (FT)
20779	0	A	2008.05	2008.05	0.00	2009.05	2009.05	0.00
21013	773	B	2007.79	2007.79	0.00	2009.05	2009.05	0.00
21128	961	C	2008.60	2008.60	0.00	2009.05	2009.05	0.00
21229	1145	D	2008.87	2008.87	0.00	2009.59	2009.59	0.00
21385	1425	E	2009.12	2009.12	0.00	2010.03	2010.03	0.00
21409	--	--	2009.17	2009.17	0.00	2010.12	2010.12	0.00
21431	--	--	2009.23	2009.23	0.00	2010.23	2010.23	0.00
21445	1600	F	2009.31	2009.31	0.00	2010.29	2010.29	0.00
21456	--	--	2013.13	2013.14	0.01	2013.79	2013.79	0.00
21481	--	--	2013.25	2013.27	0.02	2014.10	2014.14	0.04
21485 [1]	--	--	2013.25	--	--	2014.10	--	--
21515	--		2013.26	2013.27	0.02	2014.11	2014.15	0.04
21525	--	--	2013.26	2013.28	0.02	2014.12	2014.15	0.03
21609	1800	G	2013.26	2013.28	0.02	2014.14	2014.19	0.05
21726	--	--	2013.26	2013.28	0.03	2014.16	2014.21	0.05
21857	2123	H	2013.27	2013.30	0.03	2014.24	2014.24	0.00
21983	n/a	n/a	2013.31	2013.33	n/a	2014.28	2014.27	n/a
22423	2704	I	2013.64	2013.64	0.00	2014.45	2014.45	0.00
22972	3144	J	2014.60	2014.60	0.00	2015.26	2015.27	0.01
23005	--	--	2015.28	2015.28	0.00	2016.10	2016.10	0.00
23050	3287	K	2015.39	2015.39	0.00	2016.21	2016.21	0.00
23090	3387	L	2015.65	2015.65	0.00	2016.61	2016.61	0.00
23446	3721	M	2018.10	2018.10	0.00	2019.02	2019.02	0.00
23887	4318	N	2022.99	2022.99	0.00	2023.79	2023.79	0.00
24430	--	--	2029.56	2029.56	0.00	2029.72	2029.72	0.00

[1] XS converted to bridge with culverts in model

Table 12. CEM and ECM model results for the Unnamed Tributary

RAS Station	FEMA Station	XS Letter	1% Annual Chance Flood Event			Floodway		
			CEM (FT NAVD)	ECM (FT NAVD)	Difference (FT)	CEM (FT NAVD)	ECM (FT NAVD)	Difference (FT)
-1303	0	A	2008.05	2008.05	0.00	2009.05	2009.05	0.00
-1019	283	B	2008.36	2008.36	0.00	2009.05	2009.05	0.00
-880	422	C	2008.42	2008.42	0.00	2009.05	2009.05	0.00
-466	836	D	2008.42	2008.42	0.00	2009.05	2009.05	0.00
-89	910	E	2008.42	2008.42	0.00	2009.05	2009.05	0.00
1	1,378	F	2009.70	2009.70	0.00	2010.70	2010.70	0.00
149	1,525	G	2009.70	2009.70	0.00	2010.70	2010.70	0.00
343	1,720	H	2009.70	2009.70	0.00	2010.70	2010.70	0.00
383	1,760	I	2009.70	2009.70	0.00	2010.70	2010.70	0.00
472	1,849	J	2009.70	2009.70	0.00	2010.70	2010.70	0.00
576	1,952	K	2009.95	2009.95	0.00	2010.67	2010.67	0.00
651	2,028	L	2011.13	2011.13	0.00	2011.07	2011.07	0.00
918	2,295	M	2011.63	2011.63	0.00	2011.63	2011.63	0.00
1472	2,849	N	2012.72	2012.72	0.00	2012.71	2012.71	0.00
1510			2013.26	2013.26	0.00	2013.26	2013.26	0.00
1528	2,905	O	2014.30	2014.30	0.00	2014.31	2014.31	0.00
1557	2,933	P	2014.32	2014.32	0.00	2014.32	2014.32	0.00
1963	3,339	Q	2019.66	2019.66	0.00	2019.63	2019.63	0.00
1989			2020.06	2020.06	0.00	2020.08	2020.08	0.00
2080			2020.65	2020.65	0.00	2020.65	2020.65	0.00
2100	3,485	R	2020.86	2020.86	0.00	2020.86	2020.86	0.00
2110			2020.90	2020.90	0.00	2020.90	2020.90	0.00
2120	3,509	S	2020.93	2020.93	0.00	2020.93	2020.93	0.00
2651	4,040	T	2023.37	2023.37	0.00	2023.38	2023.38	0.00
3126	4,515	U	2026.19	2026.19	0.00	2026.19	2026.19	0.00

Proposed or Post-Project Conditions Models

The Proposed Conditions models (PCM) reflect the construction of the infiltration facilities along the Golf Course Overflow Reach and the Unnamed Tributary. The post-project conditions model was developed by making the following modifications to the Existing Conditions models:

Golf Course Overflow:

- As the proposed infiltration facility will intercept all flow up through and including the 0.2% annual-chance-flood, the model was shortened and assigned new stationing based on Thorpe Road as the new downstream limit reference point (Station 0). Thorpe Road is the location at which the flow path is considered to enter the flood control facility. Table 13 provides a comparison of existing and revised model and FEMA stationing.

- Existing cross sections north (downstream) of Thorpe Road were removed. This includes FEMA XS A (RS 0) through F (RS 1600). This corresponds with effective RAS cross sections 20,779 through 21,481. Two cross sections were added downstream of Thorpe Road in order to represent the proposed concrete open channel between Thorpe Road and the entrance to the culverts that carry north along the west side of S Madison Rd to the proposed bioswale and infiltration facility. It should be noted that the RAS model changes were not used to design the open channel, culverts, or any other components of the flood control facility (anything north of Thorpe Road). These components were added to the RAS model based on design plans provided by WCE.

- The model geometry was modified to include the replacement of existing culverts under Thorpe Road with a concrete box culvert with a 3 foot rise and 25 foot effective span, perpendicular to flow.

- Downstream boundary conditions at the entrance to the Madison Road culverts were assigned as known water surface elevations based on an XP SWMM model used to model the Madison Road culverts.

- Floodway stations upstream of Thorpe Rd were maintained at a generally similar width to the effective FIS; however, since the current/proposed culvert location differs in location from the existing overtopping point of Thorpe Road in the effective FIS, the floodway location was shifted for cross sections 964 through -41 to align with the current centerline of the overflow path.

Unnamed Tributary:

The Proposed Conditions models (PCM) reflect the construction of the infiltration facility within SA6 and the conversion of Gustin Ditch to a culvert. The post-project conditions model was developed by making the following modifications to the ECM:

With downstream levee condition

- The model was truncated at SA6. Since the infiltration facility will contain all flows up to and including the 0.2% annual-chance flood, the main channel of the tributary no longer continues to Painted Hills. Cross sections between SA6 and Highway 27 were removed and replaced with the cross sections needed to model the proposed culvert. The new downstream most river station in the RAS model is is 548. It should be noted that it appears FEMA shifted the stationing of the FIS maps products on this reach, so they do not correspond directly to the original RAS model stationing. Table 14 provides a comparison of existing and revised model and FEMA stationing.

- Gustin Ditch between the current Highway 27 outlet and the entrance to SA1 was converted to a culvert and the cross sections along this reach were removed.

- No PCM was developed for the Without Downstream Levee condition since that scenario no longer exists as the leveed reach will be within a culvert and a without-levee scenario is no longer required.

Existing vs Proposed Conditions model results for the 1% annual chance flood event and the floodway are summarized in Table 13 and Table 14. A comparison of the floodplain widths is provided in Table 15 and Table 16. As seen in Table 13 and Table 14 the proposed project will not cause any increase in water surface elevations for the 1% annual chance base flood or floodway elevations. Although a levee failure scenario was not conducted for the levee south of Thorpe for the effective FIS, current FEMA standards require that the failure scenario be considered for analysis and remapping of this area. Accordingly, the final revised BFEs and mapped floodplain downstream of XS 528 on the Golf Course Overflow depict this scenario. A comparison of with- and without-levee scenario base flood elevations is provided in Table 17. Although the levee breach scenario contributes significantly more flow to this reach, the proposed water surface elevations are still lower than the effective FIS due to the flood control improvements, with the exception of revised cross section 964, F (effective XS I). At this cross section the CLOMR will result in the published based flood elevation increasing by 0.1 feet. This is not due to the proposed project (which only serves to lower flood elevations), but is strictly artifact of the revised hydraulic model having additional cross sections and thus more detail than the FIS model. Additionally, the published base flood elevation for XS 2100 on the Unnamed Tributary will increase by 0.1 feet. Again, this is not due to the proposed project but is a function of the correction made to the Highway 27 culvert outlet elevation, in the revised hydraulic model. Post-Project Conditions model output is provided in Appendix E.

The proposed flood control facilities would have the following impacts:

Golf Course Overflow

- There will be no increase in base flood or floodway elevations due to the proposed project. Proposed conditions flood elevations will either remain unchanged or be reduced when compared to existing conditions. Reductions will be between 0.0 and 1.1 feet.

- SA1 would be completely removed from the 1% annual chance floodplain. This includes an area of approximately 94 acres.

- The portion of the floodway north of Thorpe Rd along the Golf Course Overflow reach would be removed from the floodplain mapping.

- The floodway would be 3 feet wider at cross section 964 on the revised FIRM panel. This change is not due to the proposed project but is an artifact of the revised hydraulic model having additional cross sections and thus more detail than the FIS model.

- The BFE at XS 964 will be increased by 0.1 feet on the revised FIRM panel. This change is not due to the proposed project. The proposed project will cause no adverse impact to water surface elevations.

Unnamed Tributary

- The 1% annual chance floodplain will effectively be removed for the areas downstream of Highway 27. This includes Gustin Ditch, all of the left overbank flow path (without DS levee condition) and the floodplain downstream of SA6 between the pre-project SA6 outlet and the Left Overbank Flow path.

- The floodway downstream of SA6 and along the left overbank would be removed from the mapping.

Table 13. ECM and PCM model results for the Golf Course Overflow

Effective			Revised			1% Annual Chance Flood Event			Floodway		
RAS Station	FEMA Station	XS Letter	RAS Station	FEMA Station	XS Letter	ECM (FT NAVD)	PCM (FT NAVD)	Differen ce (FT)	ECM (FT NAVD)	PCM (FT NAVD)	Differen ce (FT)
20779	0	A [2]	--	--	--	2008.05	--	--	2009.05	--	--
21013	773	B [2]	--	--	--	2007.79	--	--	2009.05	--	--
21128	961	C [2]	--	--	--	2008.60	--	--	2009.05	--	--
21229	1145	D [2]	--	--	--	2008.87	--	--	2009.59	--	--
21385	1425	E [2]	--	--	--	2009.12	--	--	2010.03	--	--
21409	--	--[2]	--	--	--	2009.17	--	--	2010.12	--	--
21431	--	--[2]	--	--	--	2009.23	--	--	2010.23	--	--
21445	1600	F [2]	--	--	--	2009.31	--	--	2010.29	--	--
21456	--	--[2]	--	--	--	2013.14	--	--	2013.79	--	--
21481	--	--[2]	--	--	--	2013.27	--	--	2014.14	--	--
--	--	--	-41	-41	-- [1]	--	2009.49	--	--	2011.05	--
--	--	--	-32	-32	-- [1]	--	2009.49	--	--	2011.05	--
21515	--	--	23	23	-- [1]	2013.27	2009.51	-3.76	2014.15	2011.06	-3.09
21525	--	--	36	36	A	2013.28	2012.20	-1.08	2014.15	2012.24	-1.91
21609	1800	G	178	178	B	2013.28	2012.63	-0.65	2014.19	2013.09	-1.10
21726	--	--	276	276	C	2013.28	2012.67	-0.62	2014.21	2013.20	-1.01
21857	2123	H	402	402	D	2013.30	2012.82	-0.48	2014.24	2013.39	-0.84
21983	--	--	528	528	E	2013.33	2013.09	-0.24	2014.27	2013.59	-0.68
22423	2704	I	964	964	F	2013.64	2013.62	-0.02	2014.45	2014.11	-0.34
22972	3144	J	1404	1404	G	2014.60	2014.60	0.00	2015.27	2015.27	0.00
23005	--	--	1489	1489	H	2015.28	2015.28	0.00	2016.10	2016.10	0.00
23050	3287	K	1547	1547	I	2015.39	2015.39	0.00	2016.21	2016.21	0.00
23090	3387	L	1647	1647	J	2015.65	2015.65	0.00	2016.61	2016.61	0.00
23446	3721	M	1981	1981	K	2018.10	2018.10	0.00	2019.02	2019.02	0.00
23887	4318	N	2578	2578	L	2022.99	2022.99	0.00	2023.79	2023.79	0.00
24430	--	--	2863	2863	--	2029.56	2029.56	0.00	2029.72	2029.72	0.00

[1] New XS added to PCM

[2] Removed XS from PCM

Table 14. ECM and PCM model results for the Unnamed Tributary

RAS Station	FEMA Station	XS Letter	1% Annual Chance Flood Event			Floodway		
			ECM (FT NAVD)	PCM (FT NAVD)	Difference (FT)	ECM (FT NAVD)	PCM (FT NAVD)	Difference (FT)
-1303	0	A [2]	2008.05	--	--	2009.05	--	--
-1019	283	B [2]	2008.36	--	--	2009.05	--	--
-880	422	C [2]	2008.42	--	--	2009.05	--	--
-466	836	D [2]	2008.42	--	--	2009.05	--	--
-89	910	E [2]	2008.42	--	--	2009.05	--	--
1	1,378	F [2]	2009.70	--	--	2010.70	--	--
149	1,525	G [2]	2009.70	--	--	2010.70	--	--
343	1,720	H [2]	2009.70	--	--	2010.70	--	--
383	1,760	I [2]	2009.70	--	--	2010.70	--	--
472	1,849	J [2]	2009.70	--	--	2010.70	--	--
548	--	-- [1]	--	1991.95	--	--	1992.10	--
576	1,952	K	2009.95	--	--	2010.67	--	--
651	2,028	L	2011.13	--	--	2011.07	--	--
665	--	-- [1]	--	1999.23	--	--	1999.23	--
918	2,295	M [2]	2011.63	--	--	2011.63	--	--
1472	2,849	N [2]	2012.72	--	--	2012.71	--	--
1510	--	-- [2]	2013.26	--	--	2013.26	--	--
1528	2,905	O [2]	2014.30	--	--	2014.31	--	--
1557	2,933	P [2]	2014.32	--	--	2014.32	--	--
1963	3,339	Q [2]	2019.66	--	--	2019.63	--	--
1989	--	--	2020.06	2019.11	-0.95	2020.08	2019.11	-0.97
2080	--	--	2020.65	2020.65	0.00	2020.65	2020.65	0.00
2100	3,485	R	2020.86	2020.86	0.00	2020.86	2020.86	0.00
2110	--	--	2020.90	2020.90	0.00	2020.90	2020.90	0.00
2120	3,509	S	2020.93	2020.93	0.00	2020.93	2020.93	0.00
2651	4,040	T	2023.37	2023.37	0.00	2023.38	2023.38	0.00
3126	4,515	U	2026.19	2026.19	0.00	2026.19	2026.19	0.00

[1] New XS added to PCM
[2] Removed XS from PCM

Table 15. Change in Top Width for Golf Course Overflow

Effective			Revised			Top Width Base Flood (ft)			Top Width Floodway (ft)		
RAS Station	FEMA Station	XS Letter	RAS Station	FEMA Station	XS Letter	ECM (FT)	PCM (FT)	Difference (FT)	ECM (FT)	PCM (FT)	Difference (FT)
20779	0	A [2]	--	--	--	1985	0	-1985	--	--	--
21013	773	B [2]	--	--	--	395	0	-395	--	--	--
21128	961	C [2]	--	--	--	443	0	-443	--	--	--
21229	1145	D [2]	--	--	--	546	0	-546	35	0	-35
21385	1425	E [2]	--	--	--	286	0	-286	30	0	-30
21409	--	-- [2]	--	--	--	284	0	-284	25	0	-25
21431	--	-- [2]	--	--	--	223	0	-223	25	0	-25
21445	1600	F [2]	--	--	--	143	0	-143	20	0	-20
21456	--	-- [2]	--	--	--	115	0	-115	30	0	-30
21481	--	-- [2]	--	--	--	640	0	-640	45	0	-45
--	--	--	-41	-41	-- [1]	--	24	--	--	24	--
--	--	--	-32	-32	-- [1]	--	24	--	--	24	--
21515	--	--	23	23	-- [1]	521	29	-492	29	29	0
21525 [1]	--	--	36	36	A	521	133	-388	29	29	0
21609	1800	G	178	178	B	484	439	-45	44	44	0
21726	--	--	276	276	C	364	245	-119	44	44	0
21857	2123	H	402	402	D	250	204	-46	43	43	0
21983	--	--	528	528	E	180	130	-50	43	43	0
22423	2704	I	964	964	F	203	202	-1	40	43	3
22972	3144	J	1404	1404	G	54	54	0	14	14	0
23005	--	--	1489	1489	H	136	136	0	27	27	0
23050	3287	K	1547	1547	I	152	152	0	22	22	0
23090	3387	L	1647	1647	J	155	155	0	20	20	0
23446	3721	M	1981	1981	K	208	208	0	20	20	0
23887	4318	N	2578	2578	L	160	160	0	20	20	0
24430	--	--	2863	2863	--	37	37	0	20	20	0

[1] XS 21609 in DEM model

[2] Removed XS from PCM

Table 16. Change in top width for Unnamed Tributary

RAS Station	FEMA Station	XS Letter	Top Width Base Flood (ft)			Top Width Floodway (ft)		
			ECM (FT)	PCM (FT)	Difference (FT)	ECM (FT)	PCM (FT)	Difference (FT)
-1303	0	A [2]	104	0	-104	31	0	-31
-1019	283	B [2]	48	0	-48	21	0	-21
-880	422	C [2]	362	0	-362	40	0	-40
-466	836	D [2]	389	0	-389	46	0	-46
-89	910	E [2]	346	0	-346	40	0	-40
1	1,378	F [2]	102	0	-102	117	0	-117
149	1,525	G [2]	176	0	-176	180	0	-180
343	1,720	H [2]	267	0	-267	271	0	-271
383	1,760	I [2]	280	0	-280	283	0	-283
472	1,849	J [2]	193	0	-193	9	0	-9
576	1,952	K	6	0	-6	5	0	-5
651	2,028	L	64	0	-64	16	0	-16
918	2,295	M [2]	43	0	-43	8	0	-8
1472	2,849	N [2]	5	0	-5	5	0	-5
1528	2,905	O [2]	10	0	-10	10	0	-10
1557	2,933	P [2]	8	0	-8	8	0	-8
1963	3,339	Q [2]	15	0	-15	9	0	-9
1989	--	--	48	0	-48	9	0	-9
2080	--	--	16	16	0	15	15	0
2100	3,485	R	15	15	0	15	15	0
2110	--	--	16	16	0	15	15	0
2120	3,509	S	16	16	0	15	15	0
2651	4,040	T	7	7	0	7	7	0
3126	4,515	U	10	10	0	10	10	0

Table 17. PCM model with- and without-levee results comparison for Golf Course Reach

Effective			Revised			1% Annual Chance Flood Event		
RAS Station	FEMA Station	XS Letter	RAS Station	FEMA Station	XS Letter	PCM With Levee	PCM Without Levee	Difference (FT)
--	--	--	-41	-41	-- [1]	2009.49	2010.12	0.63
--	--	--	-32	-32	-- [1]	2009.49	2010.12	0.63
21515	--	--	23	23	-- [1]	2009.51	2010.14	0.63
21525	--	--	36	36	A	2012.20	2012.31	0.11
21609	1800	G	178	178	B	2012.63	2012.80	0.17
21726	--	--	276	276	C	2012.67	2012.86	0.19
21857	2123	H	402	402	D	2012.82	2013.11	0.29
21983	--	--	528	528	E	2013.09	2013.33	0.24
22423	2704	I	964	964	F	2013.62	2013.64	0.02
22972	3144	J	1404	1404	G	2014.60	2014.60	0.00
23005	--	--	1489	1489	H	2015.28	2015.28	0.00
23050	3287	K	1547	1547	I	2015.39	2015.39	0.00
23090	3387	L	1647	1647	J	2015.65	2015.65	0.00
23446	3721	M	1981	1981	K	2018.10	2018.10	0.00
23887	4318	N	2578	2578	L	2022.99	2022.99	0.00
24430	--	--	2863	2863	--	2029.56	2029.56	0.00

FLOODPLAIN MAPPING

Work maps showing existing and proposed floodplain mapping is provided in Appendix H. An annotated FIRM showing existing and proposed floodplain mapping is provided in Appendix G along with revised flood profiles and floodway data tables. The proposed floodplain mapping reflects the proposed flood control improvements. Since portions of the main channel of Chester Creek abut an uncertified levee within the project area, and since Dishman Mica Road is acting as a non-levee embankment for a short stretch of channel under the without-downstream levee (Trailer Park levee) scenario downstream of Dishman-Mica Road, some portions of the project site between the fill and the main channel of Chester Creek have been mapped as 1% annual chance floodplain per the BFE's in the effective FIS.

CERTIFICATION FORMS

Completed FEMA MT-2 forms are included in Appendix A. Supporting documentation that includes a copy of public notices and the Biological Opinion are provided in Appendix K.

SUMMARY

A hydraulic analysis was conducted for a proposed development within the Chester Creek floodplain. The hydraulic analysis was completed to support a Conditional Letter of Map Revision (CLOMR) application for the proposed development per requirements of the City of Spokane Valley, Spokane County, and FEMA. The revised hydraulic models and mapping products reflect the proposed fill and construction of two infiltration and storage facilities and associated infrastructure. The results of the analysis indicate the proposed development will provide significant flood protection for the surround area, will not cause any increase in base flood or floodway elevations when compared to existing conditions, and will significantly reduce the floodplain extent within the extents of the CLOMR.

REFERENCES

Federal Emergency Management Agency, *Procedure Memorandum No. 51, Guidance for Mapping of Non-Levee Embankments*, February 27, 2009

Federal Emergency Management Agency, *Flood Insurance Study, Spokane County, Washington and Incorporated Areas*, July 6, 2010.

Federal Emergency Management Agency, *Guidelines and Specifications for Flood Hazard Partners*, July 6, 2003.

U.S. Army Corps of Engineers, *HEC-RAS River Analysis System User's Manual, Version 4.1*, January 2010.

Whipple Consulting Engineers, Inc., *Painted Hills Flood Control Development Narrative,* September 26, 2014.

WEST Consultants. Inc., *Technical Memorandum Chester Creek Flood Insurance Study Hydrology Re-evaluation,* January 14, 2008.

WEST Consultants. Inc., *Flood Insurance Study Hydrologic Analysis for Chester Creek,* December 8, 2004.

Inland Pacific Engineering Company, *Preliminary Geotechnical Evaluation Phase I Painted Hills Golf Course Property, December 31, 2013.*

Inland Pacific Engineering Company, *Geotechnical Evaluation Levee Evaluation and Certification 4403 South Dishman-Mica Road Spokane County, Washington, February 12, 2015*

Biology Soil & Water, Inc, *Critical Areas Assessment, Buffer Averaging, and Habitat Management Plan for the Painted Hills PRD, May 14, 2015*

APPENDIX A
FEMA FORMS

APPENDIX B

DUPLICATE EFFECTIVE MODEL

APPENDIX C

CORRECTIVE EFFECTIVE HEC-RAS MODEL

APPENDIX D

EXISTING CONDITIONS HEC-RAS MODEL

APPENDIX E

POST-PROJECT CONDITIONS HEC-RAS MODEL

APPENDIX F

EFFECTIVE FLOOD INSURANCE RATE MAP (FIRM), FLOOD PROFILE, AND FLOODWAY DATA TABLE

APPENDIX G

REVISED FLOOD PROFILES AND FLOODWAY DATA TABLES

APPENDIX H

FLOODPLAIN WORK MAPS

APPENDIX I

GEOTECHNICAL EVALUATION/GROUNDWATER ANALYSIS

REPORT 1: PRELIMINARY GEOTECHNICAL EVALUATION, PHASE 1

REPORT 2: GEOTECHNICAL EVALUATION, PROPOSED STORMWATER POND

REPORT 3: GEOTECHNICAL EVALUATION, PHASE 2

REPORT 4: SUPPLEMENTAL GEOTECHNICAL EVALUATION

REPORT 5: FULL-SCALE DRYWELL TESTING

APPENDIX J

INFILTRATION FACILITIES DESIGN REPORT, SITE PLANS, O&M PLANS

NOTE: O&M PLANS AWAITING COMPLETION PER JURISDICTION COMMENTS

APPENDIX K

REQUIRED SUPPORTING DOCUMENTATION