# DRAFT CLOMR APPLICATION

# FOR THE PROPOSED PAINTED HILLS DEVELOPMENT

# CITY OF SPOKANE VALLEY, WASHINGTON


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**Note: Report results do not reflect proposed modifications to the Unnamed Tributary due to Gustin Ditch Levee improvements. Revisions to be completed. Report results based on existing channel and berm geometry.**

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# INTRODUCTION

A 91 acre mixed used development is proposed for the former Painted Hills Golf Course property located in Spokane Valley, Washington. The development includes both residential and commercial property, open space, and a small golf course. The property, designated Storage Area 1 (SA1) within the effective FEMA Flood Insurance Study (FIS) is designated 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, dry wells are currently in wide use throughout the Chester Creek floodplain and are included in the effective FIS hydrologic model. The inclusion of infiltration facilities within the proposed plan will create a net benefit by significantly reducing flood elevations within and nearby the subject property. Two existing levees are proposed to be certified, and one new certified levee is proposed to be built to help protect the development property. The infiltration facilities and certified levees will result in approximately 118 acres being removed from the 1% annual chance floodplain, and the removal of 0.7 river miles of floodway.

Geotechnical analysis and levee design and was conducted by Inland Pacific Engineering Company. Hydraulic analysis and design of the infiltration and storage facilities was conducted by Whipple Consulting Engineers. WEST Consultants, Inc, conducted the hydraulic and hydrologic 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 for the 1% annual chance event, 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 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. Six primary 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 main channel of Chester Creek 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.

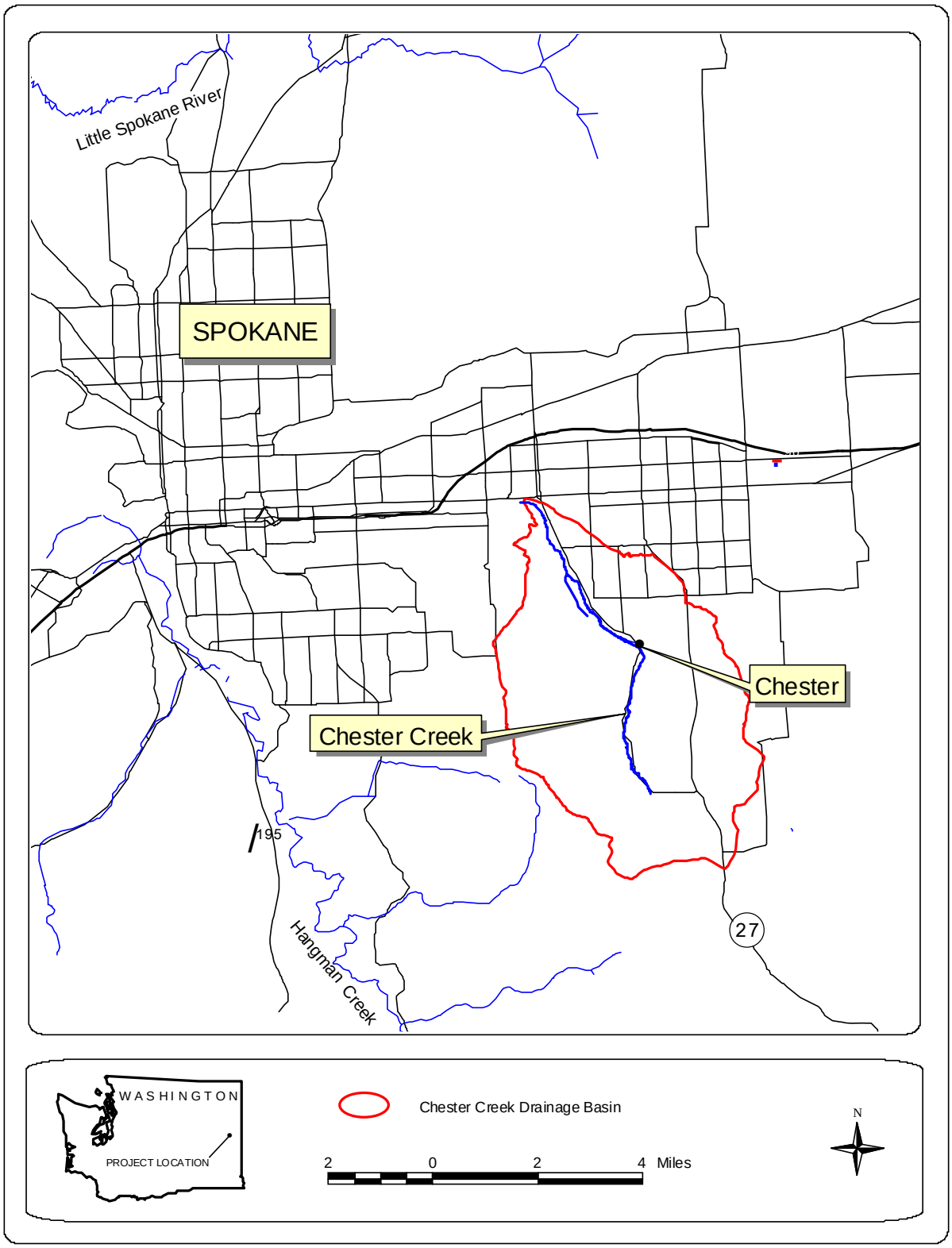


Figure 1. Chester Creek Location Map

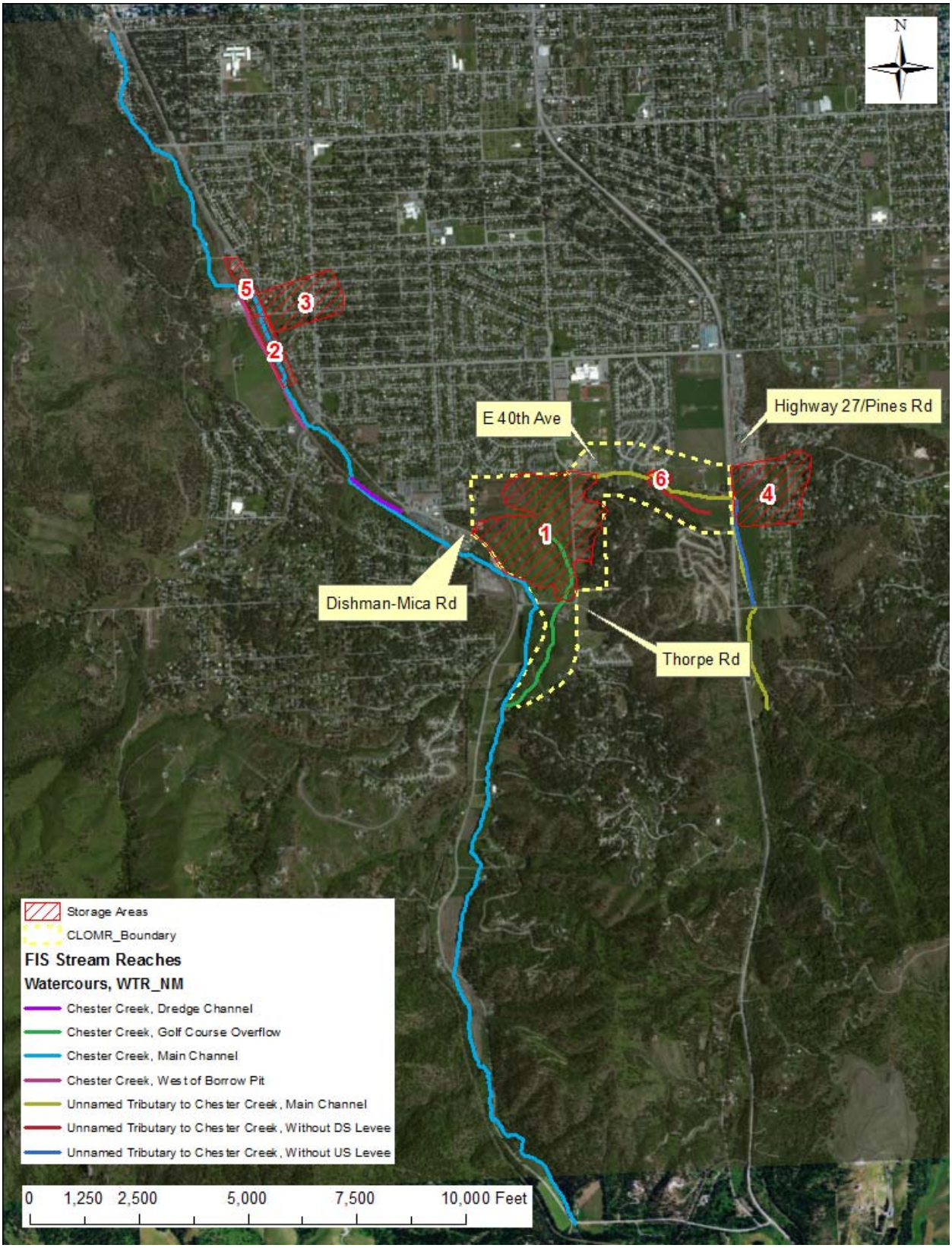


Figure 2. Effective FIS stream reaches and storage areas

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. For the with-levee condition, the 1% annual chance flow downstream of SA6 that continues to SA1 is 4 cfs. For the without downstream levee condition in which the levee between Highway 27 and SA6 is removed, the 1% annual chance flow that could continue to SA1 is 20 cfs.

The 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**).** 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. Flood flows that enter SA1 pond until they infiltrate.

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 and a small levee system along the right bank of the main channel. As the golf course has no outlet, floodwaters are stored until they infiltrate.

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 would result in all floodwaters (1% annual chance flow of 20 cfs) potentially leaving the channel and flowing to the low ground of the left overbank where it would flow west along low ground, bypassing SA6 before rejoining joining the regular flowpath downstream of SA6, where it would continue until reaching SA1.

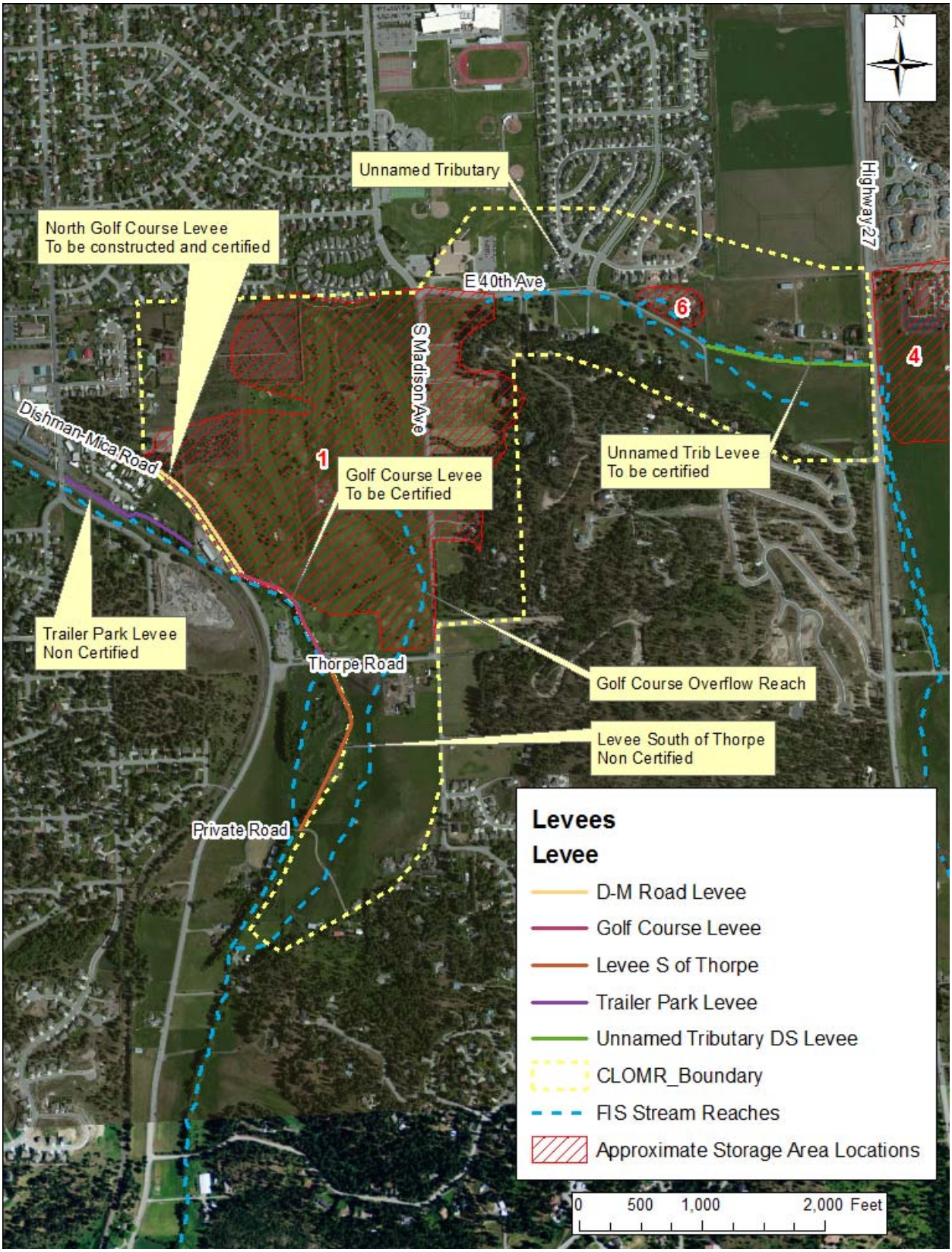


Figure 3. Detail of project area and levees

## Levees

Four non-accredited levees/non-levee embankments 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-accredited levee 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-accredited levee is located along the east bank of Chester Creek between Thorpe Road and Dishman-Mica 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).

Based on current FEMA policy as described in Procedure Memorandum 51 (FEMA, 2009) the portion of D-M Road that borders the northwest corner of the property and divides the floodwaters of Chester Creek from those of SA1 (Figure 1) is considered a 'non levee embankment'. Based on the data from the effective study, floodwaters up to 3 feet deep exist on the west side of Dishman-Mica Road. Because the effective FIS predated PM51 and because floodwaters of similar elevations are mapped on both sides of D-M Road, a without levee analysis was not conducted for the road during the 2005 study.

Another non-accredited levee embankment 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.

In order to protect the proposed development and remove it from the 1%-annual change floodplain, three of the four levees/embankments discussed above are proposed to be improved and certified. Geotechnical analysis and levee design and certification is being conducted by Inland Pacific Engineering Company (IP). The golf course levee between Thorpe Road and D-M Road, as well as the levee along the Unnamed Tributary are being improved to meet FEMA requirements for certification. Based on the effective FIS, D-M Road is acting as a levee; however, as certification of roads to provide levee protection is typically not possible, a new levee is proposed to be built immediately east of and parallel to D-M Road which would tie into high ground to the north and the existing (to be certified) levee to the south. Geotechnical evaluation and certification reports for these three levees are provided in Exhibit J.

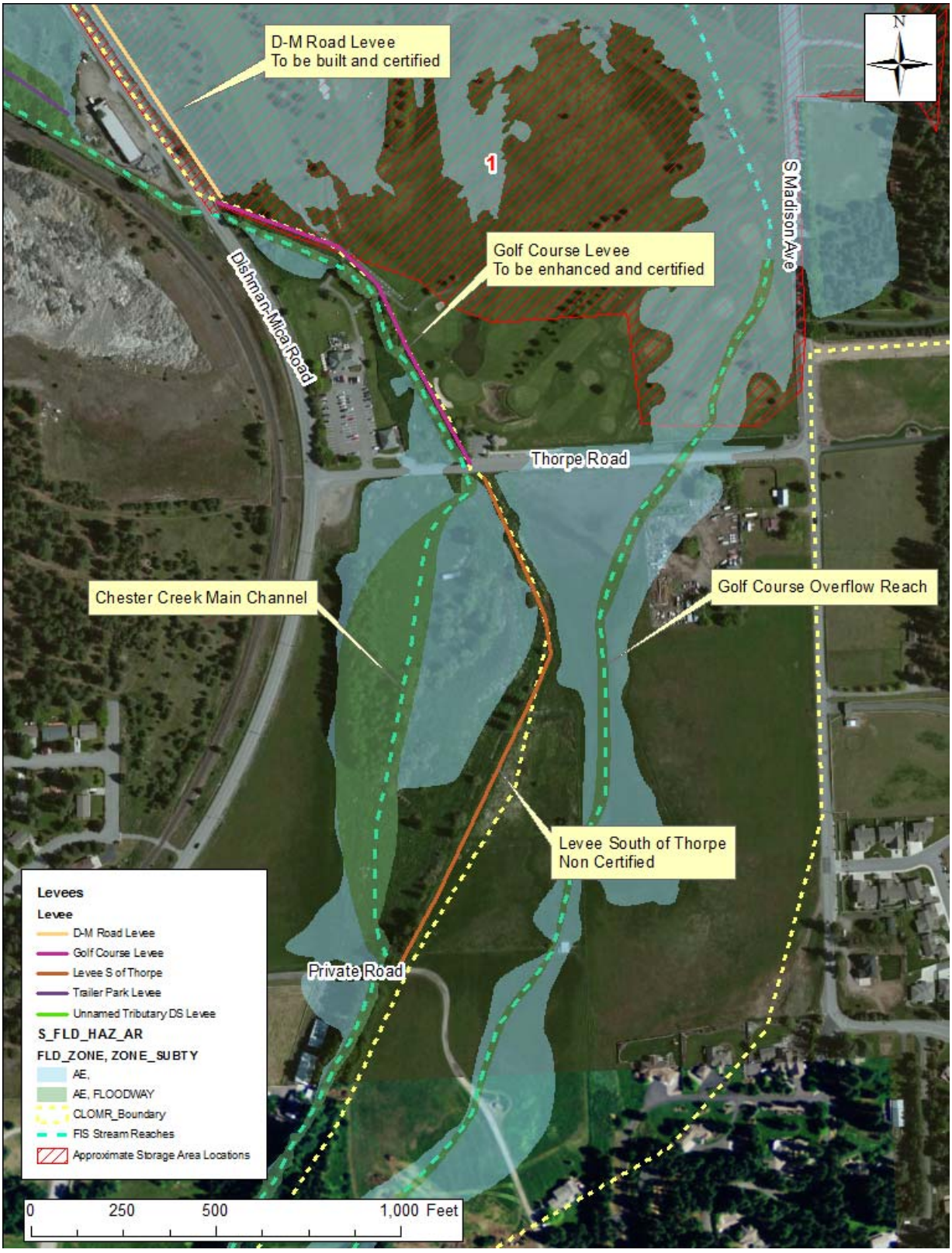


Figure 4. FEMA Floodplain and levee south of Thorpe Road

The levee south of Thorpe Road is not proposed to be modified or certified. A review of the effective FIS HEC-RAS model and additional modeling were conducted by WEST, for the levee. The conclusions of that analysis area as follows:

1. Much of the effective floodplain no longer abuts the levee due to historic rerouting of the channel to the nearby pond, in the west overbank of Chester Creek (Figure 4). Based on the effective FIS, the base flood floodplain does not touch the levee along the southern 1100 feet of its 1500 foot overall length.
2. In the areas where floodwaters do abut the levee, flood velocities are low (approximately 0.45ft/s – 2.2 ft/s for the 1% annual chance flood) and an average of 1 foot or less in depth between the base flood elevation and the toe of the levee.
3. Any waters that were to escape the levee and merge with the Golf Course Overflow in the right overbank would be intercepted by the proposed infiltration facility which has a conservative design capacity that exceeds the 1%-annual change-flood flood peak discharge for the Golf Course Overflow Reach by 35 cfs (design capacity of 99 cfs is 54% greater than FIS 1% peak flow of 64 cfs). Further, the infiltration facility also includes a ten acre overflow storage area to help store floodwaters that are not included in the design capacity calculations.

**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, store, and infiltrate flows from the Golf Course Overflow and the Unnamed Tributary before they enter the Project site. This will result in the entire storage area being removed from the 1% annual chance floodplain. The infiltration facilities, designed and analyzed by WCE, have several components described below. Further details regarding the facility design beyond what is described below can be found in the technical memo, *Painted Hills Flood Control Development Narrative (Storage Area 1, SA1)*, by WCE (WCE, 2014). The report is provided in Exhibit K. A geotechnical investigation was conducted by IP in order to help WCE determine the design infiltration capacity of the proposed drywells. More information can be found in the report, *Preliminary Geotechnical Evaluation Phase I,* located in Exhibit J

Golf Course Overflow - 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 via three 18” culverts under Thorpe Road, and via overtopping of the roadway.

The proposed facility that will intercept this flow path includes three collection ponds, a gravel infiltration gallery, 128 dry wells and a 10 acre park that serves as a final measure of protection (Figure 5).

The first pond in the series is the Collection Pond which is located immediately south of Thorpe Road. This pond is approximately 215 feet wide, 215 feet long, and 7 feet deep. Flows can exit the Collection Pond via four 36" culverts under Thorpe Road which connect to the Discharge Pond (Figure 5). Thorpe Road is proposed to be increased in height by 1 foot. Flows exceeding the storage capacity of both ponds can exit the Fore bay Pond via a 10 foot wide, 240 foot long broad crested weir which connects the Fore bay to the Discharge Pond. The Discharge Pond contains four manholes with beehive grates which convey flood waters to the subsurface gravel infiltration gallery and a collection of 128 drywells which discharge to the aquifer. Based on the design and modeling conducted by WCE the infiltration system has a design infiltration rate capacity of approximately 99 cfs, which is 11 cfs greater than the 0.2% annual chance flow, and 35 cfs greater than the 1% annual chance flow for the Golf Course Overflow Reach. Further, the facility is surrounded by a 10 acre park set below surrounding topography which would provide additional flood storage, if the capacity of the system were exceeded, in order to provide for a conservative measure of protection.

Unnamed Tributary – The Unnamed Tributary 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 pit was purchased by the project owners so that it could be converted to a dedicated infiltration facility. Proposed changes to the existing pit include regrading to increase overall storage capacity, moving the entrance from the south side to the southeast corner of the pit, construction of a rock spillway, enlargement of the channel immediately upstream of the spillway, and construction of 18 double depth drywells (Figure 6). Based on the effective FIS, SA6 attenuates the 1% peak flow exiting the pit by 75%, (16 -> 4 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 level of safety. Based on the proposed design for SA6 and the certification of the levee, the revised 1% annual chance floodplain will terminate at SA6. Since the levee will not be certified for the 0.2% annual chance flood, the floodplain south of the levee along the left overbank, and downstream of SA6 will be mapped as Shaded X/0.2% based on the hydraulic model output.

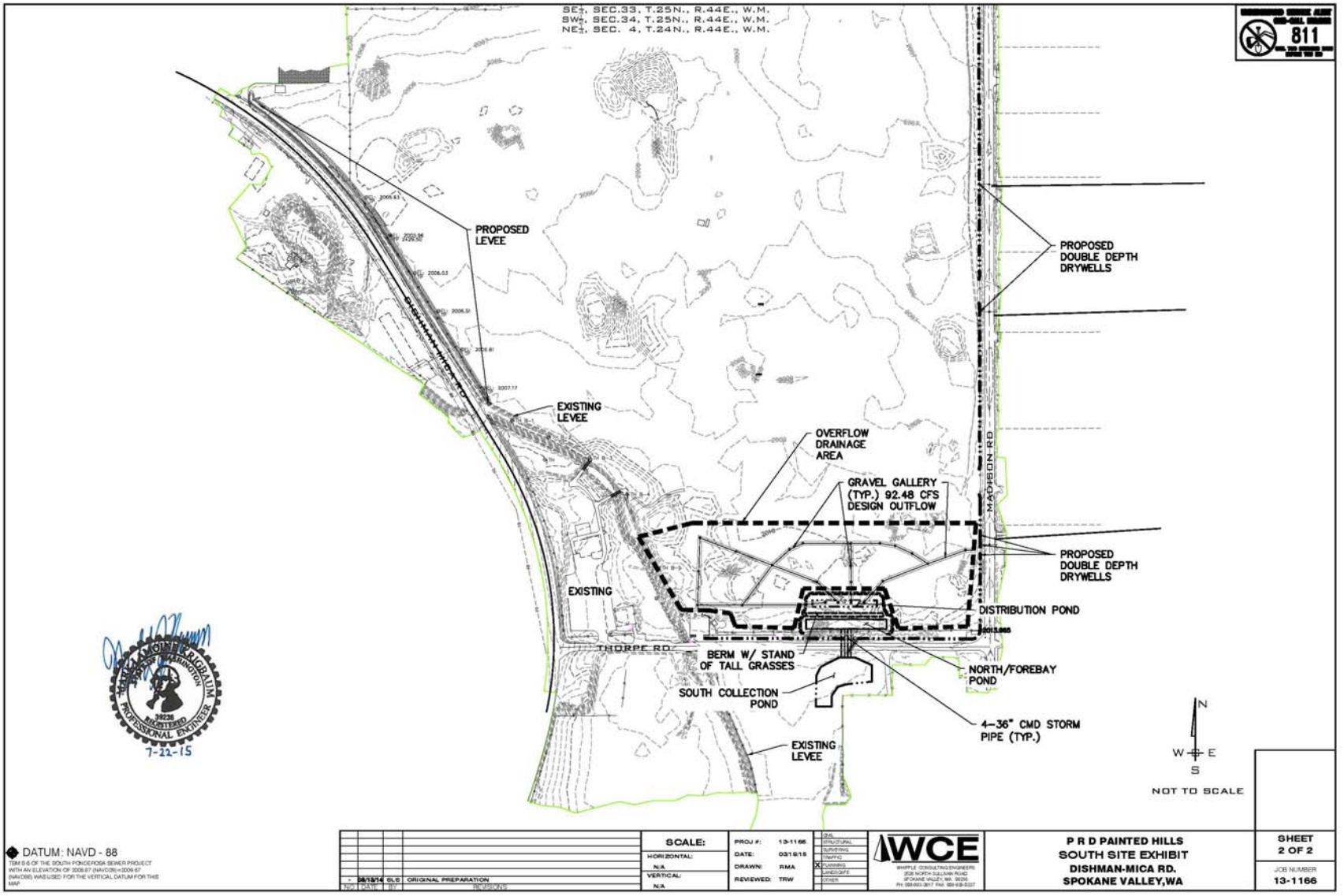


Figure 5. Golf Course Overflow facilities design drawing

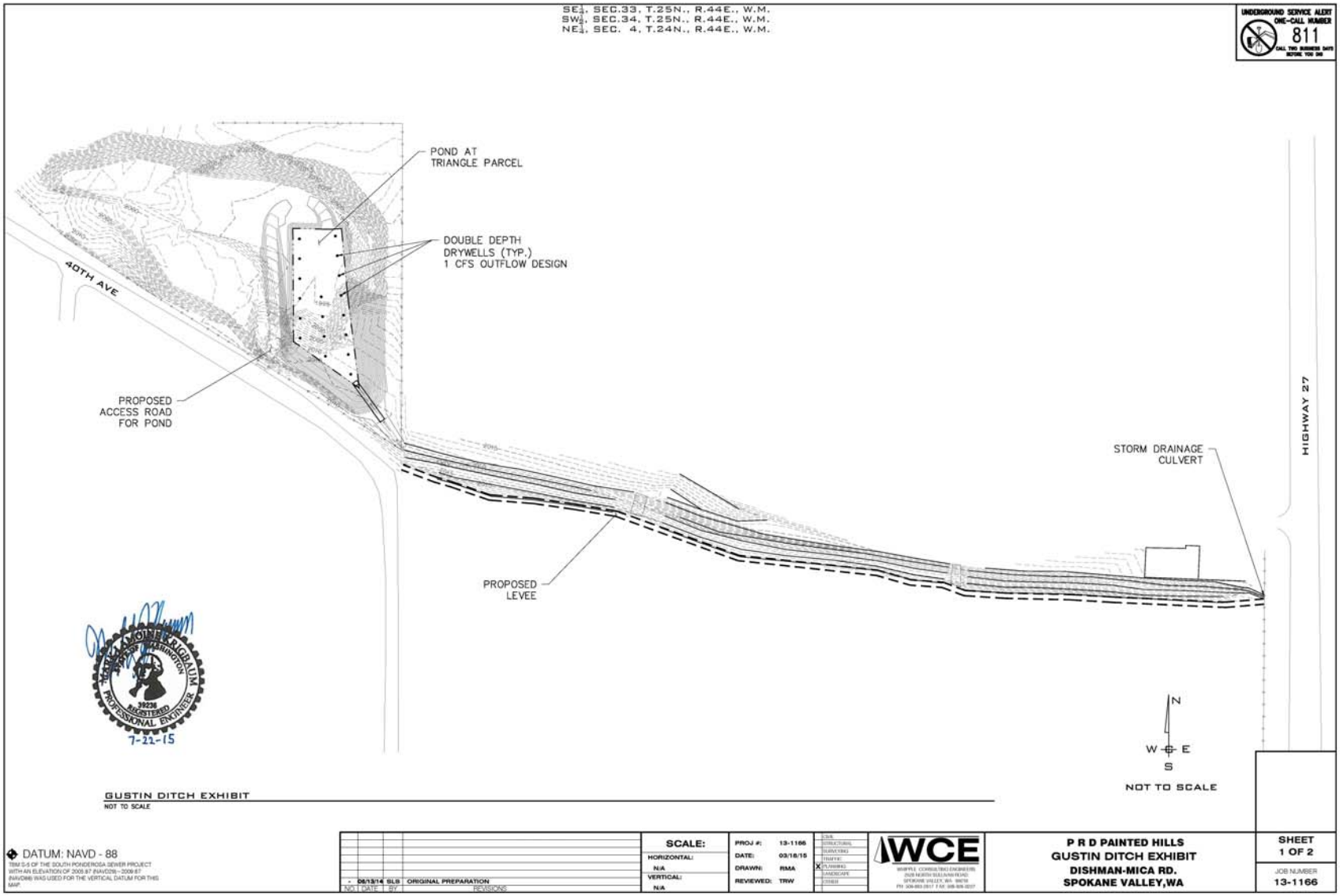


Figure 6. Unnamed Tributary facility design drawing

## Interior Drainage

Figure 7 shows the interior basin area that could drain to the project site and which would not be intercepted by the two primary infiltration facilities. This basin area of 0.55 square miles is well under the 1 sq mile threshold that FEMA requires for flood analysis. Storm water inflows from the largely undeveloped 0.33 square mile area east of Madison Road (shown in yellow) will be addressed by drywells to be installed at the existing culvert locations under the road which could convey minor flows from east to west into the project site. During the road improvement associated with the project, the existing culverts will be connected to multiple drywells to receive incoming storm water. Drywell quantity per culvert was determined based on unit discharge and drainage area ratios from the existing FIS hydrologic model output.

The remaining 0.22 square mile area west of Madison Road 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 could address 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 0.2% annual chance flood unit discharge of 180 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 40 cfs was estimated. At 1 cfs per drywell, the estimated total of 103 proposed drywells would have approximately 2.6 times the capacity needed to address the peak 0.2% annual chance flood event drainage, interior to the project site.

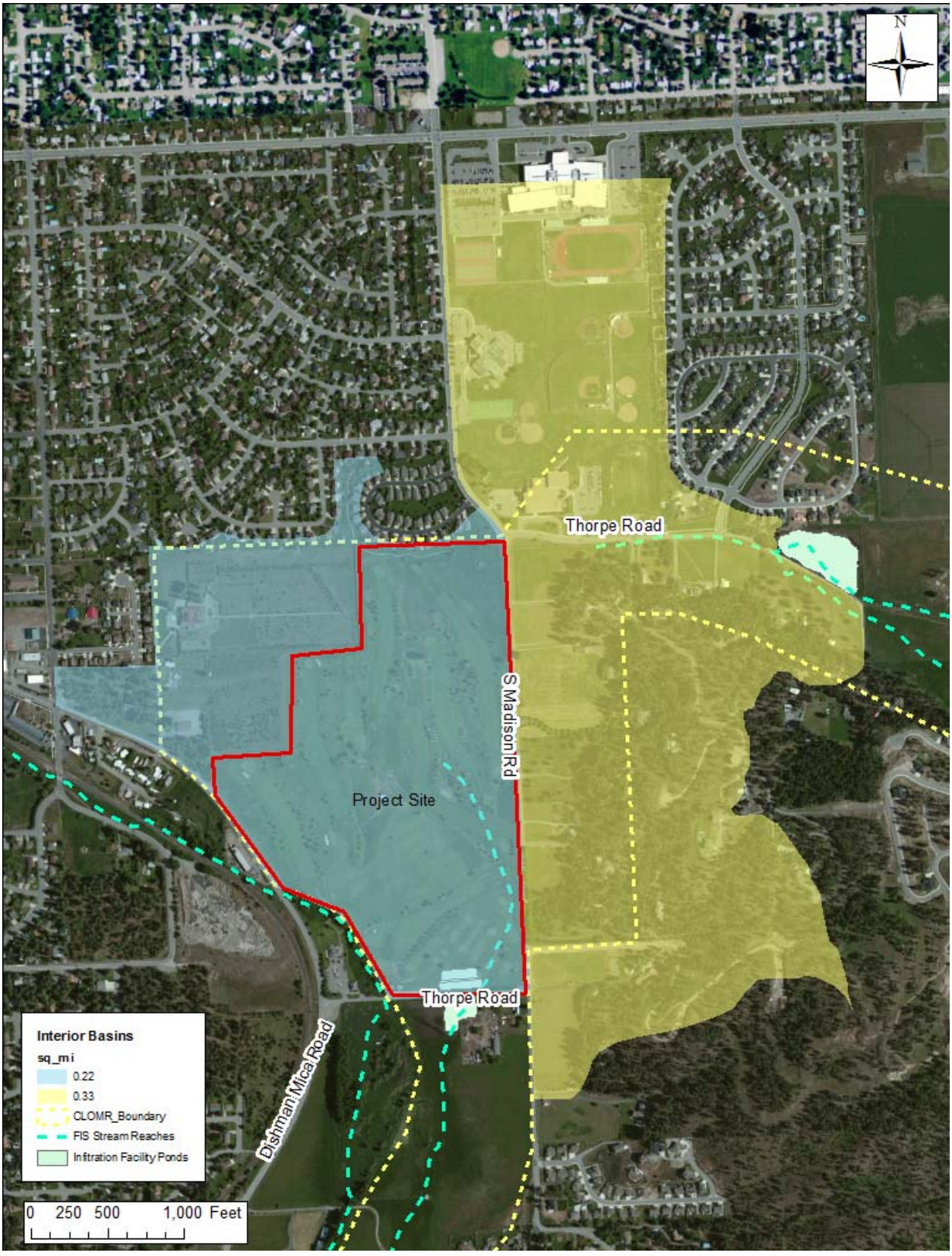


Figure 7. Interior drainage basin

## SITE INVESTIGATION

A site visit was conducted on 12/18/2015 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. 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 discharge was obtained directly from the effective FIS hydraulic model.

Table 1. Discharges Used in HEC-RAS Models

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

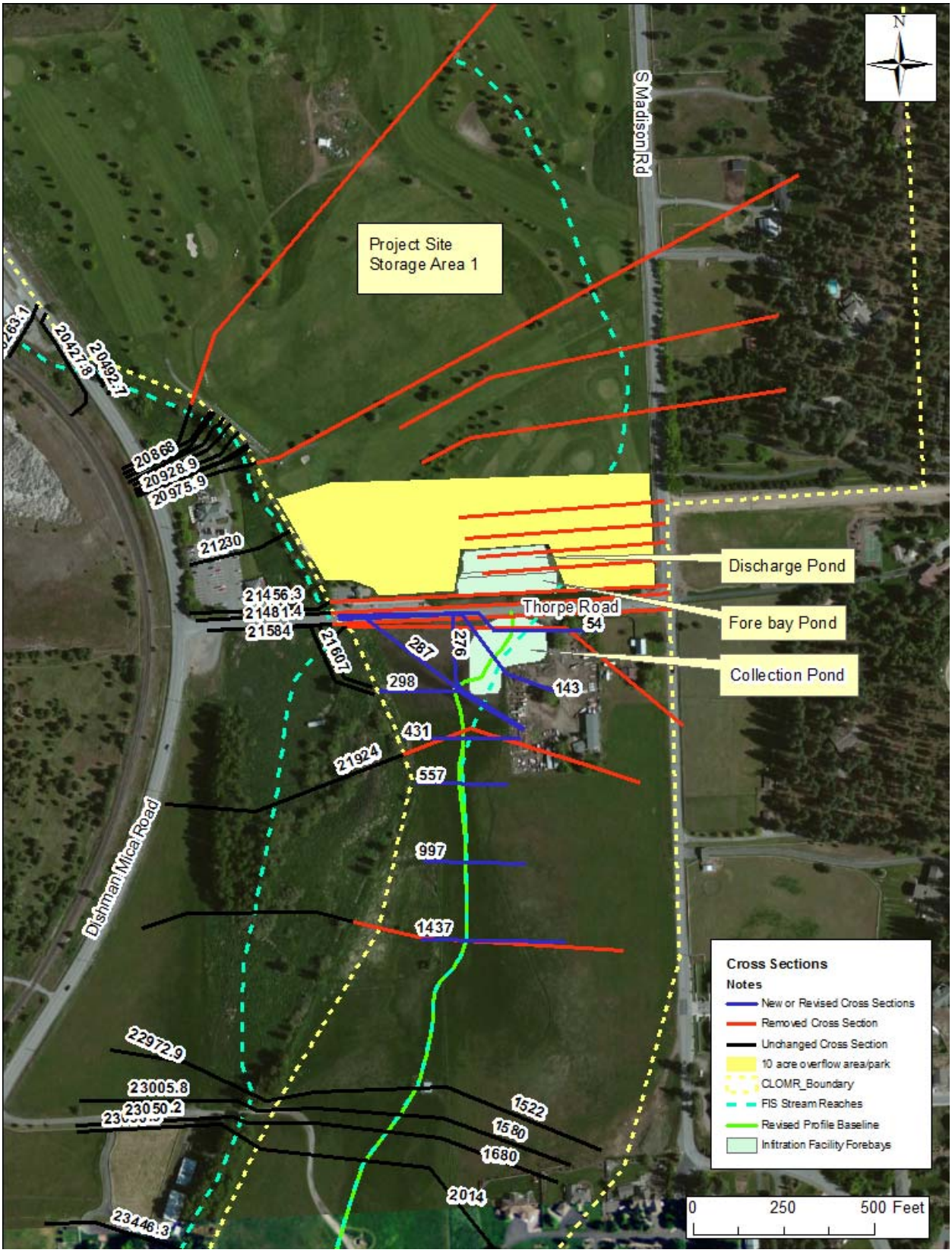


Figure 8. Layout of HEC-RAS Cross Sections for Chester Creek Golf Course Overflow

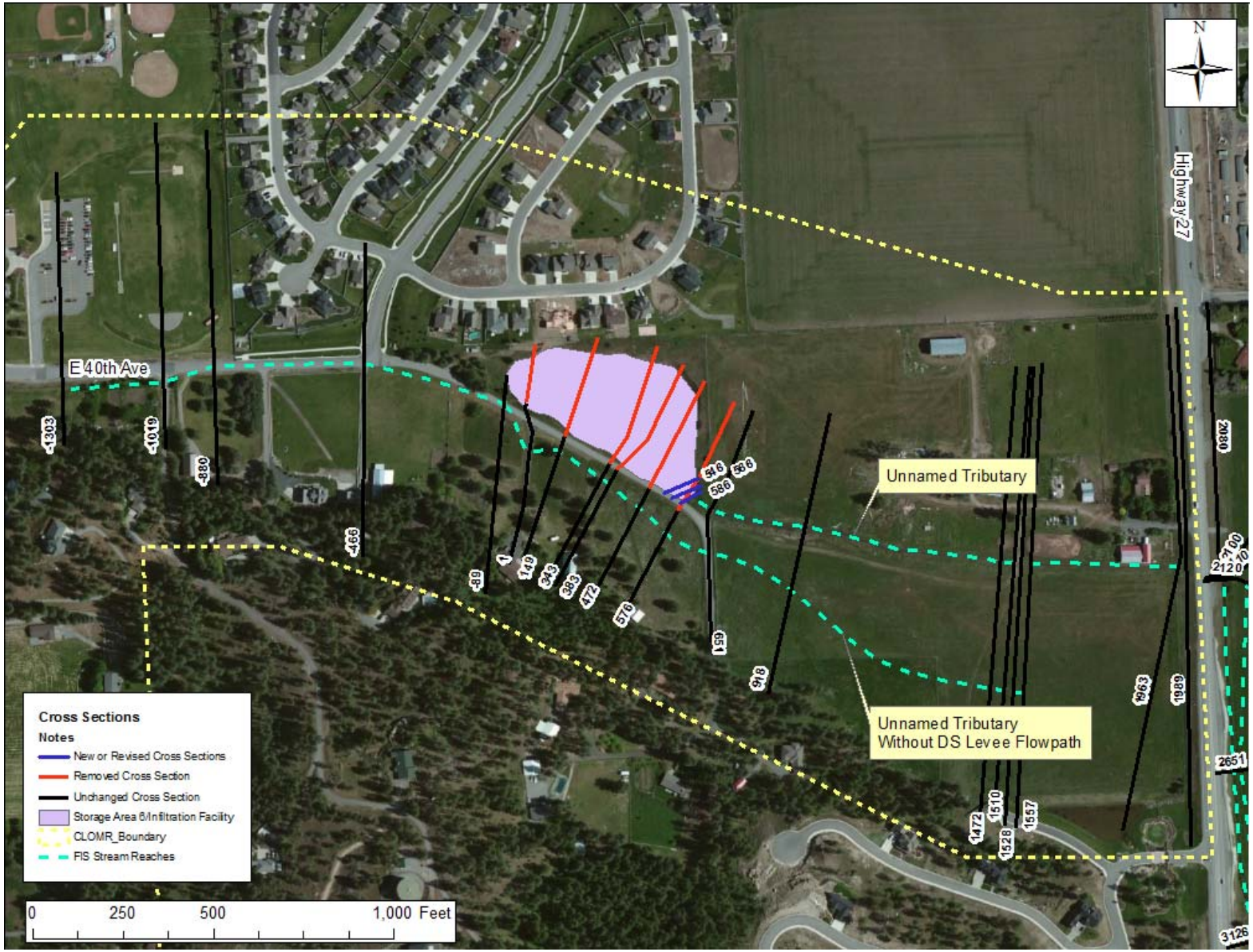


Figure 9. Layout of HEC-RAS Cross Sections for the Unnamed Tributary

# 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.

## 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 2 and Table 3. As shown in Table 2 and Table 3, 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 cross section B and C 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 B 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 B results in a slight calculated increase of 0.1 feet at cross section C.

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, 2003). HEC-RAS DEM model results are provided in Exhibit C, and an electronic version of the DEM model is included on the CD provided in Exhibit M.

Table 2. Comparison of FIS and DEM model results for Golf Course Overflow Reach

| XS Letter | Effective FIS WSE (ft) | | DEM WSE (ft) | | Difference (ft) | |
|---|---|---|---|---|---|---|
| | 1% Annual Chance Flood Event | Floodway Event | 1% Annual Chance Flood Event | Floodway Event | 1% Annual Chance Flood Event | Floodway Event |
| A | 2008.1 | -- | 2008.1 | 2009.1 | 0.0 | -- |
| B | 2008.1 | -- | 2007.8 | 2009.1 | -0.3 | -- |
| C | 2008.5 | -- | 2008.6 | 2009.1 | 0.1 | -- |
| D | 2008.9 | 2009.6 | 2008.9 | 2009.6 | 0.0 | 0.0 |
| E | 2009.1 | 2010.0 | 2009.1 | 2010.0 | 0.0 | 0.0 |
| F | 2009.3 | 2010.3 | 2009.3 | 2010.3 | 0.0 | 0.0 |
| G | 2013.3 | 2014.1 | 2013.3 | 2014.1 | 0.0 | 0.0 |
| H | 2013.3 | 2014.2 | 2013.3 | 2014.2 | 0.0 | 0.0 |
| I | 2013.5 | 2014.5 | 2013.5 | 2014.5 | 0.0 | 0.0 |
| J | 2014.8 | 2015.3 | 2014.8 | 2015.3 | 0.0 | 0.0 |
| K | 2015.4 | 2016.2 | 2015.4 | 2016.2 | 0.0 | 0.0 |
| L | 2015.7 | 2016.6 | 2015.7 | 2016.6 | 0.0 | 0.0 |
| M | 2018.1 | 2019.0 | 2018.1 | 2019.0 | 0.0 | 0.0 |
| N | 2023.0 | 2023.8 | 2023.0 | 2023.8 | 0.0 | 0.0 |

Table 3. Comparison of FIS and DEM model results for Unnamed Tributary

| XS Letter | Effective FIS WSE (ft) | | DEM WSE (ft) | | Difference (ft) | |
|---|---|---|---|---|---|---|
| | 1% Annual Chance Flood Event | Floodway Event | 1% Annual Chance Flood Event | Floodway Event | 1% Annual Chance Flood Event | Floodway Event |
| A | 2008.1 | 2009.1 | 2008.1 | 2009.1 | 0.0 | 0.0 |
| B | 2008.4 | 2009.1 | 2008.4 | 2009.1 | 0.0 | 0.0 |
| C | 2008.4 | 2009.1 | 2008.4 | 2009.1 | 0.0 | 0.0 |
| D | 2008.4 | 2009.1 | 2008.4 | 2009.1 | 0.0 | 0.0 |
| E | 2008.4 | 2009.1 | 2008.4 | 2009.1 | 0.0 | 0.0 |
| F | 2009.7 | 2010.7 | 2009.7 | 2010.7 | 0.0 | 0.0 |
| G | 2009.7 | 2010.7 | 2009.7 | 2010.7 | 0.0 | 0.0 |
| H | 2009.7 | 2010.7 | 2009.7 | 2010.7 | 0.0 | 0.0 |
| I | 2009.7 | 2010.7 | 2009.7 | 2010.7 | 0.0 | 0.0 |
| J | 2009.7 | 2010.7 | 2009.7 | 2010.7 | 0.0 | 0.0 |
| K | 2010.0 | 2010.7 | 2010.0 | 2010.7 | 0.0 | 0.0 |
| L | 2011.0 | 2011.1 | 2011.0 | 2011.1 | 0.0 | 0.0 |
| M | 2011.5 | 2011.6 | 2011.5 | 2011.6 | 0.0 | 0.0 |
| N | 2012.8 | 2012.8 | 2012.8 | 2012.7 | 0.0 | -0.1 |
| O | 2014.3 | 2014.3 | 2014.3 | 2014.3 | 0.0 | 0.0 |
| P | 2014.3 | 2014.3 | 2014.3 | 2014.3 | 0.0 | 0.0 |
| Q | 2019.7 | 2019.7 | 2019.7 | 2019.6 | 0.0 | -0.1 |
| R | 2020.8 | 2020.8 | 2020.8 | 2020.8 | 0.0 | 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, 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. For the Unnamed Tributary the topography and 'n' values within the effective models are considered to be reasonable and representative of site conditions; therefore, the CEM model is identical to the DEM and no changes were made. For the Golf Course Overflow, two cross sections were added to the model. It was determined that one additional cross section (RS 21498) was needed to better define the influence of Thorpe Road and a second cross section (RS 21983) was needed approximately 550 feet upstream of Thorpe Road to better define local topography. 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 4 and Table 5.

Table 4. DEM and CEM model results for the Golf Course Overflow

| RAS Station | FEMA Station | XS Letter | 1% Annual Chance Flood Event | | | Floodway | | |
|---|---|---|---|---|---|---|---|---|
| | | | DEM | CEM | Difference | DEM | CEM | Difference |
| 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 | 2013.25 | 0.00 | 2014.10 | 2014.1 | 0.00 |
| 21498* | n/a | n/a | n/a | 2013.25 | n/a | n/a | 2014.1 | n/a |
| 21515 | -- | -- | 2013.25 | 2013.26 | 0.01 | 2014.11 | 2014.13 | 0.02 |
| 21548 | 1800 | G | 2013.26 | 2013.26 | 0.00 | 2014.13 | 2014.15 | 0.02 |
| 21924 | 2123 | H | 2013.27 | 2013.27 | 0.00 | 2014.23 | 2014.23 | 0.00 |
| 21983* | n/a | n/a | n/a | 2013.32 | n/a | n/a | 2014.27 | n/a |
| 22423 | 2704 | I | 2013.51 | 2013.64 | 0.13 | 2014.48 | 2014.48 | 0.00 |
| 22972 | 3144 | J | 2014.82 | 2014.60 | -0.22 | 2015.26 | 2015.26 | 0.00 |
| 23005 | -- | -- | 2015.25 | 2015.28 | 0.03 | 2016.10 | 2016.1 | 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 |

* New cross section

Table 5. DEM and CEM model results for the Unnamed Tributary

| RAS Station | FEMA Station | XS Letter | 1% Annual Chance Flood Event | | | Floodway | | |
|---|---|---|---|---|---|---|---|---|
| | | | DEM | CEM | Difference | DEM | CEM | Difference |
| -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 | 2010.95 | 0.00 | 2011.07 | 2011.07 | 0.00 |
| 918 | 2,295 | M | 2011.45 | 2011.45 | 0.00 | 2011.63 | 2011.63 | 0.00 |
| 1472 | 2,849 | N | 2012.83 | 2012.83 | 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 | -- | -- | 2020.61 | 2020.61 | 0.00 | 2020.61 | 2020.61 | 0.00 |
| 2100 | 3,485 | R | 2020.83 | 2020.83 | 0.00 | 2020.83 | 2020.83 | 0.00 |

**Existing or 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 with the floodplain are the addition of three, 18" 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 6 and

Table 7.

Table 6. CEM and ECM model results for the Golf Course Overflow

| RAS Station | FEMA Station | XS Letter | 1% Annual Chance Flood Event | | | Floodway | | |
|---|---|---|---|---|---|---|---|---|
| | | | CEM | ECM | Difference | CEM | ECM | Difference |
| 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 | 2008.6 | 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 | -- | | 2013.14 | 2013.14 | 0.00 | 2013.79 | 2013.79 | 0.00 |
| 21481 | -- | | 2013.25 | 2013.25 | 0.00 | 2014.1 | 2014.09 | -0.01 |
| 21498 [1] | n/a | n/a | 2013.25 | n/a | n/a | 2014.1 | n/a | n/a |
| 21515 | -- | | 2013.26 | 2013.25 | -0.01 | 2014.13 | 2014.09 | -0.04 |
| 21548 | 1800 | G | 2013.26 | 2013.25 | -0.01 | 2014.15 | 2014.1 | -0.05 |
| 21924 | 2123 | H | 2013.27 | 2013.27 | 0.00 | 2014.23 | 2014.18 | -0.05 |
| 21983* | n/a | n/a | 2013.32 | 2013.31 | n/a | 2014.27 | 2014.2 | n/a |
| 22423 | 2704 | I | 2013.64 | 2013.64 | 0.00 | 2014.48 | 2014.24 | -0.24 |
| 22972 | 3144 | J | 2014.60 | 2014.6 | 0.00 | 2015.26 | 2015.26 | 0.00 |
| 23005 | -- | | 2015.28 | 2015.28 | 0.00 | 2016.1 | 2016.1 | 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 | 2018.1 | 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

* New cross section

Table 7. CEM and ECM model results for the Unnamed Tributary

| RAS Station | FEMA Station | XS Letter | 1% Annual Chance Flood Event | | | Floodway | | |
|---|---|---|---|---|---|---|---|---|
| | | | CEM | ECM | Difference | CEM | ECM | Difference |
| -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 | 2010.95 | 0.00 | 2011.07 | 2011.07 | 0.00 |
| 918 | 2,295 | M | 2011.45 | 2011.45 | 0.00 | 2011.63 | 2011.63 | 0.00 |
| 1472 | 2,849 | N | 2012.83 | 2012.83 | 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 | | | 2020.61 | 2020.61 | 0.00 | 2020.61 | 2020.61 | 0.00 |
| 2100 | 3,485 | R | 2020.83 | 2020.83 | 0.00 | 2020.83 | 2020.83 | 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). 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 20779 through 21481. Upstream of Thorpe Road, Effective cross sections G (RA 1800) and H (RS 2120) were removed (corresponds with RAS stations 21515 through 21924).

- Ten new cross sections were added to the model to accurately reflect the proposed infiltration facility and new hydraulic conditions caused by reducing the effective BFEs and slight redirection of flow lines. Seven cross sections are located upstream of Thorpe Road (XS 0 through 557, based on revised stationing), and three downstream (XS -160 through -80). Note that these cross sections could not be added to the Existing Conditions model as the proposed facilities will alter flow dynamics in the floodplain. Accordingly, the Proposed Conditions cross section alignments in the vicinity of the project cannot appropriately represent existing conditions.

- The model geometry was modified to represent the proposed increased height of Thorpe Road (raised approximately 1 foot at low point)

- The model geometry was modified to include the replacement of existing culverts under Thorpe Road with 36" CMPs

- Downstream boundary conditions were assigned to known water surface elevations based on the output from the Hydro flow modeling of the infiltration facility conducted by WCE (WCE, 2015). The known water surface elevations used are the peak water surface elevations for the distribution pond, as reported by WCE.

- Floodway stations were maintained at a similar width to the effective FIS, however, the width was increased for cross sections 0 through 298 such that the floodway encompasses the entire collection pond of the infiltration facility.

Unnamed Tributary:

For the with levee condition, the model was truncated at SA6. Three cross sections were added at the downstream end of the model to define the rock spillway (RS 546, 566, 586). For the without DS levee condition, no cross section or geometry changes were made as all flow is assumed to leave the perched channel and flow to the low ground of the left overbank; therefore, changes made to the main channel in the vicinity of SA6 do not impact results. The without levee model is only used for the 0.2% annual chance flood. Since the model flows and geometry remain unchanged, the results for the 0.2% flood elevations only change at near the downstream terminus of the model where the flow enters SA1. At this location, the fixed elevation 0.2% boundary condition in the model (based on HSPF model output) was changed from a fixed elevation of 2008.64 to 2007.19 to reflect the proposed conditions in which 0.2% water surface elevations from

flooding in SA1 are reduced by the interception of the Golf Course Overflow Reach.

Post-Project Conditions model output is provided in Exhibit F, and an electronic version of this model is included on the CD provided in Exhibit K.

The Proposed Conditions model results for the 1% annual chance flood event and the floodway are summarized in Table 8 and Table 9. A comparison of the floodplain widths as determined from the CEM and the Post-Project models is provided in Table 10, Table 11 and Table 12. The proposed infiltration facilities and levee certification would have the following impacts:

- SA1 would be completely removed from the 1% annual chance floodplain. This includes an area of approximately 94 acres. BFEs upstream of Thorpe Road would be reduced by as much as 3 feet.

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

- A large portion of the 1% annual chance floodplain (24 acres) will be removed from the Unnamed Tributary reach. This includes all of the left overbank flowpath (without DS levee condition) as the floodplain downstream of SA6.

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

- Along the unnamed tributary a slight increase in water surface elevations (0.01 to 0.2 feet) will occur at four cross sections between SA6 and Highway 27.

Table 8. CEM and ECM 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 | PCM | Difference | ECM | PCM | Difference |
| 20779 | 0 | A | -- | -- | -- | 2008.05 | -- | -- | 2009.05 | -- | -- |
| 21013 | 773 | B | -- | -- | -- | 2007.79 | -- | -- | 2009.05 | -- | -- |
| 21128 | 961 | C | -- | -- | -- | 2008.6 | -- | -- | 2009.05 | -- | -- |
| 21229 | 1145 | D | -- | -- | -- | 2008.87 | -- | -- | 2009.59 | -- | -- |
| 21385 | 1425 | E | -- | -- | -- | 2009.12 | -- | -- | 2010.03 | -- | -- |
| 21409 | -- | -- | -- | -- | -- | 2009.17 | -- | -- | 2010.12 | -- | -- |
| 21431 | -- | -- | -- | -- | -- | 2009.23 | -- | -- | 2010.23 | -- | -- |
| 21445 | 1600 | F | -- | -- | -- | 2009.31 | -- | -- | 2010.29 | -- | -- |
| 21456 | -- | -- | -- | -- | -- | 2013.14 | -- | -- | 2013.79 | -- | -- |
| 21481 | -- | -- | -- | -- | -- | 2013.25 | -- | -- | 2014.09 | -- | -- |
| 21515 | -- | -- | -- | -- | -- | 2013.25 | -- | -- | 2014.09 | -- | -- |
| -- | -- | -- | -160 | -- | -- | -- | 2007.81 | -- | -- | 2007.81 | -- |
| -- | -- | -- | -105 | -- | -- | -- | 2009.96 | -- | -- | 2009.96 | -- |
| -- | -- | -- | -80 | -- | -- | -- | 2009.95 | -- | -- | 2009.95 | -- |
| 21548 | 1800 | G | 54 | 54 | A | 2013.25 | 2010.27 | -2.98 | 2014.1 | 2010.27 | -3.83 |
| -- | -- | -- | 143 | 143 | B | -- | 2010.27 | -- | -- | 2010.27 | -- |
| -- | -- | -- | 276 | 276 | C | -- | 2012.06 | -- | -- | 2012.1 | -- |
| -- | -- | -- | 287 | 287 | D | -- | 2012.28 | -- | -- | 2012.45 | -- |
| -- | -- | -- | 298 | 298 | E | -- | 2012.35 | -- | -- | 2012.53 | -- |
| 21924 | 2123 | H | 431 | 431 | F | 2013.27 | 2012.85 | -0.42 | 2014.18 | 2013.03 | -1.15 |
| 21983 | -- | -- | 557 | 557 | G | 2013.31 | 2013.09 | -0.22 | 2014.2 | 2013.52 | -0.68 |
| 22423 | 2704 | I | 997 | 997 | H | 2013.64 | 2013.62 | -0.02 | 2014.24 | 2014.22 | -0.02 |
| 22972 | 3144 | J | 1437 | 1437 | I | 2014.6 | 2014.6 | 0.00 | 2015.26 | 2015.26 | 0.00 |
| 23005 | -- | -- | 1522 | -- | -- | 2015.28 | 2015.28 | 0.00 | 2016.1 | 2016.1 | 0.00 |
| 23050 | 3287 | K | 1580 | 1580 | J | 2015.39 | 2015.39 | 0.00 | 2016.21 | 2016.21 | 0.00 |
| 23090 | 3387 | L | 1680 | 1680 | K | 2015.65 | 2015.65 | 0.00 | 2016.61 | 2016.61 | 0.00 |
| 23446 | 3721 | M | 2014 | 2014 | L | 2018.1 | 2018.1 | 0.00 | 2019.02 | 2019.02 | 0.00 |
| 23887 | 4318 | N | 2611 | 2611 | M | 2022.99 | 2022.99 | 0.00 | 2023.79 | 2023.79 | 0.00 |
| 24430 | -- | -- | 3121 | -- | -- | 2029.56 | 2029.56 | 0.00 | 2029.72 | 2029.72 | 0.00 |

Table 9. CEM and ECM model results for the Unnamed Tributary

| Effective | | | Revised | | | 1% Annual Chance Flood Event | | | Floodway | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RAS Station | FEMA Station | XS Letter | RAS Station | FEMA Station | XS Letter | ECM | PCM | Difference | ECM | PCM | Difference |
| -1303 | 0 | A | -1303 | 0 | A | 2008.05 | -- | -- | 2009.05 | -- | -- |
| -1019 | 283 | B | -1019 | 283 | B | 2008.36 | -- | -- | 2009.05 | -- | -- |
| -880 | 422 | C | -880 | 422 | C | 2008.42 | -- | -- | 2009.05 | -- | -- |
| -466 | 836 | D | -466 | 836 | D | 2008.42 | -- | -- | 2009.05 | -- | -- |
| -89 | 910 | E | -89 | 910 | E | 2008.42 | -- | -- | 2009.05 | -- | -- |
| 1 | 1,378 | F | 1 | 1,378 | F | 2009.70 | -- | -- | 2010.70 | -- | -- |
| 149 | 1,525 | G | 149 | 1,525 | G | 2009.70 | -- | -- | 2010.70 | -- | -- |
| 343 | 1,720 | H | 343 | 1,720 | H | 2009.70 | -- | -- | 2010.70 | -- | -- |
| 383 | 1,760 | I | 383 | 1,760 | I | 2009.70 | -- | -- | 2010.70 | -- | -- |
| 472 | 1,849 | J | 472 | 1,849 | J | 2009.70 | -- | -- | 2010.70 | -- | -- |
| -- | -- | -- | 546 [1] | -- | -- | -- | 1991.10 | -- | -- | 1991.10 | -- |
| -- | -- | -- | 566 [1] | -- | -- | -- | 2000.35 | -- | -- | 2000.35 | -- |
| 576 | 1,952 | K | 586 [1] | 1,952 | K | 2009.95 | 2008.85 | -1.10 | 2010.67 | 2008.85 | -1.82 |
| 651 | 2,028 | L | 651 | 2,028 | L | 2010.95 | 2010.97 | 0.02 | 2011.07 | 2010.97 | -0.10 |
| 918 | 2,295 | M | 918 | 2,295 | M | 2011.45 | 2011.65 | 0.20 | 2011.63 | 2011.65 | 0.02 |
| 1472 | 2,849 | N | 1472 | 2,849 | N | 2012.83 | 2012.71 | -0.12 | 2012.71 | 2012.71 | 0.00 |
| 1510 | -- | -- | 1510 | -- | -- | 2013.26 | 2013.26 | 0.00 | 2013.26 | 2013.26 | 0.00 |
| 1528 | 2,905 | O | 1528 | 2,905 | O | 2014.30 | 2014.31 | 0.01 | 2014.31 | 2014.31 | 0.00 |
| 1557 | 2,933 | P | 1557 | 2,933 | P | 2014.32 | 2014.32 | 0.00 | 2014.32 | 2014.32 | 0.00 |
| 1963 | 3,339 | Q | 1963 | 3,339 | Q | 2019.66 | 2019.81 | 0.15 | 2019.63 | 2019.84 | 0.21 |
| 1989 | -- | -- | 1989 | -- | -- | 2020.06 | 2020.01 | -0.05 | 2020.08 | 2020.07 | -0.01 |
| 2080 | -- | -- | 2080 | -- | -- | 2020.61 | 2020.61 | 0.00 | 2020.61 | 2020.61 | 0.00 |
| 2100 | 3,485 | R | 2100 | 3,485 | R | 2020.83 | 2020.83 | 0.00 | 2020.83 | 2020.83 | 0.00 |

1 New cross section

Table 10. 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 | CEM | PCM | Difference | CEM | PCM | Difference |
| 20779 | 0 | A | -- | -- | -- | 1985 | 0 | -1985 | 1344 | -- | -1344 |
| 21013 | 773 | B | -- | -- | -- | 395 | 0 | -395 | 173 | -- | -173 |
| 21128 | 961 | C | -- | -- | -- | 443 | 0 | -443 | 25 | -- | -25 |
| 21229 | 1145 | D | -- | -- | -- | 546 | 0 | -546 | 35 | -- | -35 |
| 21385 | 1425 | E | -- | -- | -- | 286 | 0 | -286 | 30 | -- | -30 |
| 21409 | -- | -- | -- | -- | -- | 284 | 0 | -284 | 25 | -- | -25 |
| 21431 | -- | -- | -- | -- | -- | 223 | 235 [1] | 12 | 25 | -- | -25 |
| 21445 | 1600 | F | -- | -- | -- | 143 | 235 [1] | 16 | 20 | -- | -20 |
| 21456 | -- | -- | -- | -- | -- | 115 | 240 [1] | -9 | 30 | -- | -30 |
| 21481 | -- | -- | -- | -- | -- | 634 | 0 | -634 | 37 | -- | -37 |
| 21498 | -- | -- | -- | -- | -- | 484 | n/a | n/a | 40 | n/a | n/a |
| 21515 | -- | -- | -- | -- | -- | 623 | 0 | -623 | 44 | -- | -44 |
| -- | -- | -- | -160 | -- | -- | -- | 221 | -- | -- | -- | -- |
| -- | -- | -- | -105 | -- | -- | -- | 271 | -- | -- | -- | -- |
| -- | -- | -- | -80 | -- | -- | -- | 271 | -- | -- | -- | -- |
| 21548 | 1800 | G | 54 | 54 | A | 600 | 164 | -436 | 45 | 163.6 [2] | 118 |
| -- | -- | -- | 143 | 143 | B | -- | 113 | -- | -- | 113 | -- |
| -- | -- | -- | 276 | 276 | C | -- | 126 | -- | -- | 74 | -- |
| -- | -- | -- | 287 | 287 | D | -- | 285 | -- | -- | 90 | -- |
| -- | -- | -- | 298 | 298 | E | -- | 197 | -- | -- | 80 | -- |
| 21924 | 2123 | H | 431 | 431 | F | 260 | 207 | -53 | 43 | 51 | 8 |
| -- | -- | -- | 557 | 557 | G | -- | 130 | -- | -- | 26 | -- |
| 22423 | 2704 | I | 997 | 997 | H | 203 | 202 | -1 | 40 | 40 | 0 |
| 22972 | 3144 | J | 1437 | 1437 | I | 54 | 54 | 0 | 14 | 14 | 0 |
| 23005 | -- | -- | 1522 | -- | -- | 135 | 135 | 0 | 27 | 27 | 0 |
| 23050 | 3287 | K | 1580 | 1580 | J | 152 | 152 | 0 | 22 | 22 | 0 |
| 23090 | 3387 | L | 1680 | 1680 | K | 155 | 155 | 0 | 20 | 20 | 0 |
| 23446 | 3721 | M | 2014 | 2014 | L | 208 | 208 | 0 | 20 | 20 | 0 |
| 23887 | 4318 | N | 2611 | 2611 | M | 160 | 160 | 0 | 20 | 20 | 0 |
| 24430 | -- | -- | 3121 | -- | -- | 37 | 37 | 0 | 20 | 20 | 0 |

1 width of infiltration facility pond

Table 11. Change in Top Width for Unnamed Tributary

| Effective | | | Revised | | | Top Width Base Flood (ft) | | | Top Width Floodway (ft) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RAS Station | FEMA Station | XS Letter | RAS Station | FEMA Station | XS Letter | CEM | PCM | Difference | CEM | PCM | Difference |
| -1303 | 0 | A | -1303 | 0 | A | 104 | 0 | -104.00 | 31 | 0 | -31.00 |
| -1019 | 283 | B | -1019 | 283 | B | 48 | 0 | -48.00 | 21 | 0 | -21.00 |
| -880 | 422 | C | -880 | 422 | C | 362 | 0 | -362.00 | 40 | 0 | -40.00 |
| -466 | 836 | D | -466 | 836 | D | 389 | 0 | -389.00 | 46 | 0 | -46.00 |
| -89 | 910 | E | -89 | 910 | E | 346 | 0 | -346.00 | 40 | 0 | -40.00 |
| 1 | 1,378 | F | 1 | 1,378 | F | 102 | -- [2] | -- | n/a [1] | n/a [1] | -- |
| 149 | 1,525 | G | 149 | 1,525 | G | 176 | -- [2] | -- | n/a [1] | n/a [1] | -- |
| 343 | 1,720 | H | 343 | 1,720 | H | 267 | -- [2] | -- | n/a [1] | n/a [1] | -- |
| 383 | 1,760 | I | 383 | 1,760 | I | 280 | -- [2] | -- | n/a [1] | n/a [1] | -- |
| 472 | 1,849 | J | 472 | 1,849 | J | 193 | 0 | -193.00 | 9 | 0 | -9.00 |
| -- | -- | -- | 546 | -- | -- | -- | 13 | -- | -- | 13 | -- |
| -- | -- | -- | 566 | -- | -- | -- | 10 | -- | -- | 10 | -- |
| 576 | 1,952 | K | 586 | 1,952 | K | 6 | 10 | 4 | 5 | 10 | 5 |
| 651 | 2,028 | L | 651 | 2,028 | L | 54 | 55 | 1 | 16 | 15 | -1 |
| 918 | 2,295 | M | 918 | 2,295 | M | 11 | 45 | 34 | 8 | 8 | 0 |
| 1472 | 2,849 | N | 1472 | 2,849 | N | 5 | 5 | 0 | 5 | 5 | 0 |
| 1510 | -- | -- | 1510 | -- | -- | 6 | 6 | 0 | 6 | 6 | 0 |
| 1528 | 2,905 | O | 1528 | 2,905 | O | 10 | 10 | 0 | 10 | 10 | 0 |
| 1557 | 2,933 | P | 1557 | 2,933 | P | 8 | 8 | 0 | 8 | 8 | 0 |
| 1963 | 3,339 | Q | 1963 | 3,339 | Q | 15 | 20 | 5 | 9 | 9 | 0 |
| 1989 | -- | -- | 1989 | -- | -- | 48 | 41 | -7 | 9 | 9 | 0 |
| 2080 | -- | -- | 2080 | -- | -- | 15 | 15 | 0 | 15 | 15 | 0 |
| 2100 | 3,485 | R | 2100 | 3,485 | R | 15 | 15 | 0 | 15 | 15 | 0 |

1 No floodway in SA6 in effective FIS

Table 12. Change in Top Width for Unnamed Tributary without DS levee (left overbank flowpath)

| Effective | | | Revised | | | Top Width Base Flood (ft) | | | Top Width Floodway (ft) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RAS Station | FEMA Station | XS Letter | RAS Station | FEMA Station | XS Letter | CEM | PCM | Difference | CEM | PCM | Difference |
| -1303 | 0 | A | -1303 | 0 | A | 104 | 0 | -104 | 31 | 0 | -31 |
| -1019 | 283 | B | -1019 | 283 | B | 72 | 0 | -72 | 21 | 0 | -21 |
| -880 | 422 | C | -880 | 422 | C | 368 | 0 | -368 | 40 | 0 | -40 |
| -466 | 836 | D | -466 | 836 | D | 403 | 0 | -403 | 46 | 0 | -46 |
| -89 | 910 | E | -89 | 910 | E | 388 | 0 | -388 | 40 | 0 | -40 |
| 1 | 1,378 | F | 1 | 1,378 | F | 113 | 0 | -113 | 15 | 0 | -15 |
| 149 | 1,525 | G | 149 | 1,525 | G | 270 | 0 | -270 | 15 | 0 | -15 |
| 343 | 1,720 | H | 343 | 1,720 | H | 282 | 0 | -282 | 15 | 0 | -15 |
| 383 | 1,760 | I | 383 | 1,760 | I | 215 | 0 | -215 | 15 | 0 | -15 |
| 472 | 1,849 | J | 472 | 1,849 | J | 215 | 0 | -215 | 15 | 0 | -15 |
| 576 | 1,952 | K | 586 | 1,952 | K | 155 | 0 | -155 | 15 | 0 | -15 |
| 651 | 2,028 | L | 651 | 2,028 | L | 96 | 0 | -96 | 15 | 0 | -15 |
| 918 | 2,295 | M | 918 | 2,295 | M | 231 | 0 | -231 | 15 | 0 | -15 |
| 1472 | 2,849 | N | 1472 | 2,849 | N | 68 | 0 | -68 | 15 | 0 | -15 |
| 1510 | -- | -- | 1510 | -- | -- | 129 | 0 | -129 | 15 | 0 | -15 |
| 1528 | 2,905 | O | 1528 | 2,905 | O | 119 | 0 | -119 | 3 | 0 | -3 |
| 1557 | 2,933 | P | 1557 | 2,933 | P | 140 | 0 | -140 | 15 | 0 | -15 |

## FLOODPLAIN MAPPING

An annotated FIRM showing existing and proposed floodplain mapping is provided in Exhibit H along with revised flood profiles and floodway data tables. The proposed floodplain mapping reflects the proposed infiltration facilities and levee certifications. In the effective FIS, the 0.2% annual chance floodplain within SA1 was based on model output for the Golf Course Overflow reach. Since the infiltration facility will be intercepting up to the 0.2% annual change flood, and since the D-M Road levee, and the golf course levee will not be certified for the 0.2% annual chance flood event the mapping for that flood in SA1 is based on projection of the water surface elevations from the riverward side of the levee. The downstream end of the Unnamed Tributary (mapping and profile) reflect this condition.

## CERTIFICATION FORMS

Completed FEMA certification forms are included in Exhibit A. Exhibit A contains Forms 1, 2 and 3. Supporting documentation that includes a copy of public notices and the Biological Opinion are provided in Exhibit L.

## 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 and FEMA. The revised hydraulic models and mapping products reflect the proposed certification of 2 levees, construction of one additional levee, and construction of two large infiltration and storage facilities. The results of the analysis indicate that with limited exceptions, the proposed development and will significantly reduce the floodplain extent and water surface elevations for both the base flood and floodway conditions within the extents of the CLOMR.

## REFERENCES

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