October 28, 2020
Preliminary Hydrologic & Hydraulic Assessment
Ostrea Solar Project, Yakima County Washington

Prepared for:

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Table 1: Table of Data Sources

Data Type	Data Source
Elevation Data	National Map Data Elevation Mapping – 1 arc second
Rainfall	NOAA Atlas 2 Rainfall Data, taken at the centroid of each basin
Soils Data	NRCS/SSURGO Soils Information
Flood Zones	FEMA Firm Panels and Shapefiles
Land Use	USDA Shapefiles

Introduction

On behalf of Ostrea Solar, LLC Sierra Overhead Analytics, Inc (SOA) has prepared this hydrology report (report) for the Ostrea Solar Project, located in Yakima County, Washington. This report summarizes the results of the hydrology study which was performed to assess peak flows and flood risk across the project site. A rainfall-runoff model was developed using HEC-HMS to determine the impacts from a 100-year recurrence interval storm event. A two-dimensional (2D) hydraulic model was developed for the 100-year storm using HEC-RAS rain on grid modeling to assess on-site depth and velocity during a large storm. Publicly available rainfall data, United States Department of Agriculture (USDA) SSURGO database soils data, land use mapping, and United States Geological Survey (USGS) digital elevation mapping (DEM) topographic data was used to delineate the watersheds and to approximate runoff volumes across the project area. The methods used in this report generally follow the guidelines of the National Resource Conservation Service (NRCS), and HEC documentation. Relevant excerpts are contained in **Appendix A.**

1. Site Description/Existing Conditions

The site is in Yakima County, approximately ten miles south of Desert Aire, Washington, is bounded to the south by State Route 24, and surrounded by, range land, or agricultural land. The approximate center point of the project is located at: 46.566667˚N, -120.134833˚W. The project site is primarily agricultural/range land that appears to be well kept and is oriented on a generally south-facing hillside. Multiple small channels are evident in satellite imagery and hydraulic modeling results. None of the man-made structures near the site appear to have a great effect on the hydraulics of the project site. The entirety of the project is located within a FEMA Zone X flood zone.

1.1. Pre-Development Drainage

The existing drainages are characterized by primarily agricultural/range land. The site model contains 11 sub-basins (9 on-site basins), which generally drain to the south or southwest. Channelized areas of flow are found on site as evidenced by modeled flow patterns and satellite imagery. The site is generally gradually sloping with some moderate to high velocity flow found in the channelized portions of the site. Little ponding of water is shown in the models beyond mapped ponding locations.

The site falls entirely in FEMA Zone X – outside of the 100-year floodplain.

1.2. Site Soils

NRCS soils mapping and land use shows on site soils ranging from A to D, representing well-draining to poorly draining soil and low to high runoff potential when saturated. The average curve number for the site is approximately 70, meaning that of the approximate 2.2 inches of water that falls on the site during the 100-year return period storm, 1.5 inches will be excess flow that will impact onsite and downstream structures. Within the site boundaries, erosion potential appears to be low to moderate based on computational modeling. A list of soils types has been included in Table 1. Soil Conservation Service area-weighted curve numbers ranged from 60-81, as shown in Appendix 2.

1.3. Topography

Due to the size of the basins affecting the construction location, SOA utilized National Map Data to create the model domain. The site has general southern exposure, with all basins draining to the south or southwest.

Table 2: Basin Soil Types

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
3	Bakeoven very cobbly silt loam, 0 to 30 percent slopes	83.1	5.30%
33	Esquatzel silt loam, 2 to 5 percent slopes	2.8	0.20%
35	Finley fine sandy loam, 0 to 5 percent slopes	32.1	2.10%
36	Finley cobbly fine sandy loam, 0 to 5 percent slopes	6	0.40%
58	Hezel loamy fine sand, 2 to 15 percent slopes	3.5	0.20%
65	Kiona stony silt loam, 15 to 45 percent slopes	93.5	6.00%
68	Lickskillet very stony silt loam, 5 to 45 percent slopes	10	0.60%
81	Mikkalo silt loam, 15 to 30 percent slopes	15.2	1.00%
83	Moxee silt loam, 2 to 15 percent slopes	559.1	35.70%
127	Scooteney cobbly silt loam, 0 to 5 percent slopes	17.8	1.10%
129	Selah silt loam, 5 to 8 percent slopes	30.8	2.00%
130	Selah silt loam, 8 to 15 percent slopes	80.7	5.20%
132	Shano silt loam, 2 to 5 percent slopes	75.9	4.80%
142	Starbuck silt loam, 2 to 15 percent slopes	30.2	1.90%
143	Starbuck-Rock outcrop complex, 0 to 45 percent slopes	59.5	3.80%
179	Warden silt loam, 8 to 15 percent slopes	10.1	0.60%
180	Warden silt loam, 15 to 30 percent slopes	12.3	0.80%
187	Willis silt loam, 2 to 5 percent slopes	56.6	3.60%
189	Willis silt loam, 8 to 15 percent slopes	383.7	24.50%
208	Kiona stony silt loam, 15 to 45 percent slopes	1.5	0.10%
209	Lickskillet very stony silt loam, 5 to 45 percent slopes	0.9	0.10%
214	Willis silt loam, 8 to 15 percent slopes	0.2	0.00%
215	Bakeoven very cobbly silt loam, 0 to 30 percent slopes	0.3	0.00%
Totals for Area of Interest		**1565.90**	100%

2. Methods

2.1. Computational Hydrologic Modeling

HEC-1 modeling software was used to calculate the rainfall-runoff hydrographs for the basins. Pre-construction and post-construction HEC-1 models were created and run for 100-year return period storm. It should be noted that upon final design the engineer of record shall establish that the selected BMP and other water quantity and quality measures adhere to the standards set forth by the governing AHJ. No specific requirements could be found for this area of Washington for the purpose of this model.

2.1.1. Basin Delineation

Basins impacting the site were delineated using TOPAZ software, ARCGIS basin delineation mapping, and National Map Data Publicly Available Data. For the purpose of one-dimensional hydrologic routing, nine basins were delineated across the site. Locations and boundaries of the basins are shown in Figure 4. Shapefiles of the basin outlines and 1D flow centerlines are available upon request.

2.1.2. Rainfall

Rainfall depth was determined at the centroid of each basin through NOAA ATLAS 2. Given the nature of the mapping, the entire site was modeled to receive 1.5" of rainfall in the 100-year 24-hour event. Rainfall for each basin was temporally distributed through use of the Type-II, 24-hour storm. The basins' main characteristics (e.g. area, curve numbers) are shown in **Table 2**. Full information about each basin is given in **Appendix B.**

Table 3: Basin Drainage Data

Basin	1B	2B	6B	7B	8B	9B	10B	12B	13B	14B
Area (mi^2)	**2.741**	**0.386**	**0.269**	**1.126**	**1.185**	**0.436**	**0.629**	**0.735**	**0.491**	2.62
Pre-CN	69.98	73.37	77.15	73.63	60.08	63.37	71.13	69.19	81.56	68.86

For this site, it is anticipated that the solar arrays will be spaced accordingly for evaluation as a pervious surface and that native vegetation will largely remain or be replanted at the end of construction. Therefore, an estimate for only gravel roads and concrete pads was considered for the post-construction impervious percentage for all basins. Further investigation of the final site layout should be undertaken before a final pervious/non-pervious areal estimate for the system is made.

2.1.3. Curve Numbers

Basin curve numbers for the existing condition were determined using SSURGO soils data and USDA land use data. Composite curve numbers were determined from percent areas of each soil type / land use combination, typical values for which are available in TR-55 **Appendix A**. The soil curve numbers used were estimated according to NRCS method as per TR-55. The pre-construction conditions assumed zero impervious area unless otherwise stated in the detailed curve number calculation, **Appendix B**. Post-construction curve numbers are discussed in the previous section. The current curve numbers are approximations, and will be verified by site geotechnical reports.

2.1.4. Time of Concentration

Lag time was calculated using the SCS Unit Hydrograph method, the equation for which is:

$$T_{lag} = \frac{L^{0.8}(S+1)^{0.7}}{1900\ (\%Slope)^{0.5}}$$

L is the longest drainage path in feet, S = (1000/CN)-10, CN is SCS curve number, and %Slope is the average slope of the watershed, determined through topographic analysis. Time of Concentration is determined by dividing Lag Time by 0.6.

2.1.5. Antecedent Moisture Condition

Antecedent Moisture condition (AMC) is defined by the USDA as the preceding relative moisture of the pervious surfaces prior to the rainfall event. The "Average" AMC-II condition was used for the site. This resulted in no modification to the curve numbers calculated in Section 4.1.3.

2.2. 2D Hydraulic Modeling

A 2D hydraulic model was developed for the 100-year storm event to model maximum depths and velocities across the site for the pre-construction scenario. The chosen modeling software was HEC-RAS. Grid cells of 40 feet by 40 feet were used for the model. Topography was interpolated to the grid cells based on the LiDAR data also used to delineate and route the one-dimensional flood waves on Section 4.1. An average Manning's n value of 0.1 was assigned to each open area / cropland grid cell to represent a mix of croplands and light brush. Heavily forested areas and channels were assigned a Manning's n value of 0.085 to represent vegetation-lined channels as was observed on site. The 100-year rainfall return event was temporally distributed using the Type II curve and was used as in input to the rain-on-grid HEC-RAS model.

The two-dimensional set of equations was solved using the diffuse wave method. Stability was maintained through variable timestepping dictated by maximal and minimal Courant numbers (0.25 and 0.95, respectively). The small cell size dictated a small timestep, on average around 3.5 seconds.

Only excess rainfall was modeled as contributing to overland flow. Initial abstraction was calculated by the following equation, where λ is a fixed initial abstraction parameter (0.2) and CN is the average Curve Number of the site, estimated at 70 for this site:

$$I_a = \lambda\left(\frac{1000}{CN} - 10\right) = 0.7\ inches\ of\ water$$

3. Discussion of Post Construction BMP

As previously stated, this model and its results generally assume that the site is maintained, post-construction, to pre-construction levels and types of vegetative cover. The model results also assume that only gravel roads and concrete pads will be added to the sub basins as impervious surfaces.

No infiltration basins have been modeled. Given the assumptions listed above, increase to surface runoff is minimal to moderate, and should be able to be remediated using vegetative cover or lined channels therefore maximizing buildable area on site.

Final design and infiltration parameters shall be the responsibility of the Civil EOR chosen for the project.

4. Results

4.1. Computational Hydrologic Modeling

The results of the hydrologic modeling are discussed below. Without knowledge of the post construction site layout, no assumptions were made about pre-construction versus post-construction one-dimensional runoff beyond a small increase to the impervious area percentage for each basin. Final volumetric flowrate difference calculations can be determined once a final layout is chosen and provided for hydraulic modeling purposes.

4.2. 2D Hydraulic Model Results

4.2.1. Pre-Construction (Existing Condition)

The 100-year rainfall return event was temporally distributed using the Type II curve and was used as in input to the rain-on-grid HEC-RAS model to obtain the maximum depths and velocities anticipated in the 100-year event. HEC-RAS output for maximum depth, velocity, and scour is shown on Figures 1-3. Figure 4 shows the impacting drainage basins.

Scour depth was calculated using the methods of Chapter 7 of the HEC 18 Scour Manual. K1, K2, and K3 were calculated to be 1.1, 1.3, and 1.1 respectively, and a box pile of dimensions a=1/2′ and L=1/3′ were used. For simplicity, the angle of attack was assumed to be zero for all piles. The proper excerpt pages are included in Appendix B.

Channelized flow is apparent on site in natural flow concentration areas. Flow depths within these areas appear to reach just over 13 feet in the deepest part of the channels. Overland flow is negligible as enough channels exist on site to adequately drain most overland flow before it can pool. No ponding areas are visible within the site, nor is evidence of ponding found in the publicly available aerial images. The site is banded along topographic lines with very shallow overland flow, which is an artifact of the elevation data and modeling method. This data was not smoothed as to not artificially affect the results. Tiff surfaces are available upon request

Site flow velocities follow a similar pattern to flow depth onsite. Channelized flow sees velocities as high as 6.5 feet per second, while overland flow is generally very low velocity. Scour depth does not exceed 2.0 feet and is limited to the naturally occurring channels. Generally, the soil matrix on site appears to be stable given the aerial images and model results, but further investigation in the form of a Geotechnical Site Investigation would be required before final determinations could be made. Overall, brushing, grading, and slope stabilization within the site may promote increased drainage, while minimizing site soil erosion. Offsite channels should be protected from scour if imperviousness is increased. SOA can run further 2D site models as grading plans are developed. Within the buildable area, flow velocity and erosion potential are not critical items of concern for this site. The site should remain stable under normal flow characteristics. Increased impervious areas can lead to further concentrated flow areas, and therefore a post-construction study should be undertaken before construction begins. Stabilization should be added to the pre-existing drainage structures in order to preserve their integrity.

Table 4 shows the anticipated increase in runoff due to PV installation. Results of the model run show an increase to effected basins, totaling approximately 2.7-acre feet, based on additional impervious area estimates. The methods used to determine this additional runoff volume rely on HEC-1 modeling of impervious area over the entire basin area. Once final grading plans are developed, individual onsite basins should be investigated for additional runoff volume due to additional impervious area. The developer and engineer of the project should account for this additional storage volume in their design.

Table 4: Basin Peak Flows and Volume Increases

Basin	Pre-construction Peak Q (cfs)	Post-construction Peak Q (cfs)	Percent Increase	Runoff Volume Difference (acre-ft)
1B	152.835	152.835	0.00%	0.0000
2B	49.55	49.57	0.05%	0.2340
6B	41.98	41.99	0.03%	0.1590
7B	104.28	104.33	0.05%	0.3550
8B	10.28	10.28	0.00%	0.1460
9B	8.51	8.54	0.36%	0.4330
10B	45.21	45.24	0.06%	0.2270
12B	35.94	35.97	0.08%	0.3350
13B	101.44	101.46	0.02%	0.3110
14B	92.34	92.49	0.16%	0.4850

Assumptions

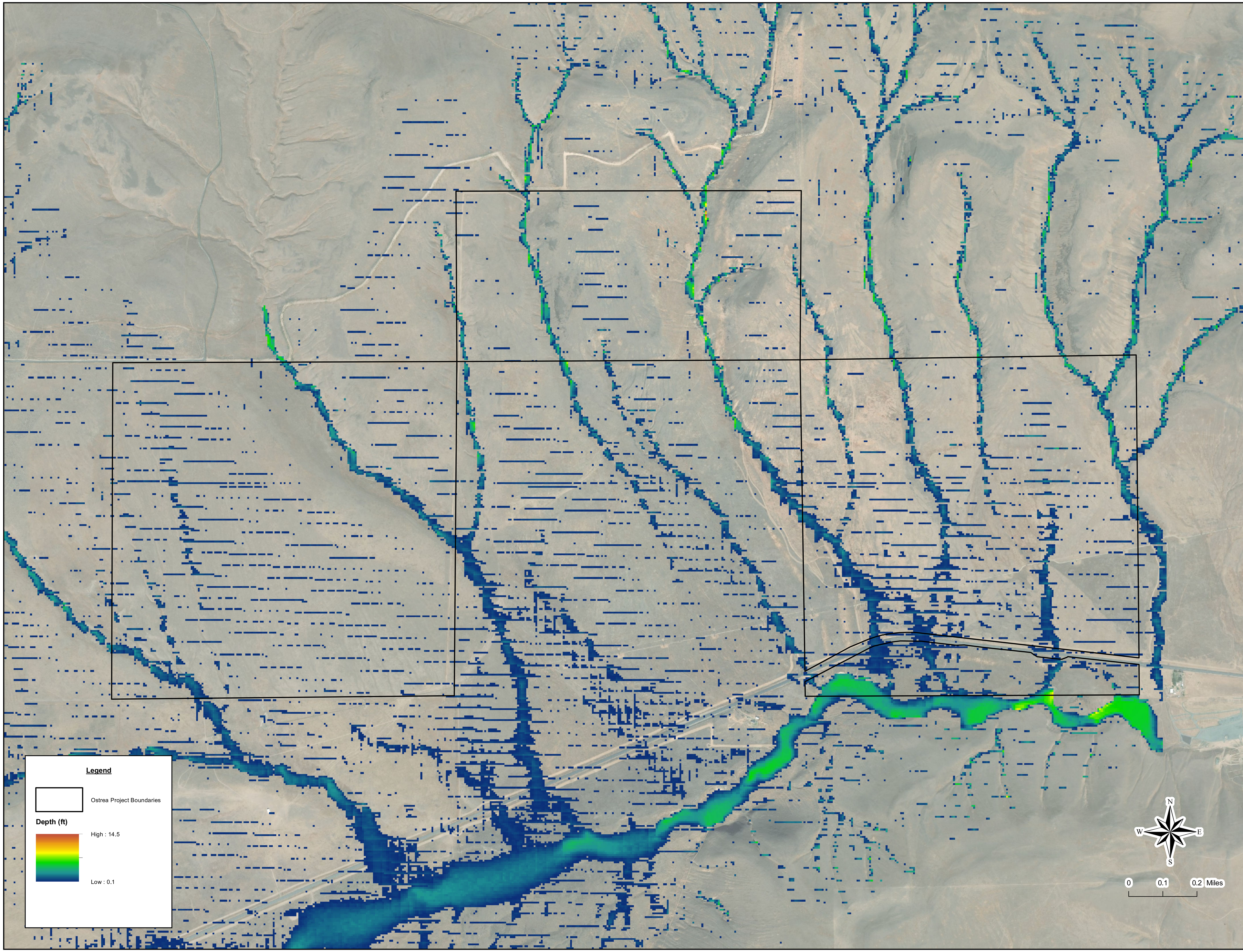
1. National Map data is adequate for 2D modeling purposes
2. The elevation data has been deemed appropriate for use in pre-construction 2D hydraulic modeling (HEC-RAS)
3. To the greatest extent practical this model represents ponding and flow conditions for excess rainfall occurring on the model surface. This model is an approximation of real-life flow conditions but is limited in its accuracy by the type and accuracy of its inputs. If future calibration data is gathered, the model can be rerun using the calibration data as inputs to check the viability and accuracy of the model.

SIERRA OVERHEAD ANALYTICS

FIGURES

Ostrea, LLC.

Sierra Overhead Analytics, Inc.



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REV #	DESCRIPTION	DATE

PROJECT NAME: Ostrea Solar, WA

PROJECT ADDRESS: 46.539° lat, -119.962° long.

SEAL:

DATE: 2020-10-20

PROJECT #: 2020-CCR-9

DRAWN BY: OTR

CHECKED BY: DRG

SHEET NAME: 100-Year 24-Hour Event Maximum Depth

SHEET NUMBER: Figure 1

REV #:

Coordinate System: NAD 1983 2011 StatePlane Washington South FIPS 4602 Ft US   Basemap Source: ESRI   Land Ownership and PLSS Source: BLM   SEZ Source: Argonne National Laboratory

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REV #	DESCRIPTION	DATE

PROJECT NAME:
Ostrea Solar, WA

PROJECT ADDRESS:
46.539˚ lat, -119.962˚ long.

SEAL:

DATE:
2020-10-20

PROJECT #:
2020-CCR-9

DRAWN BY:
OTR

CHECKED BY:
DRG

SHEET NAME:
100-Year 24-Hour Event Maximum Velocity

SHEET NUMBER:
Figure 2

REV #:

Coordinate System: NAD 1983 2011 StatePlane Washington South FIPS 4602 Ft US   Basemap Source: ESRI   Land Ownership and PLSS Source: BLM   SEZ Source: Argonne National Laboratory

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REV #	DESCRIPTION	DATE

PROJECT NAME:
Ostrea Solar, WA

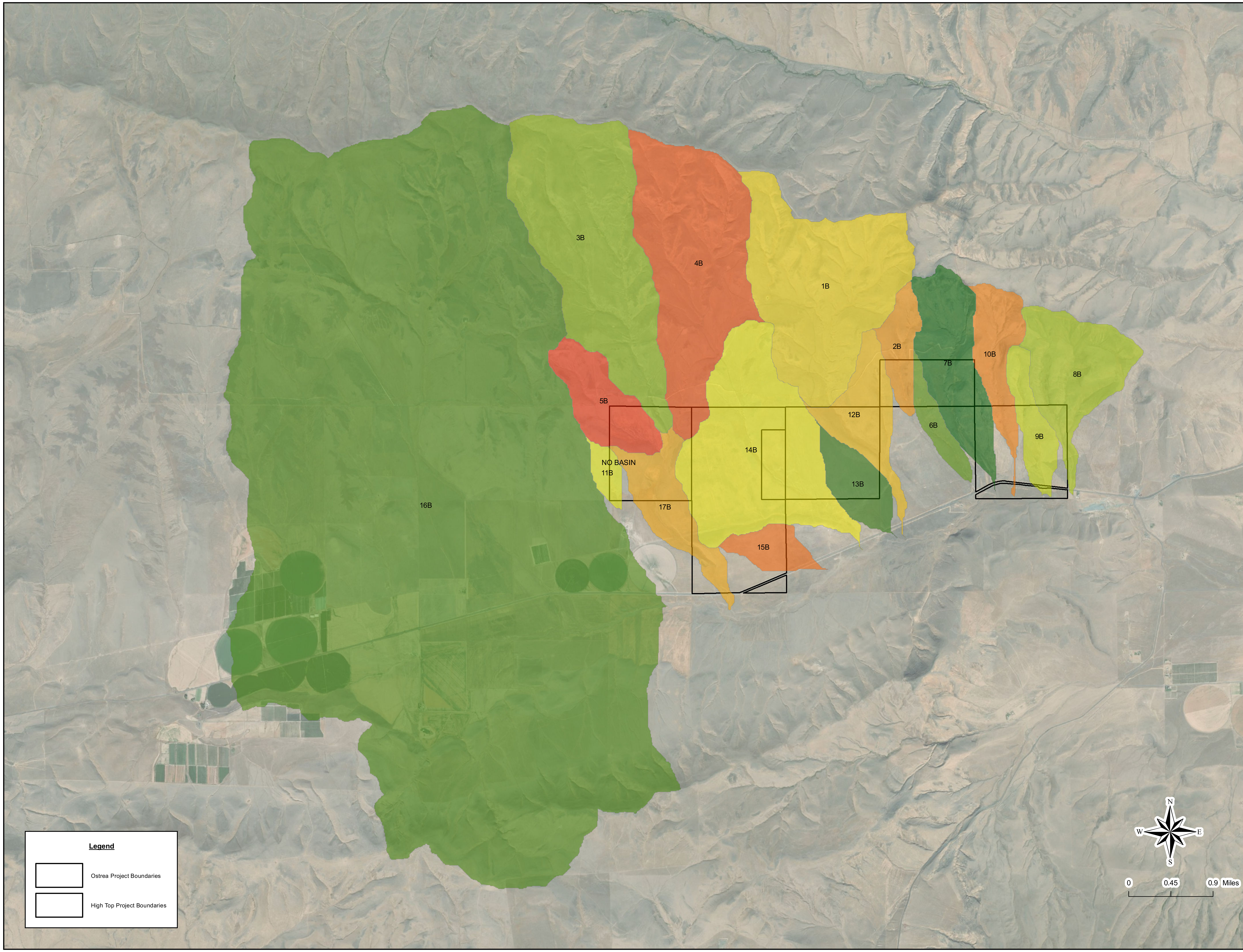
PROJECT ADDRESS:
46.539˚ lat, -119.962˚ long.

SEAL:	DATE: 2020-10-20
	PROJECT #: 2020-CCR-9
	DRAWN BY: OTR
	CHECKED BY: DRG

SHEET NAME:
100-Year 24-Hour Event Maximum Scour Depth

SHEET NUMBER:	REV #:
Figure 3	

Coordinate System: NAD 1983 2011 StatePlane Washington South FIPS 4602 Ft US   Basemap Source: ESRI   Land Ownership and PLSS Source: BLM   SEZ Source: Argonne National Laboratory



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REV #	DESCRIPTION	DATE

PROJECT NAME:
High Top and Ostrea Solar, WA

PROJECT ADDRESS:
46.539˚ lat, -119.962˚ long.

SEAL:

DATE:
2020-10-20

PROJECT #:
2020-CCR-9

DRAWN BY:
OTR

CHECKED BY:
DRG

SHEET NAME:
Sub-Watershed Basins

SHEET NUMBER:
Figure 4

REV #:

Coordinate System: NAD 1983 2011 StatePlane Washington South FIPS 4602 Ft US Basemap Source: ESRI Land Ownership and PLSS Source: BLM SEZ Source: Argonne National Laboratory

APPENDIX A

Supporting Documentation

Soils Mapping

FEMA Panels

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2]	Hydrologic condition [3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

1 Average runoff condition, and I_a=0.2S
2 Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.
3 Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c Runoff curve numbers for other agricultural lands [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2/]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3/]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4/]	48	65	73
Woods—grass combination (orchard or tree farm). [5/]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6/]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4/]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.
2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.
3 *Poor*: <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.
4 Actual curve number is less than 30; use CN = 30 for runoff computations.
5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.
6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2d Runoff curve numbers for arid and semiarid rangelands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition [2]	A [3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

1 Average runoff condition, and I_a, = 0.2S. For range in humid regions, use table 2-2c.
2 Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.
3 Curve numbers for group A have been developed only for desert shrub.

Figure 2-3 Composite CN with connected impervious area.

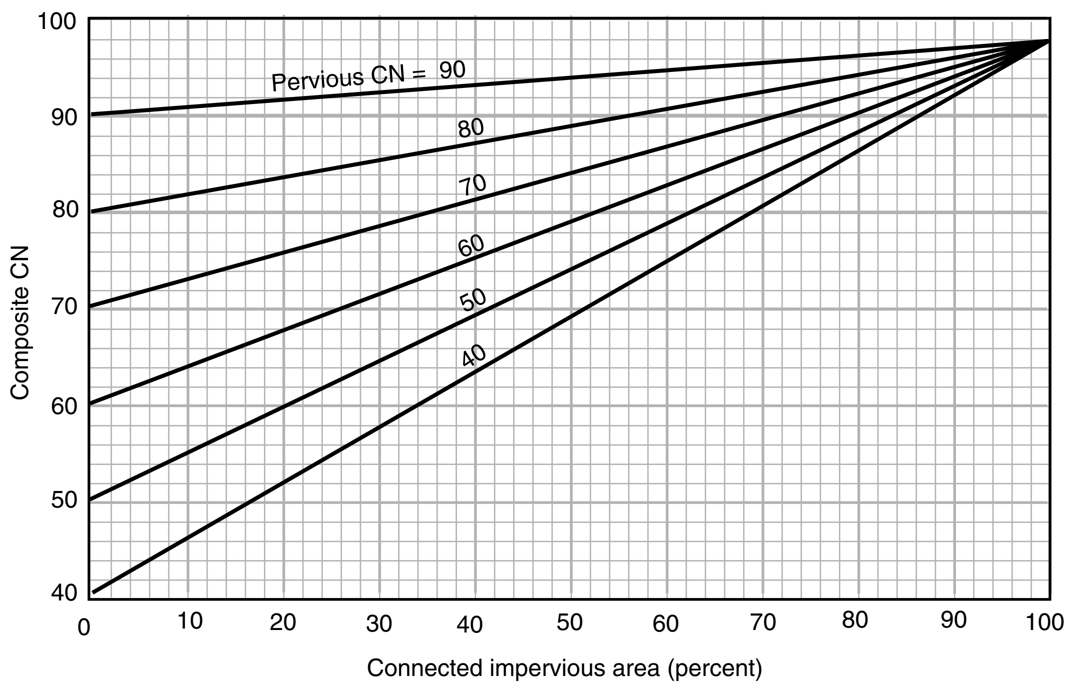
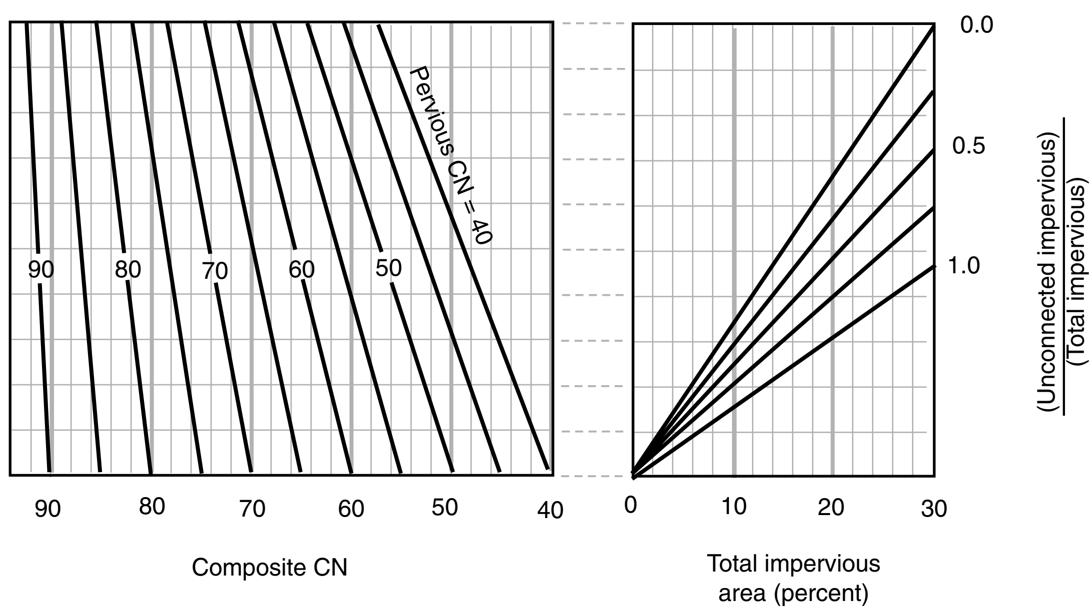


Figure 2-4 Composite CN with unconnected impervious areas and total impervious area less than 30%



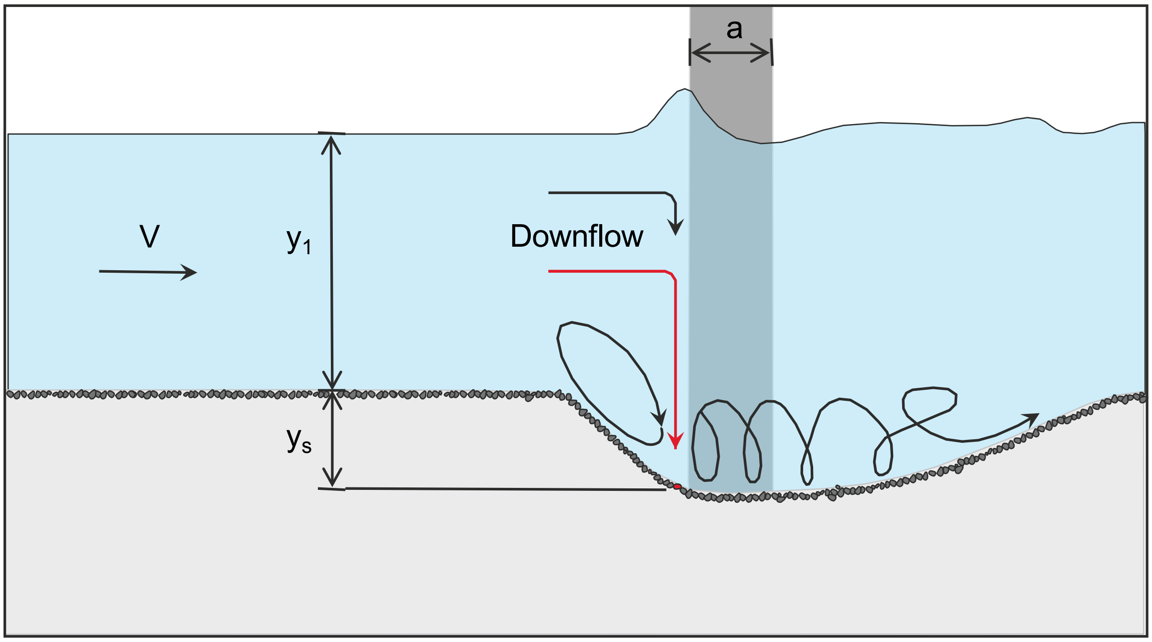


Figure 7.2. Definition sketch for pier scour.

The HEC-18 equation is:

$$\frac{y_s}{y_1} = 2.0\ K_1\ K_2\ K_3 \left(\frac{a}{y_1}\right)^{0.65} Fr_1^{0.43} \tag{7.1}$$

As a Rule of Thumb, the maximum scour depth for round nose piers aligned with the flow is:

$y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$ (7.2)
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

In terms of y_s/a, Equation 7.1 is:

$$\frac{y_s}{a} = 2.0\ K_1\ K_2\ K_3 \left(\frac{y_1}{a}\right)^{0.35} Fr_1^{0.43} \tag{7.3}$$

where:

y_s	=	Scour depth, ft (m)
y_1	=	Flow depth directly upstream of the pier, ft (m)
K_1	=	Correction factor for pier nose shape from Figure 7.3 and Table 7.1
K_2	=	Correction factor for angle of attack of flow from Table 7.2 or Equation 7.4
K_3	=	Correction factor for bed condition from Table 7.3
a	=	Pier width, ft (m)
L	=	Length of pier, ft (m)
Fr_1	=	Froude Number directly upstream of the pier = $V_1/(gy_1)^{1/2}$
V_1	=	Mean velocity of flow directly upstream of the pier, ft/s (m/s)
g	=	Acceleration of gravity (32.2 ft/s^2) (9.81 m/s^2)

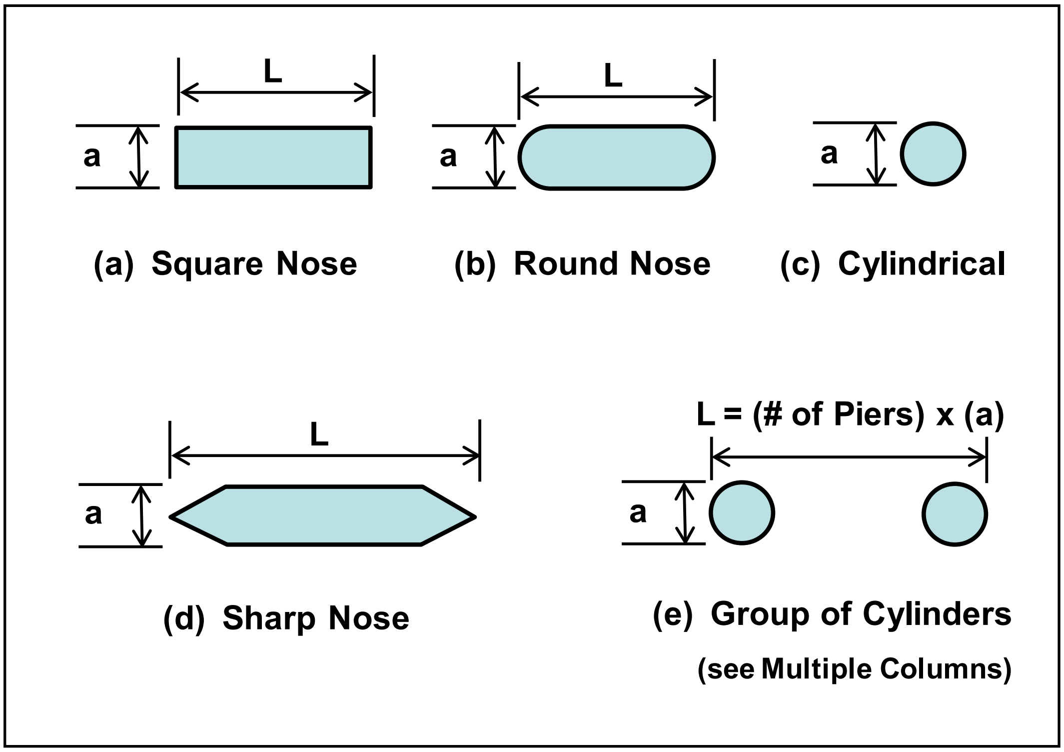


Figure 7.3. Common pier shapes.

The correction factor, K_2, for angle of attack of the flow, 2, is calculated using the following equation:

$$K_2 = (\text{Cos}\ \theta + \frac{L}{a}\ \text{Sin}\ \theta)^{0.65} \qquad (7.4)$$

If L/a is larger than 12, use L/a = 12 as a maximum in Equation 7.4 and Table 7.2. Table 7.2 illustrates the magnitude of the effect of the angle of attack on local pier scour.

Table 7.1. Correction Factor, K_1, for Pier Nose Shape.

Shape of Pier Nose	K_1
(a) Square nose	1.1
(b) Round nose	1.0
(c) Circular cylinder	1.0
(d) Group of cylinders	1.0
(e) Sharp nose	0.9

Table 7.2. Correction Factor, K_2, for Angle of Attack, 2, of the Flow.

Angle	L/a=4	L/a=8	L/a=12
0	1.0	1.0	1.0
15	1.5	2.0	2.5
30	2.0	2.75	3.5
45	2.3	3.3	4.3
90	2.5	3.9	5.0

Angle = skew angle of flow
L = length of pier

Table 7.3. Increase in Equilibrium Pier Scour Depths, K_3, for Bed Condition.		
Bed Condition	Dune Height ft	K_3
Clear-Water Scour	N/A	1.1
Plane bed and Antidune flow	N/A	1.1
Small Dunes	$10 > H \geq 2$	1.1
Medium Dunes	$30 > H \geq 10$	1.2 to 1.1
Large Dunes	$H \geq 30$	1.3

Notes:

1. The correction factor K_1 for pier nose shape should be determined using Table 7.1 for angles of attack up to 5 degrees. **For greater angles, K_2 dominates and K_1 should be considered as 1.0**. If L/a is larger than 12, use the values for L/a = 12 as a maximum in Table 7.2 and Equation 7.4.

2. The values of the correction factor K_2 should be applied only when the field conditions are such that the entire length of the pier is subjected to the angle of attack of the flow. Use of this factor will result in a significant over-prediction of scour if (1) a portion of the pier is shielded from the direct impingement of the flow by an abutment or another pier; or (2) an abutment or another pier redirects the flow in a direction parallel to the pier. For such cases, judgment must be exercised to reduce the value of the K_2 factor by selecting the effective length of the pier actually subjected to the angle of attack of the flow. **Equation 7.4 should be used for evaluation and design**. Table 7.2 is intended to illustrate the importance of angle of attack in pier scour computations and to establish a cutoff point for K_2 (i.e., a maximum value of 5.0).

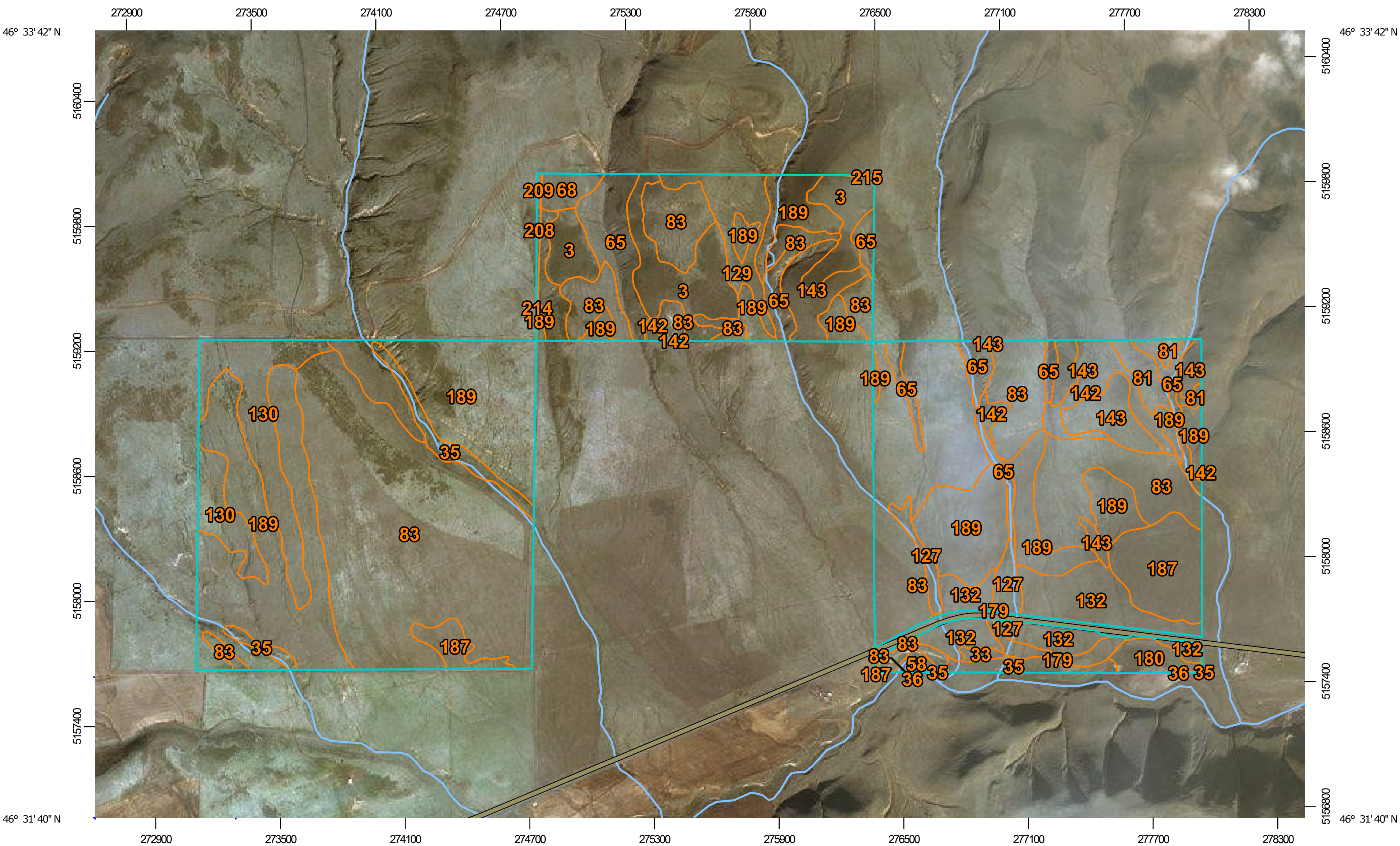
3. The correction factor K_3 results from the fact that for plane-bed conditions, which is typical of most bridge sites for the flood frequencies employed in scour design, the maximum scour may be 10 percent greater than computed with Equation 7.1. In the **unusual** situation where a dune bed configuration **with large dunes** exists at a site during flood flow, the maximum pier scour may be 30 percent greater than the predicted equation value. This may occur on very large rivers, such as the Mississippi. For smaller streams that have a dune bed configuration at flood flow, the dunes will be smaller and the maximum scour may be only 10 to 20 percent larger than equilibrium scour. For antidune bed configuration the maximum scour depth may be 10 percent greater than the computed equilibrium pier scour depth.

4. Piers set close to abutments (for example at the toe of a spill through abutment) must be carefully evaluated for the angle of attack and velocity of the flow coming around the abutment.

7.3 FLORIDA DOT PIER SCOUR METHODOLOGY

Equation 7.1 has been included in all previous versions of HEC-18 and has been used for bridge scour evaluations and bridge design for countless bridges in the U.S. and worldwide. This equation, which was developed and modified over several decades, could be improved by including bed material size and a more detailed consideration of the bridge pier flow field (see Section 3.6.2). An NCHRP study (NCHRP 2011a) evaluated 22 pier scour equations and found that although the HEC-18 equation did well in comparison to the other equations, the Sheppard and Miller (2006) equation generally performed better for both laboratory and

Soil Map—Yakima County Area, Washington; and Yakima Training Center, Parts of Kittitas and Yakima Counties, Washington
(Project Boundaries)



Map Scale: 1:26,600 if printed on A landscape (11" x 8.5") sheet.

Meters: 0 350 700 1400 2100

Feet: 0 1000 2000 4000 6000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Yakima County Area, Washington
Survey Area Data: Version 20, Jun 4, 2020

Soil Survey Area: Yakima Training Center, Parts of Kittitas and Yakima Counties, Washington
Survey Area Data: Version 17, Jun 4, 2020

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 29, 2015—Mar 5, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
3	Bakeoven very cobbly silt loam, 0 to 30 percent slopes	83.1	5.3%
33	Esquatzel silt loam, 2 to 5 percent slopes	2.8	0.2%
35	Finley fine sandy loam, 0 to 5 percent slopes	32.1	2.1%
36	Finley cobbly fine sandy loam, 0 to 5 percent slopes	6.0	0.4%
58	Hezel loamy fine sand, 2 to 15 percent slopes	3.5	0.2%
65	Kiona stony silt loam, 15 to 45 percent slopes	93.5	6.0%
68	Lickskillet very stony silt loam, 5 to 45 percent slopes	10.0	0.6%
81	Mikkalo silt loam, 15 to 30 percent slopes	15.2	1.0%
83	Moxee silt loam, 2 to 15 percent slopes	559.1	35.7%
127	Scooteney cobbly silt loam, 0 to 5 percent slopes	17.8	1.1%
129	Selah silt loam, 5 to 8 percent slopes	30.8	2.0%
130	Selah silt loam, 8 to 15 percent slopes	80.7	5.2%
132	Shano silt loam, 2 to 5 percent slopes	75.9	4.8%
142	Starbuck silt loam, 2 to 15 percent slopes	30.2	1.9%
143	Starbuck-Rock outcrop complex, 0 to 45 percent slopes	59.5	3.8%
179	Warden silt loam, 8 to 15 percent slopes	10.1	0.6%
180	Warden silt loam, 15 to 30 percent slopes	12.3	0.8%
187	Willis silt loam, 2 to 5 percent slopes	56.6	3.6%
189	Willis silt loam, 8 to 15 percent slopes	383.7	24.5%
Subtotals for Soil Survey Area		**1,562.9**	**99.8%**
Totals for Area of Interest		**1,565.9**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
208	Kiona stony silt loam, 15 to 45 percent slopes	1.5	0.1%
209	Lickskillet very stony silt loam, 5 to 45 percent slopes	0.9	0.1%
214	Willis silt loam, 8 to 15 percent slopes	0.2	0.0%
215	Bakeoven very cobbly silt loam, 0 to 30 percent slopes	0.3	0.0%
Subtotals for Soil Survey Area		**2.9**	**0.2%**
Totals for Area of Interest		**1,565.9**	**100.0%**

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures.** Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 10. The **horizontal datum** was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum.** For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, MD 20910-3282

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242,** or visit its website at http://www.ngs.noaa.gov/.

Base map information shown on this FIRM was derived from multiple sources. Base map files were provided in digital format by Yakima County GIS and Washington State Department of Natural Resources. This information was compiled at scales of 1:400 to 1:100,000 during the time period 1991-2006.

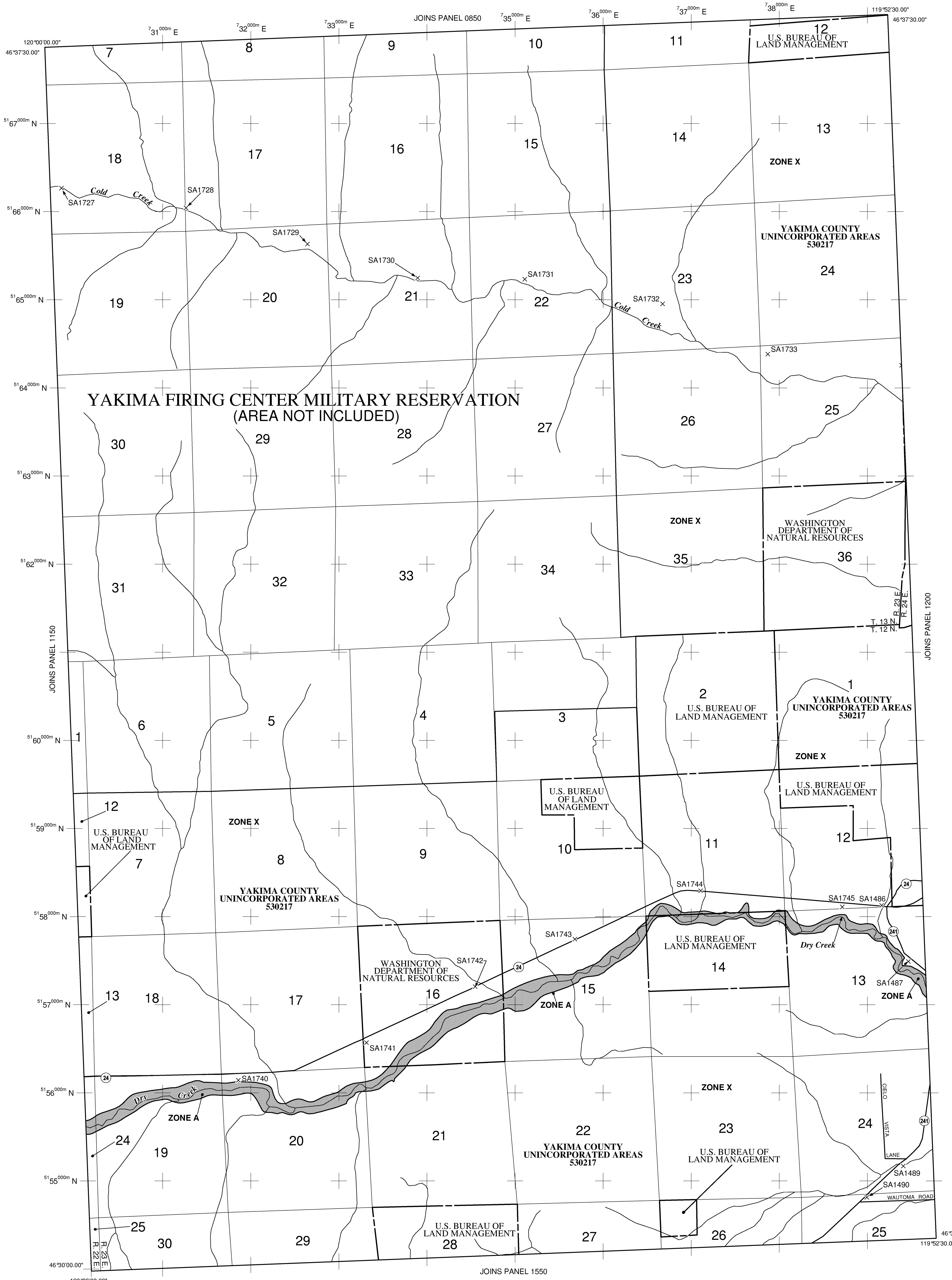
This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables *in the Flood Insurance Study report (which contains authoritative hydraulic data*) may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, *a Flood Insurance Study report*, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at http://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	Floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
~~ 513 ~~~~	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

(A)———(A)	Cross section line
(23)- - - - -(23)	Transect line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
42 75 000m N	1000-meter Universal Transverse Mercator grid ticks, zone 10
6000000 M	5000-foot grid ticks: Washington State Plane coordinate system, south zone (FIPSZONE 4602), Lambert Conformal Conic
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5	River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
November 18, 2009
EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 2000'

1000 0 2000 4000 FEET
600 0 600 1200 METERS

NFIP

PANEL 1175D

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP
YAKIMA COUNTY, WASHINGTON
AND INCORPORATED AREAS

PANEL 1175 OF 2700
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
YAKIMA COUNTY	530217	1175	D

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
53077C1175D

EFFECTIVE DATE
NOVEMBER 18, 2009

Federal Emergency Management Agency

APPENDIX B

Basin Curve Number Estimation

Runoff Curve Number Report for Basin 1B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
C	Mixed Rangeland	70	1.197	83.766
B	Mixed Rangeland	56	0.489	27.360
D	Mixed Rangeland	77	1.041	80.148
A	Mixed Rangeland	35	0.014	0.496

CN (Weighted) = Total Product \ Total Area
==
69.9819

Runoff Curve Number Report for Basin 2B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
C	Mixed Rangeland	70	0.089	6.230
D	Mixed Rangeland	77	0.260	19.986
B	Mixed Rangeland	56	0.037	2.077

CN (Weighted) = Total Product \ Total Area
==
73.3654

Runoff Curve Number Report for Basin 3B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
B	Shrub and Brush Rangeland	56	0.255	14.306
C	Shrub and Brush Rangeland	70	0.234	16.392
B	Mixed Rangeland	56	0.135	7.550
C	Mixed Rangeland	70	1.228	85.936
D	Mixed Rangeland	77	0.866	66.663
D	Shrub and Brush Rangeland	77	0.433	33.331
D	Cropland and Pasture	84	0.043	3.577
C	Cropland and Pasture	79	0.035	2.803

CN (Weighted) = Total Product \ Total Area
==
71.4066

Runoff Curve Number Report for Basin 4B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
C	Shrub and Brush Rangeland	70	0.021	1.486
D	Shrub and Brush Rangeland	77	0.191	14.709
C	Mixed Rangeland	70	0.913	63.890
D	Mixed Rangeland	77	1.111	85.533
B	Mixed Rangeland	56	0.488	27.339
C	Cropland and Pasture	79	0.021	1.677

CN (Weighted) = Total Product \ Total Area
==
70.8995

Runoff Curve Number Report for Basin 5B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
D	Mixed Rangeland	77	0.340	26.210
C	Mixed Rangeland	70	0.206	14.396
B	Mixed Rangeland	56	0.121	6.751
C	Cropland and Pasture	79	0.043	3.361
D	Cropland and Pasture	84	0.043	3.574

CN (Weighted) = Total Product \ Total Area
==
72.2264

Runoff Curve Number Report for Basin 6B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
D	Mixed Rangeland	77	0.158	12.184
C	Mixed Rangeland	70	0.014	0.963
B	Mixed Rangeland	56	0.007	0.385
D	Cropland and Pasture	84	0.062	5.201
A	Cropland and Pasture	49	0.007	0.337
C	Cropland and Pasture	79	0.021	1.630

CN (Weighted) = Total Product \ Total Area
==
77.1538

Runoff Curve Number Report for Basin 7B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
C	Mixed Rangeland	70	0.139	9.717
D	Mixed Rangeland	77	0.753	57.943
B	Mixed Rangeland	56	0.117	6.546
D	Cropland and Pasture	84	0.088	7.364
A	Mixed Rangeland	35	0.022	0.767
B	Cropland and Pasture	69	0.007	0.504

CN (Weighted) = Total Product \ Total Area
==
73.6299

Runoff Curve Number Report for Basin 8B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
C	Mixed Rangeland	70	0.362	25.350
D	Mixed Rangeland	77	0.085	6.561
B	Mixed Rangeland	56	0.575	32.210
C	Cropland and Pasture	79	0.014	1.122
D	Cropland and Pasture	84	0.007	0.596
B	Cropland and Pasture	69	0.007	0.490
A	Cropland and Pasture	49	0.014	0.696
A	Mixed Rangeland	35	0.121	4.225

CN (Weighted) = Total Product \ Total Area
==
60.0838

Runoff Curve Number Report for Basin 9B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
B	Mixed Rangeland	56	0.136	7.594
A	Mixed Rangeland	35	0.043	1.499
D	Mixed Rangeland	77	0.029	2.198
C	Mixed Rangeland	70	0.114	7.994
C	Cropland and Pasture	79	0.071	5.638
B	Cropland and Pasture	69	0.029	1.970
A	Cropland and Pasture	49	0.014	0.699

CN (Weighted) = Total Product \ Total Area
==
63.377

Runoff Curve Number Report for Basin 10B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
A	Mixed Rangeland	35	0.015	0.516
D	Mixed Rangeland	77	0.384	29.538
B	Mixed Rangeland	56	0.133	7.436
C	Mixed Rangeland	70	0.052	3.615
D	Cropland and Pasture	84	0.030	2.479
B	Cropland and Pasture	69	0.015	1.018

CN (Weighted) = Total Product \ Total Area
==
71.1294

Runoff Curve Number Report for Basin 11B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
B	Mixed Rangeland	56	0.075	4.223
C	Mixed Rangeland	70	0.075	5.279
D	Mixed Rangeland	77	0.019	1.452

CN (Weighted) = Total Product \ Total Area
==
64.5556

Runoff Curve Number Report for Basin 12B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
B	Mixed Rangeland	56	0.233	13.036
D	Mixed Rangeland	77	0.113	8.691
C	Mixed Rangeland	70	0.219	15.308
D	Cropland and Pasture	84	0.071	5.926
C	Cropland and Pasture	79	0.099	7.802

CN (Weighted) = Total Product \ Total Area
==
69.1923

Runoff Curve Number Report for Basin 13B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
D	Mixed Rangeland	77	0.074	5.727
D	Cropland and Pasture	84	0.335	28.113
C	Mixed Rangeland	70	0.030	2.082
C	Cropland and Pasture	79	0.052	4.113

CN (Weighted) = Total Product \ Total Area
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81.5606

Runoff Curve Number Report for Basin 14B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
D	Cropland and Pasture	84	0.219	18.397
A	Cropland and Pasture	49	0.007	0.346
B	Cropland and Pasture	69	0.791	54.597
C	Mixed Rangeland	70	0.572	40.058
D	Mixed Rangeland	77	0.374	28.832
C	Cropland and Pasture	79	0.064	5.023
B	Mixed Rangeland	56	0.593	33.233

CN (Weighted) = Total Product \ Total Area
==
68.8598

Runoff Curve Number Report for Basin 15B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
D	Cropland and Pasture	84	0.026	2.210
B	Cropland and Pasture	69	0.099	6.806
B	Mixed Rangeland	56	0.178	9.943
C	Mixed Rangeland	70	0.033	2.302

CN (Weighted) = Total Product \ Total Area
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63.3922

Runoff Curve Number Report for Basin 16B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
C	Mixed Rangeland	70	6.747	472.261
B	Mixed Rangeland	56	2.751	154.039
D	Mixed Rangeland	77	3.447	265.431
C	Cropland and Pasture	79	4.137	326.791
B	Cropland and Pasture	69	4.917	339.306
D	Shrub and Brush Rangeland	77	1.984	152.758
B	Shrub and Brush Rangeland	56	0.331	18.516
C	Shrub and Brush Rangeland	70	0.915	64.019

D	Cropland and Pasture	84	1.421	119.370
A	Cropland and Pasture	49	0.661	32.403
A	Mixed Rangeland	35	0.190	6.648

CN (Weighted) = Total Product \ Total Area
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70.9655

Runoff Curve Number Report for Basin 17B

HSG	Land Use Description	CN	Area mi^2	Product CN x A
B	Mixed Rangeland	56	0.064	3.595
B	Cropland and Pasture	69	0.171	11.813
C	Cropland and Pasture	79	0.257	20.287
D	Mixed Rangeland	77	0.007	0.549
D	Cropland and Pasture	84	0.178	14.980
C	Mixed Rangeland	70	0.021	1.498
A	Cropland and Pasture	49	0.036	1.748

CN (Weighted) = Total Product \ Total Area
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74.1359