Willamette Water Supply
Our Reliable Water

March 30, 2022

Oregon Department of Environmental Quality
700 NE Multnomah Street, Suite 600
Portland, OR 97232

Attention: Brian Creutzburg

Subject: Willamette Water Supply System Commission Annual Report

Dear Mr. Creutzburg,

The Willamette Water Supply System (WWSS) Commission is providing the attached annual report, consistent with the requirements of Oregon Administrative Rule 340-039-0017(3). The intent of this report is to document activities conducted in 2021 and to date in 2022 towards obtaining the credits required to offset the thermal impact of the WWSS withdrawal, as documented in the WWSS Thermal Trading Plan, which was approved by the Oregon Department of Environmental Quality in 2020. No credits have been finalized to date. However, this annual report documents activities including continued site investigations (revisions to planting plans, calculation of anticipated credits, and archaeological surveys), preparation for planting including invasives control, initial planting activities, and identification of potential additional project locations. The TTP does not require that credits be in place prior to 2026, but the WWSS will continue to document progress towards obtaining the required credits.

Sincerely,

Christina Walter, Permitting and Outreach Manager, WWSP

Enclosed:

Geosyntec Consultants, Inc. 2022. Thermal Trading Annual Report for 2022.

Geosyntec consultants

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Memorandum

Date: March 30, 2022

To: Christina Walter and Jill Chomycia, Willamette Water Supply Program

From: Jacob Krall and Rob Annear, Geosyntec Consultants, Inc.

Subject: Thermal Trading Annual Report for 2022

INTRODUCTION

The Willamette Water Supply System Commission (WWSS Commission) is an Oregon intergovernmental entity formed by Tualatin Valley Water District (TVWD), the City of Hillsboro, and the City of Beaverton. The WWSS Commission was formed to build the Willamette Water Supply System (WWSS) in response to planned growth in their service areas. The WWSS will provide an additional resilient water supply for Washington County. When complete, the WWSS will be one of Oregon's most seismically-resilient water systems—built to better withstand natural disasters, protect public health, and speed regional economic recovery through restoring critical services more quickly.

The Willamette River, one of Oregon's largest rivers, is the WWSS's new supply source. The raw water intake is located at the Willamette River Water Treatment Plant in Wilsonville. From there, raw water will be pumped to the WWSS Water Treatment Plant, a new state-of-the-art water filtration plant where multiple treatment processes will produce high quality drinking water. Drinking water will be pumped to reservoir facilities on Cooper Mountain, then will be gravity-fed to additional storage and customers in the TVWD, Hillsboro, and Beaverton service areas. The new system will be completed by 2026.

On October 23, 2020, the Oregon Department of Environmental Quality (ODEQ) approved a Thermal Trading Plan (TTP) to fulfill the temperature offset requirement of the Clean Water Act (CWA), Section 401 Water Quality Certification (WQC) as it pertains to the WWSS. The approved TTP modeled the required thermal offset to be:

- 30.2 million kilocalories per day (MMKcal/day).

SUMMARY OF ACTIVITIES IN 2021 AND TO DATE IN 2022

To date, the following activities have been conducted towards obtaining the credits required to offset the thermal impact of the WWSS withdrawal, as identified in the TTP.

- Molalla River State Park: Site preparation, archeological survey, and planting
- Additional Sites: Started the process of assessing potential sites at other Public Lands and initial outreach to State Parks

MOLALLA RIVER STATE PARK

Molalla River State Park is located at the confluence of the Molalla, Pudding, and Willamette Rivers. The WWSS has collaborated with Molalla River Watch and the Oregon Parks and Recreation Department and has funded the following efforts in 2021 and to date in 2022:

- Continuation of site analysis/investigations (e.g., revisions to planting plans (Legg et. al, 2022), thermal credit calculations, and archaeological surveys), further discussed below.
- Planting preparation/invasives control of 59.6 acres.
- Initial planting activities which are scheduled to begin in 2022.

Archaeological Survey

Some planting activities in Molalla River State Park may require a permit application to the U.S. Army Corps of Engineers (USACE) for in-water project work. As such, the Project would also be subject to the requirements of Section 106 of the National Historic Preservation Act (NHPA) of 1966 (as amended) and its implementing regulations in 36 Code of Federal Regulations (CFR) 800.

Oregon State Parks (Parks) provided WWSP with an area of potential impacts (API) for the planting work. Under contract to WWSP, Historical Research Associates (HRA) completed archaeological survey of the API under Oregon State Archaeological Permit AP 3191 and Oregon State Parks Research Permit No. 249 between October 2021 and February 2022. The findings were provided to Oregon State Parks in 2022.

Thermal Credit Generation

Thermal credit generation for the Molalla River State Park project was revised from previous estimates based on refined site revegetation plans as described below. This includes revisions to riparian areas along the Molalla River, which were previously estimated based on preliminary planting plans, and riparian area along the Willamette River that had not previously been incorporated into thermal credit estimates. A discussion of each of these areas follows.

Molalla River

Thermal credits on the Molalla River were assessed using Heat Source Version 8.08 (Boyd and Kasper, 2003).The development of the model inputs for current conditions is described in the memorandum from Legg et. al (2019), attached as Appendix A. Proposed restoration conditions are described in Legg et. al (2022), attached as Appendix B. Alternative 2, WWSP-funded Intensive Planning, described in the memorandum, represents the current planting plan and was developed using information from Ash Creek Forest Management, the planting contractor.

Where the proposed conditions area mapping described in Legg et. al (2022) resulted in shorter vegetation than the current conditions, current conditions were used. Wetted widths were based on values from the current conditions simulation of the Molalla River described in ODEQ (2008). The model was run from August 25, 2001, to September 25, 2001, since this is the time period associated with the maximum thermal impact of the WWSS withdrawal as described in the WWSS Thermal Trading Plan (WWSS, 2020).

Figure 1 shows the current conditions and future conditions effective shade based on output from Shade-a-Lator.

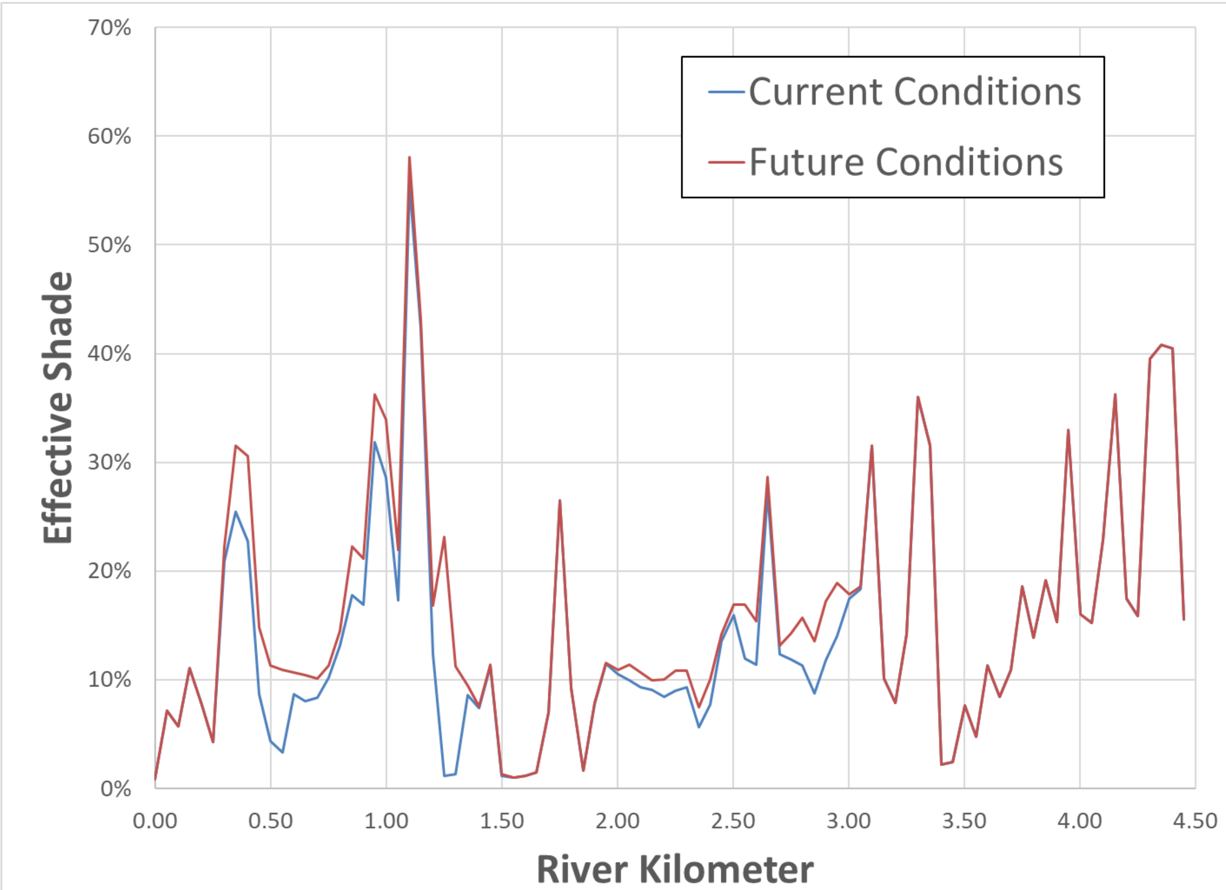

Figure 1.Modeled Effective Shade for the Molalla River State Park Area for Current and Future Conditions.

The amount of solar radiation blocked for current and future conditions is shown in Figure 2.

Integrating the results in Figure 2, 78.81 million kilocalories per day (MMKcal/day) are blocked for current conditions and 90.82 MMKcal/day are blocked for future conditions, meaning that (90.82 – 78.81)/2 = **6.01 MMKcal** credits are generated at this site once the 2:1 trading ratio is taken into account.

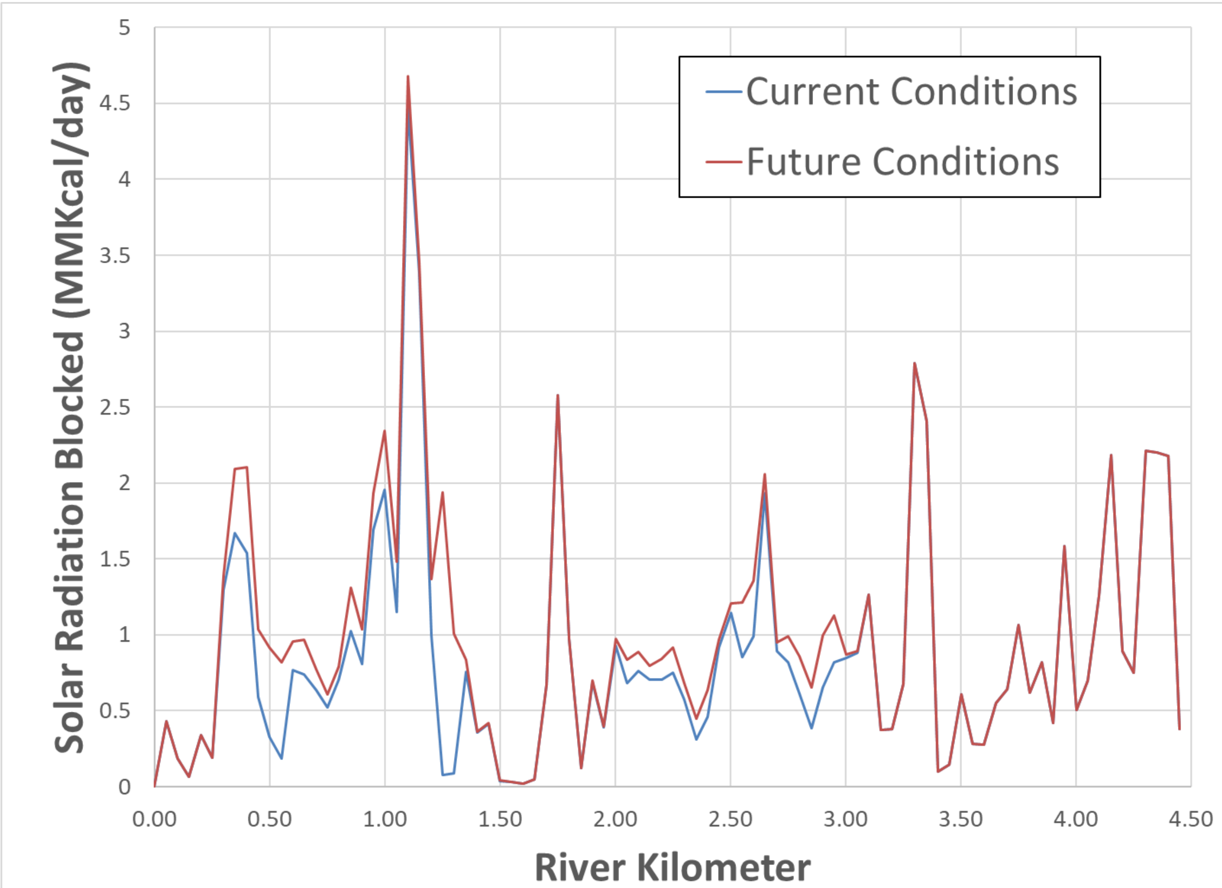

Figure 2. Modeled Solar Radiation blocked for the Molalla River State Park Area for Current and Future Conditions.

Willamette River

In addition to the increased shading on the Molalla River, the WWSS restoration activities also provide shading for a 1,050-foot reach on the right bank of the Willamette River (see the map of Alternative 2 in Legg et. al, 2022). This reach was analyzed using Shade-a-Lator 6 tool, the same tool used by Clean Water Services (CWS) in its annual reporting (CWS, 2016). Version 6 is a simpler version of the tool and samples land cover in the orthogonal direction from the stream channel rather than in a star pattern. Because this reach of the Willamette is short and relatively straight, the simpler version was considered appropriate. Wetted widths were based on measurements made standard ArcGIS background aerial imagery.

Current conditions for this stretch of the Willamette River were based on aerial photography and observations—the westernmost 200 feet of the reach were considered bare ground, and the rest of the area was modeled using DEQ's Riparian Trees, 75% density code. This code is associated with a vegetation height of 11.6 meters, very similar to the average canopy height of 11.3 meters within the non-bare ground area within 135 feet (the standard buffer distance used in Shade-a-lator 6) for this reach of the Willamette River. Future conditions for this stretch of the Willamette River were based on the same planting plan described in Alternative 2 (Legg et. al, 2022), with Willows planted in areas nearest the river channel and the standard Ash-Cottonwood-Bottomland Pasture mosaic for the remaining areas (see Legg et. al, 2022). The potential solar loading was assumed to be 480 kcal/ft^2/day, the same value used by CWS (CWS, 2016).

Figure 3 shows a plot of effective shade for each 100-foot section of the planting area (except for the easternmost section, which is only 50 feet). The effective shading shown on the plot represents only the shading due to the right bank.

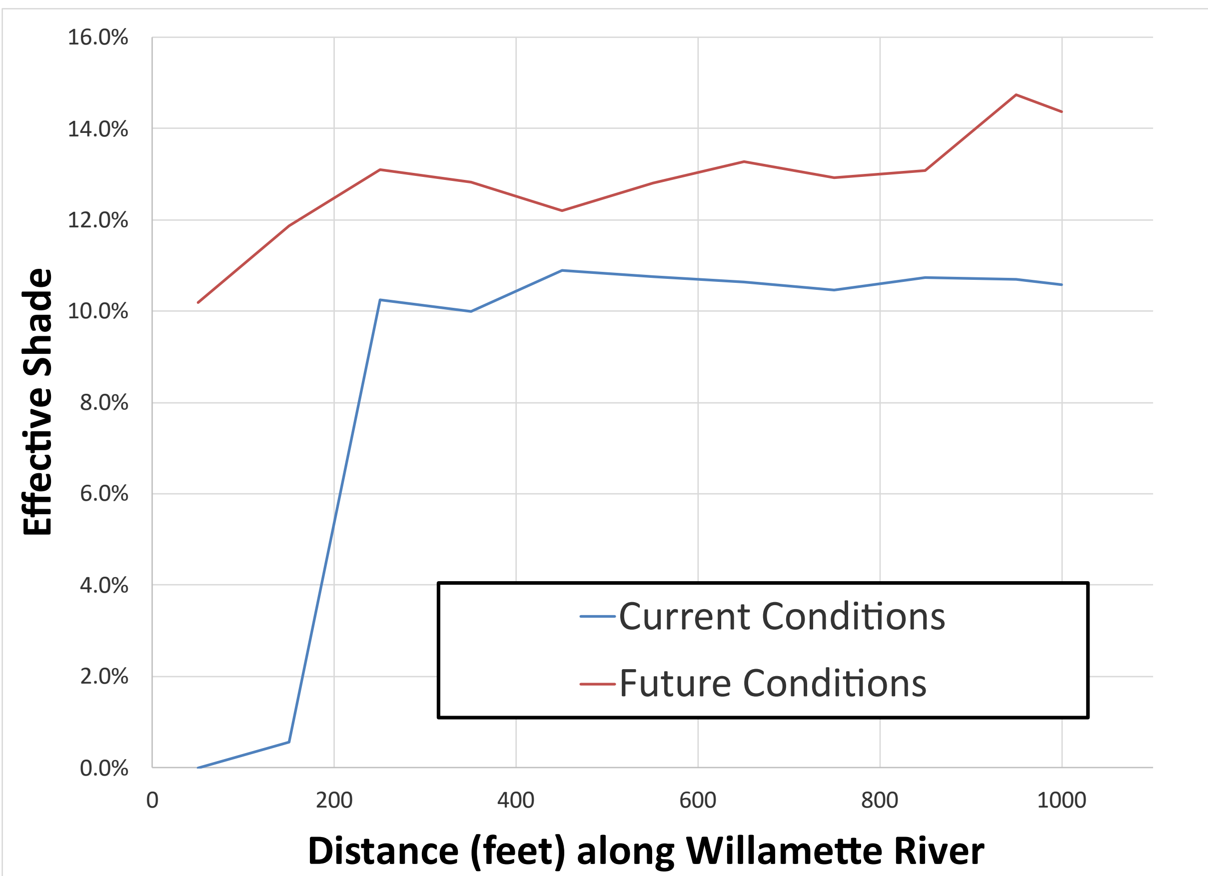

Figure 3. Modeled Effective Shade for the Willamette River due to planting at Molalla River State Park Area for Current and Future Conditions.

Figure 4 shows the blocked solar radiation for the baseline and future conditions due to shading from the right bank. Integrating the results in Figure 4, 22.28 MMKcal/day are blocked for current conditions and 33.24 MMKcal/day are blocked for future conditions, meaning that (33.24-22.28)/2 = **5.48 MMKcal** credits are generated at this site once the 2:1 trading ratio is taken into account. This calculation may be refined using Heat Source 8.08 for the next annual report.

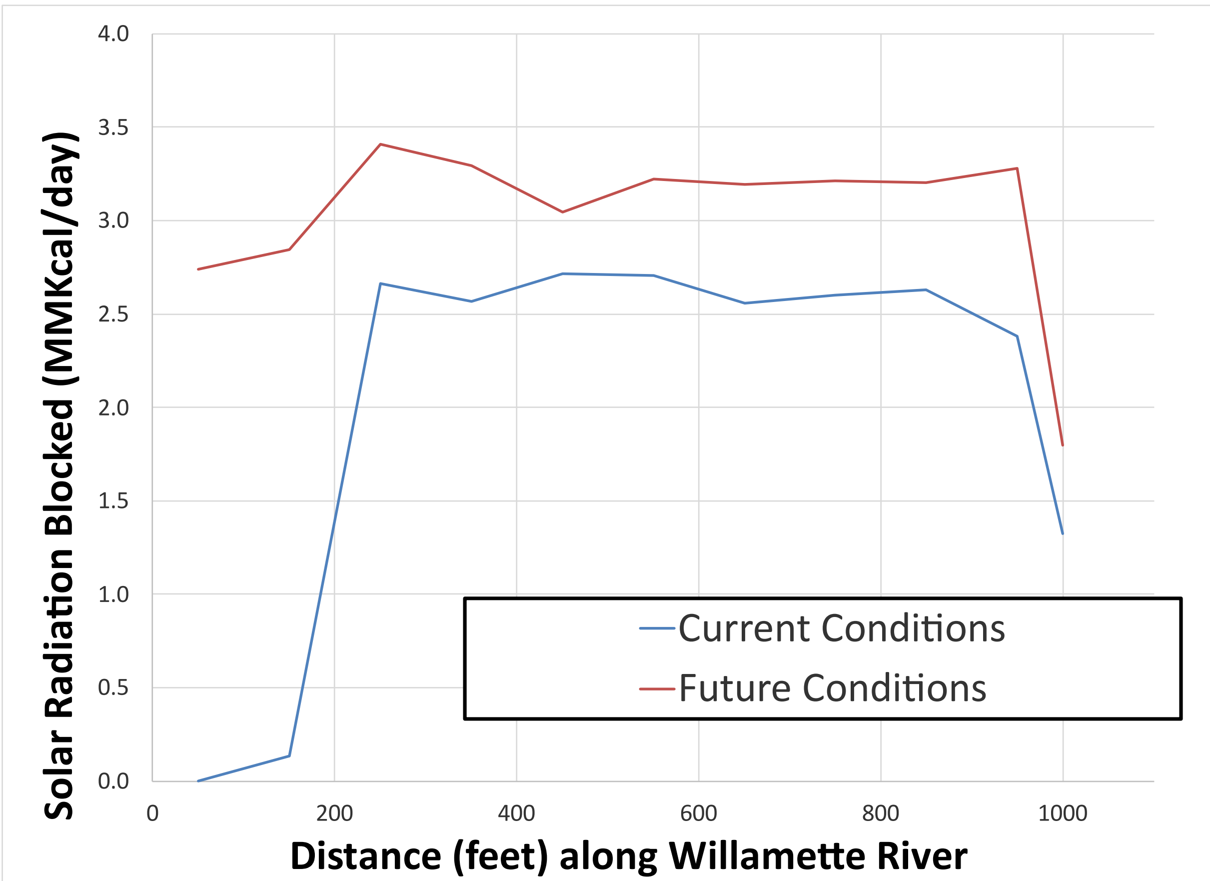

Figure 4. Modeled Solar Radiation blocked for the Willamette River due to planting at Molalla River State Park Area for Current and Future Conditions.

Total Thermal Credits Generated

The total amount of thermal credits anticipated to be generated based on 2022 planting is **6.01 + 5.48 = 11.49 MMKcal/day**, which is 38.0% of the **30.2 MMKcal/day** thermal load calculated in the WWSS thermal trading plan.

Future Work at Molalla River State Park

In 2022, quantitative monitoring will be conducted of the planting and the results and maintenance activities will be described in the next annual report.

EVALUATION OF ADDITIONAL SHADING OPPORTUNITIES

The WWSS identified potential riparian shading opportunities for generation of thermal credits at 5 locations, all identified as public lands (see the map included as Appendix C).

- Marshall Island Acres Greenway
- River Jetty Landing (North and South), Willamette River Greenway
- Bowers Rock State Park
- Sidney Access, Willamette River Greenway
- Molalla River State Park (additional location not included in current planting)

The WWSS has made initial outreach efforts to Oregon Parks and Recreation Department staff about these opportunities and is in the process of evaluating which potential projects to prioritize.

REFERENCES

Clean Water Services (2016). Thermal Load Management Plan. May 13.

Legg, N., Bowers, E., and Rudolph, J. (2019). Existing Condition Canopy Mapping and Shade-a-lator Model Vegetation Inputs. Memorandum to Jacob Krall (Geosyntec) and Asako Yamamuro (Molalla River Watch). December 6.

Legg, N., Holt, N., and Green, J. (2022). Proposed Conditions Canopy Projections and Shade-a-lator Model Vegetation Inputs. Memorandum to Jacob Krall (Geosyntec), Asako Yamamuro (Molalla River Watch), and Christina Walter and Jill Chomycia (WWSP). March 11.

Oregon Department of Environmental Quality (2008). Molalla-Pudding Subbasin TMDL & WQMP. December.

Willamette Water Supply System (2020). Thermal Trading Plan. October 23.

Appendix A: Legg et. al, 2019

Technical Memorandum

Date:	December 6, 2019
To:	Jacob Krall (Geosyntec) and Asako Yamamuro (Molalla River Watch)
From:	Nick Legg, PG; Elisabeth Bowers, PWS; Joe Rudolph (W2r)
Project:	Molalla River State Park – Thermal Trading Plan for the Willamette Water Supply
Subject:	Existing Condition Canopy Mapping and Shade-a-lator Model Vegetation Inputs

Introduction

The Willamette Water Supply Program (WWSP) has identified Molalla River State Park (MRSP) as a potential site to offset thermal impacts to the Willamette River from their proposed water supply pipe. A proposed method of thermal offset is restoration of vegetation and streamside shade in MRSP. Geosyntec is working directly with WWSP and the Oregon Department of Environmental Quality (DEQ, the regulating agency) to develop a thermal trading plan and quantify the potential of shading to address additional thermal loading from the proposed supply pipe. The primary method of quantifying shade benefits is DEQ's Shade-A-Lator Model, which is a component of their broader Heat Source Model (Boyd and Kasper 2003) for stream temperature. The Shade-A-Lator model calculates the solar radiation reaching stream based on characteristics of the stream morphology and adjacent vegetation canopy characteristics.

Given their involvement in broader stream restoration activities at MRSP, Wolf Water Resources (W2r) has mapped of existing streamside vegetation canopy types and developed associated Shade-A-Lator model inputs to support Geosyntec's shade modeling efforts. This memorandum (memo) provides documentation for the methods and rationale of that vegetative canopy mapping process.

Attachments include four maps:

1. Aerial imagery map
2. False Color Infrared (NIR) Map
3. Canopy height map
4. Canopy type (land cover code) map

Vegetative Canopy and Geospatial Mapping Methods

Supporting geospatial datasets

The vegetative canopy mapping effort made use of several datasets, including:

- High-resolution (4-band) aerial photography (1-inch spatial resolution) captured on September 26, 2018 when flow in the Molalla and Pudding Rivers were respectively 44 cubic feet per second (cfs) and 35 cfs. This imagery was acquired by contractor Geoterra for Molalla River Watch. This imagery is displayed in attached Maps 1 and 2.
- Canopy height model generated by applying photogrammetric techniques to the above imagery. This dataset provides the height of the stream canopy above the ground surface. This dataset is displayed in attached Map 3.
- Terrain
    - Base: Light detection and ranging (LiDAR) data collected by Metro (2014). Water surface elevations captured in the LiDAR were the basis for stream elevation model inputs
    - LiDAR was manipulated using survey data collected in 2018 to account river channel movement since acquisition of the Metro (2014) LiDAR
- Invasive species mapping in the State Park by Ash Creek Forest Management (mapped 2018) – note, in many cases invasive species did not form the main canopy, and so canopy mapping reflected invasive species only where they exist as monocultures.

Based on the above datasets, model inputs reflect stream and vegetation conditions in 2018.

Project coordinate systems and datums are as follows:

- Project horizontal datum: NAD_1983_2011_StatePlane_Oregon_North_FIPS_3601 – Meters
- Project elevation datum: NAVD88, meters

Vegetative Canopy Mapping Methods

In order to map the vegetative canopy surrounding the Molalla River using ArcGIS, the channel width of the river was buffered by 40 meters on both sides. Multiple geospatial data sets outlined above were imported into the map for the purpose of the vegetative canopy analysis as mentioned above. In addition to these data sets, field observations by both Ash Creek Forest Management and W2r were utilized in the vegetative canopy analysis.

First of all, the land cover codes that were used in the 2004 Molalla River Shade-A-Lator model (2004 analysis supporting the Molalla River Temperature TMDL) were used as a template for what codes to use in the current analysis with the understanding that new codes may need to be added. The vegetative canopy within the 40-meter Molalla River buffer was examined for changes or breaks in color, foliage patterning, height, and density (aerial percent cover). A polygon was created for each assemblage dominated by a certain vegetative type (e.g., Ash, Cottonwood stand with 75% density). Each polygon was assigned a land cover code based on the 2004 analysis. If a vegetative canopy type did not have a land cover code that fit its characteristics based on the 2004 analysis, a land cover code was developed for it and reused through the analysis as needed. Each vegetative canopy polygon was mapped at a scale in the range of 1:500 to 1:1000.

Vegetative Canopy Mapping and Land Cover Codes Results

The Molalla River vegetative canopy was analyzed for the extent of the aerial imagery collected for the project, which entails the Molalla River from its confluence with the Willamette River, through MRSP, approximately a half mile south of NW 22nd Avenue in Canby, Oregon. In addition, the Pudding River was analyzed from its confluence with the Molalla River to approximately a quarter mile south of the southernmost edge of MRSP.

Table 1 shows the land cover codes that were identified during the vegetative canopy analysis along the Molalla and Pudding rivers.

Table 1. Vegetative Canopy in the Vicinity of the Molalla River State Park. Emboldened land cover types are newly defined classes relative to the original 2004 model developed for the TMDL.

Land Cover Name	Code	Density (%)	Area (Acres)
Ash, Cottonwood - Bottomland Pasture Mosaic	4638	75	9.52
Water	301	0	7.71
Gravel and Sand	999	0	2.08
Willow	226	75	1.74
Japanese Knotweed Monoculture	**8752**	**75**	**0.83**
Natural Shrub	875	75	0.52
Bare/fallow	88	0	0.48
Barren - Ag. Road	403	0	0.37
Himalayan Blackberry Monoculture	**8754**	**75**	**0.36**
Christmas Tree	932	25	0.22
Natural Shrub	87	25	0.21
Willow	222	25	0.15
Willow	**224**	**50**	**0.13**
Black Hawthorn, Hedgerows, Brushy Fields	208	75	0.12
Ash, Cottonwood - Bottomland Pasture Mosaic	4634	25	0.12

Land Cover Name	Code	Density (%)	Area (Acres)
Light duty roads	400	0	0.12
Total Area Analyzed:			***24.67***

A total of 24.67 acres of riparian area along the Molalla and Pudding rivers were analyzed, which included the lower 4.45 river kilometers of the Molalla River and the lower 2.5 river kilometers of the Pudding River (both of which extend well upstream of the State Park boundary as displayed in the attached maps). The vegetative canopy type encompassing the largest area is Ash, Cottonwood – Bottomland Pasture Mosaic (see attached Map 4).

Many open patches between the forested polygons are dominated by invasive plant species, such as Japanese knotweed and Himalayan blackberry. Because there were no appropriate land cover codes from the 2004 Shade-O-Lator model for these Japanese knotweed (Figure 1) and Himalayan blackberry monoculture areas (both at densities of 75% or more), new codes were assigned to these, respectively: 8752 and 8754. This code numbers are sub-numbers of the code for "Natural Shrub, Land Cover Code 875, 75% density." In addition, there was 0.13 acre of willows at 50% density for which there was no land cover code assigned in the 2004 analysis. There were land cover codes for 25% and 75% densities of willow, but not for 50% density. Therefore, the land cover code "224" was assigned to this vegetative canopy type and added to the list for this project. Our team elected to assign canopy density values to these new classes based on professional judgement rather than field measurements, because these new codes represent a relatively small proportion of the site (~5% of the total mapping area) and are generally low height vegetation communities and so density is a relatively small factor in their shading of the river.

Land cover classes and codes were only assigned an associated canopy cover (density) value and are not assigned standard values of height and overhang (as would have been required with older versions of Shade-a-lator). The current version of TTools and Shade-a-lator allow for direct sampling of canopy height and overhang. Overhang is sampled by default our canopy cover mapping was detailed enough to capture trees that overhang the active channel, and because the canopy height layer also captures trees that overhang the channel. Therefore, direct sampling of these values captures overhang by default without the need to define a separate overhang input.

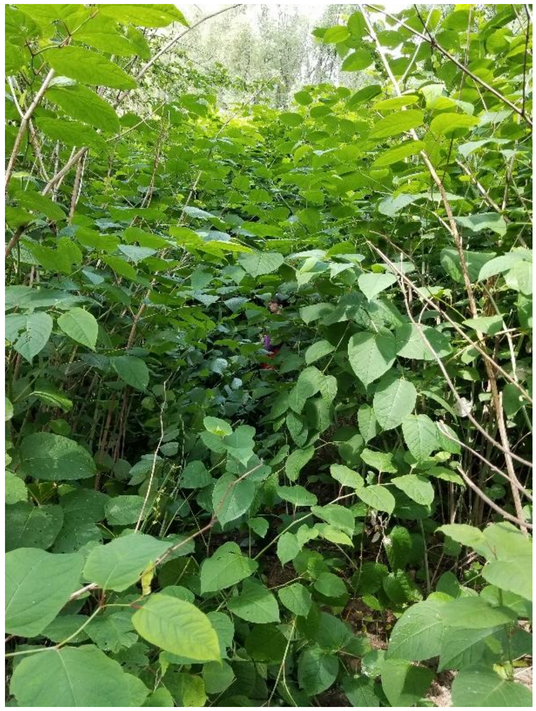

Figure 1. Typical conditions in a knotweed monoculture area onsite.

Shade-A-Lator Model Input Development

Using vegetation mapping and terrain datasets as inputs, we developed model inputs using the TTools geospatial toolbox. The current version of TTools is comprised of five Python-based tools that are run as stand-alone scripts with GIS data inputs (Michie, 2019). Shade-a-lator model inputs were developed assuming that shade modeling efforts will use the most current version (Heatsource Version 9) of the model (Boyd et al., 2019). The tools were run separately for the two rivers. Each TTool requires a series of data inputs – key input parameters are documented below. Additionally, saved TTools scripts with all data inputs are also provided as documentation of each tool run.

Tool 1 – Segment Stream

This tool generates a feature class of model nodes along the stream centerline.

Key input parameters include:

- Node spacing (node_dx) of 50 meters.

Tool 2 – Measure Channel Width

This tool measures stream width at each node using input feature classes of left and right banks.

Key input parameters include:

- Left and right banks define the approximate bankfull channel

Tool 3 – Sample Elevation Gradient (Array)

This tool measures stream slope at each model node.

Key input parameters include:

- Elevations of nodes are sampled from the water surface elevation captured in the 2014 LiDAR (Metro).

Tool 4 – Measure Topographic Angles

This tool measures angles to adjacent terrain that allow for calculation of topographic shading.

Key input parameters include:

- The terrain dataset used to sample terrain elevations was a USGS DEM (~10 m resolution) extending at least 10 km from the project area

Tool 5 – Sample Landcover (Point Method)

This tool samples landcover types and parameters from the various datasets described further above in this document. Note the version of Tool 5 using the Zone Method was not used.

Key input parameters include:

- Sampling transects were defined at 8 directions (N, NE, E, SE, S, SW, W, NW; "trans_count") with 18 samples out along each direction ("transsample_count") at a spacing of 4 meters ("transsample_distance"). This set of parameters creates a maximum sample distance of 72 m from the channel centerline.
- Landcover data type was a "CanopyCover" raster (in units of percent) which was defined from the land cover class mapping and associated assignments of standard density values.

Provided along with this memo are:

- Geospatial data layers input to and output from TTools
- TTool scripts with the saved input values for both the Molalla and Pudding Rivers
- Landcover data tables for the Molalla and Pudding Rivers which will serve as inputs to the Shade-a-lator Model

References

1. Boyd, M., and Kasper, B. 2003. Analytical methods for dynamic open channel heat and mass transfer: Methodology for heat source model Version 7.0.

2. Michie, R. 2019. TTools 9.0.0 (beta) https://github.com/rmichie/TTools

3. Boyd, M., Kasper, B., Metta, J., Michie, R., and Turner, D. 2019. HeatSource-version 9. Oregon Department of Environmental Quality https://github.com/rmichie/heatsource-9

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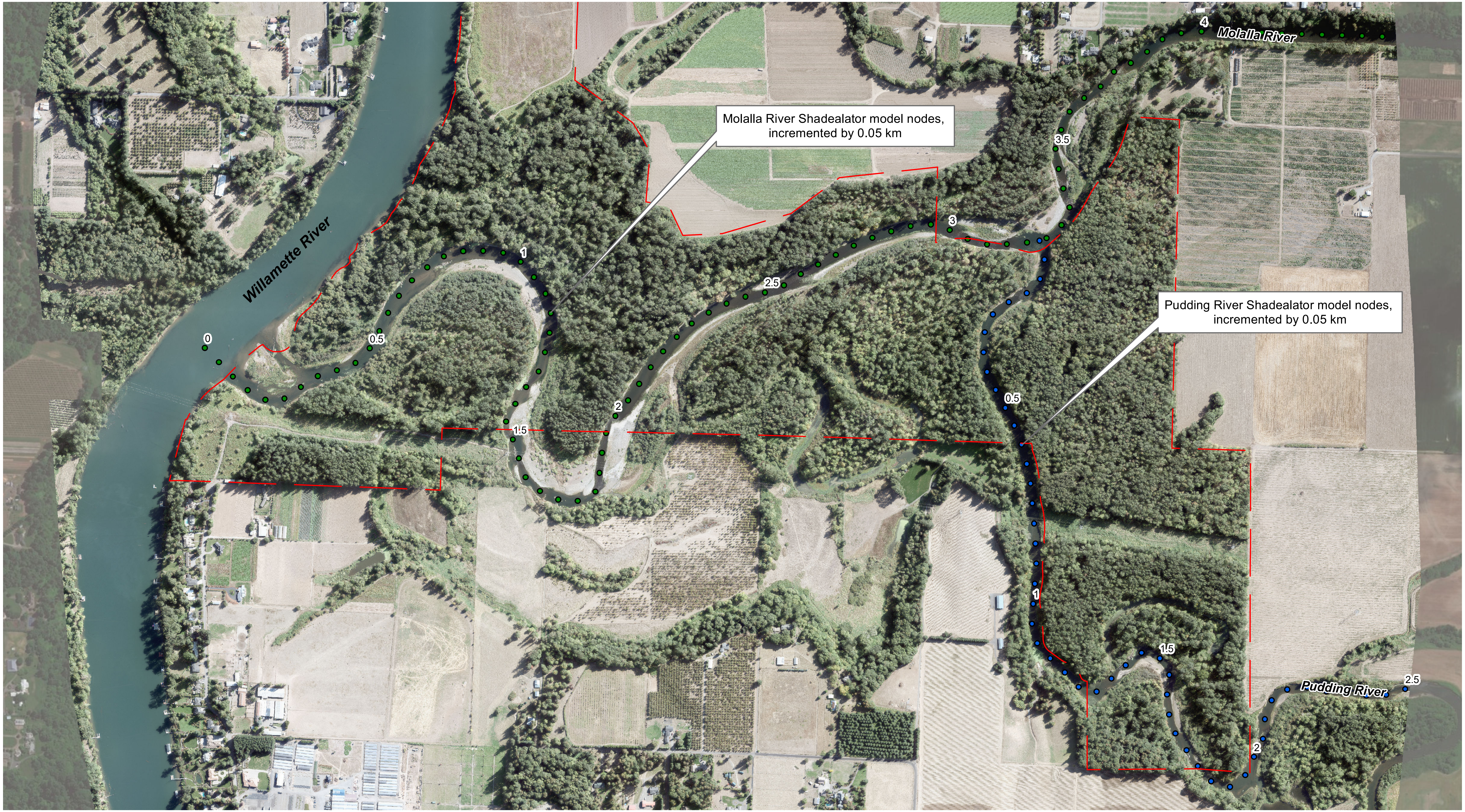
Map Attachments



0 500 1,000 2,000 Feet

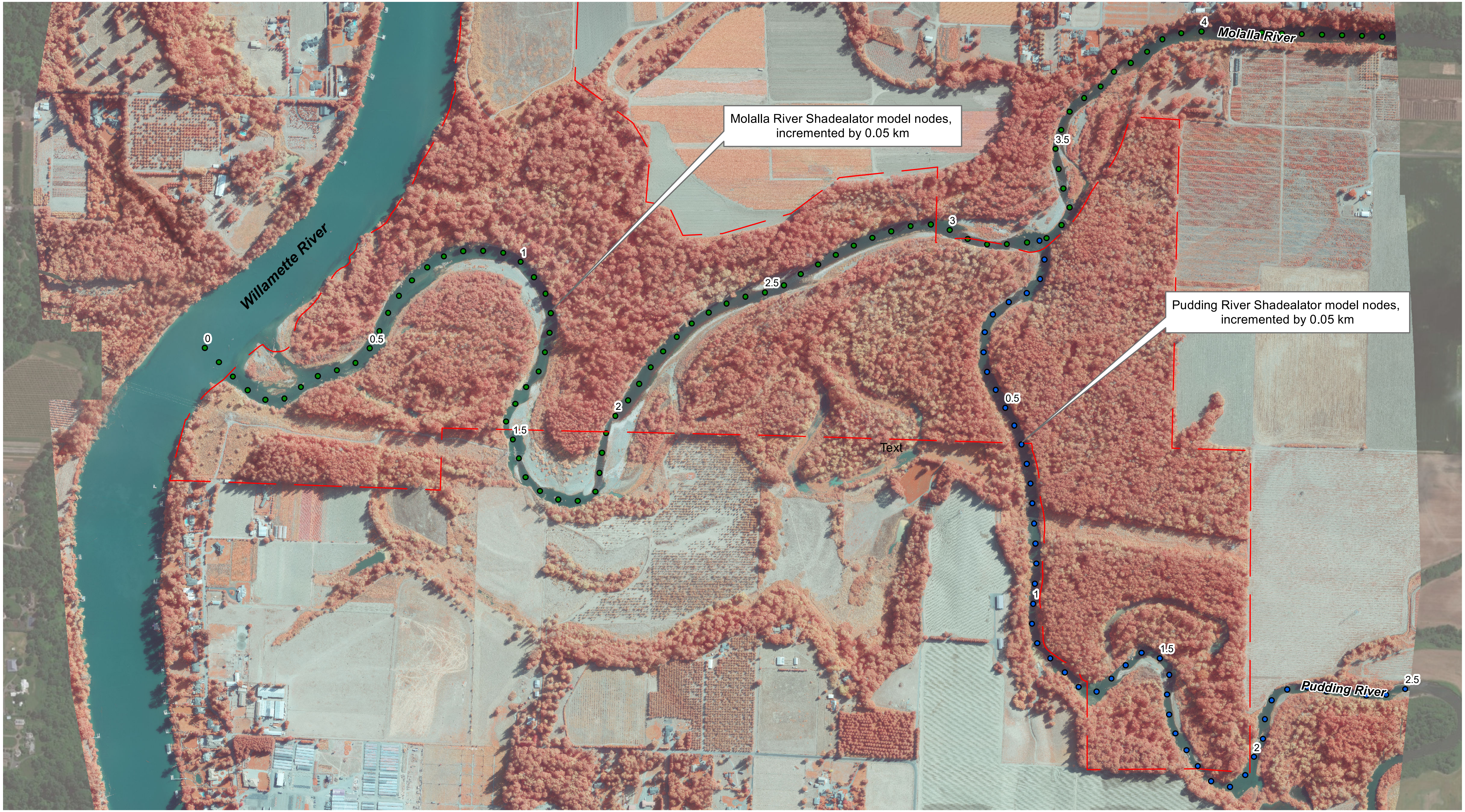
Legend

Molalla State Park Boundary

Molalla River State Park
Vegetation Mapping to Support Shade Modeling
WWSP Thermal Trading Plan

Map 1 - Aerial Map

Imagery Acquisition by Geoterra, Imagery collected on 09-26-2018



0 500 1,000 2,000 Feet

N

Legend

Molalla State Park Boundary

Imagery Acquisition by Geoterra, Imagery collected on 09-26-2018

Molalla River State Park
Vegetation Mapping to Support Shade Modeling
WWSP Thermal Trading Plan

Map 2 - False Color (NIR) Aerial Map

Legend

Molalla State Park Boundary

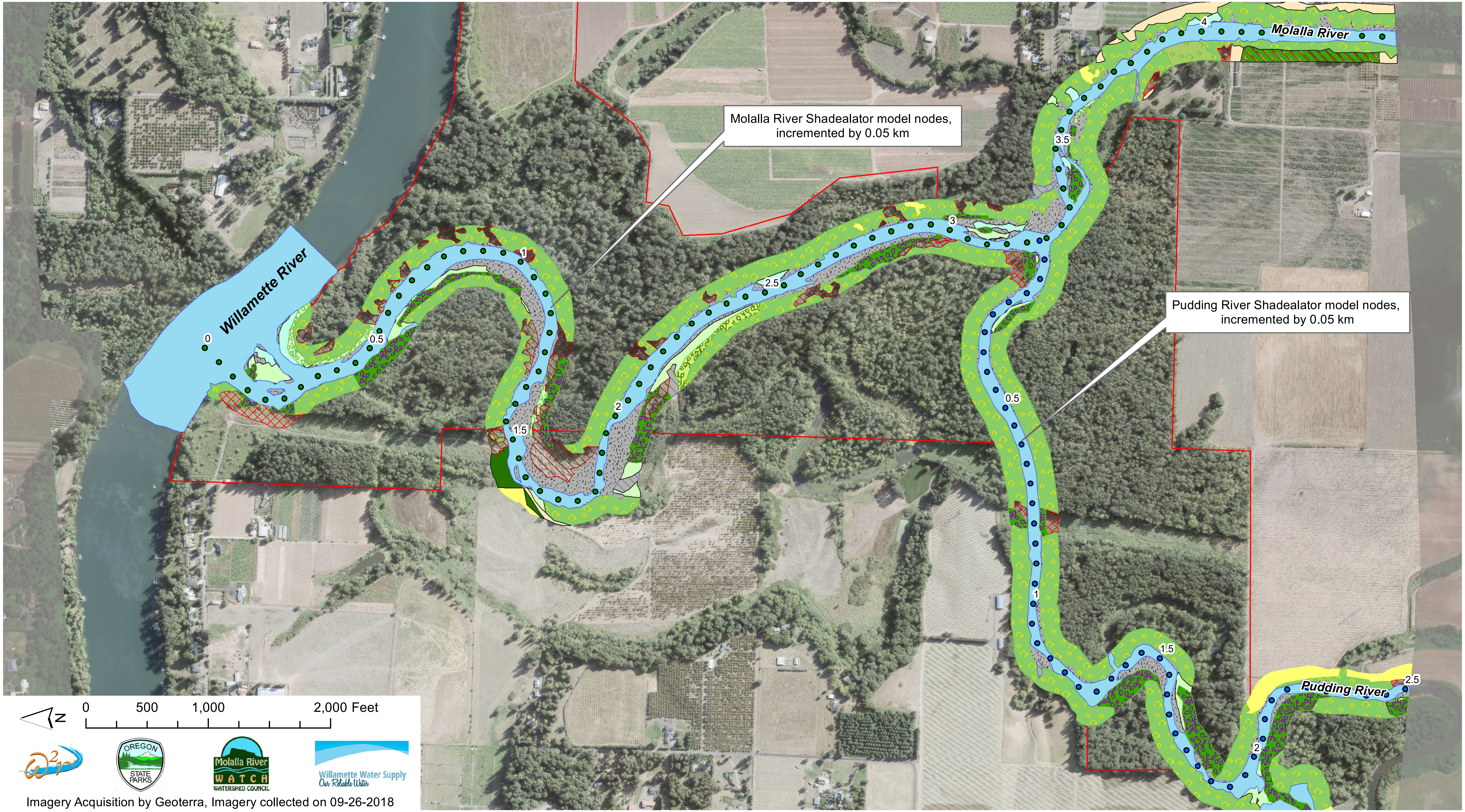
Canopy Height (ft)

10 - 20
20 - 40
40 - 70
70 - 110
110 - 195

Molalla River State Park
Vegetation Mapping to Support Shade Modeling
WWSP Thermal Trading Plan

Map 3 - Canopy Height Map

Canopy heights calculated by applying photogrammetry processing to 2018 aerial imagery (producing a digital surface model), and subtracting out the bare earth LiDAR (Metro, 2014) to yield canopy heights,Imagery Acquisition by Geoterra, Imagery collected on 09-26-2019



Canopy Cover Type

Ash, Cottonwood - Bottomland Pasture Mosaic - 4634
Ash, Cottonwood - Bottomland Pasture Mosaic - 4638
Bare/fallow - 88
Barren - Ag. Road - 403
Black Hawthorn, Hedgerows, Brushy Fields - 208
Christmas Tree - 932
Gravel and Sand - 999
Himalayan Blackberry Monoculture - 8754
Japanese Knotweed Monoculture - 8752
Light duty roads - 400
Natural Shrub - 87
Natural Shrub - 875
Water - 301
Willow - 222
Willow - 224
Willow - 226

Molalla River State Park Vegetation Mapping to Support Shade Modeling WWSP Thermal Trading Plan

Map 4 -Canopy Cover Map

Molalla State Park Boundary

Appendix B: Legg et. al, 2022

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Technical Memorandum

Date:	March 11, 2022
To:	Asako Yamamuro (Molalla River Watch); Jacob Krall (Geosyntec); Christina Walter and Jill Chomycia (WWSP)
From:	Nick Legg, PG; Natalie Holt; Jeremiah Green (W2r)
Project:	Molalla River State Park – Thermal Trading Plan for the Willamette Water Supply Program
Subject:	Proposed Conditions Canopy Projections and Shade-a-lator Model Vegetation Inputs

Introduction

The Willamette Water Supply Program (WWSP) has identified Molalla River State Park (MRSP) as a potential site to offset thermal impacts to the Willamette River from their proposed water supply pipe. A proposed method of thermal offset is restoration of vegetation and streamside shade in MRSP. Geosyntec is working directly with WWSP and the Oregon Department of Environmental Quality (DEQ, the regulating agency) to develop a thermal trading plan and quantify the potential of shading to address additional thermal loading from the proposed supply pipe. The primary method of quantifying shade benefits is DEQ's Shade-a-lator model, which is a component of their broader Heat Source Model (Boyd and Kasper 2003) for stream temperature. The Shade-a-lator model calculates the solar radiation reaching stream based on characteristics of the stream morphology and adjacent vegetation canopy characteristics.

Building on streamside vegetation mapping work from 2019 used to generate Shade-a-lator model inputs of existing channel and vegetation conditions (Legg et al. 2019), Wolf Water Resources (W2r) has generated Shade-a-lator inputs for two vegetation restoration scenarios for MRSP. This memorandum (memo) provides details on alternative vegetation restoration scenarios, potential streamside vegetation restoration actions, and methods used to produce Shade-a-lator inputs.

Attachment 1 shows the two alternatives for which Shade-a-lator model inputs were developed. Attachment 2 provides detail on WWSP-funded planting in MRSP analyzed in Alternative 2.

Vegetation Restoration Alternatives

The two alternatives include:

1. Alternative 1 – Invasive Species Removal and Mature Canopy Restoration. This alternative involves replacement of mapped streamside invasive species populations with native, mature canopy cover along the lower Molalla River. Alternative 1 provides information on thermal benefits of treating invasives and replanting with native species regardless of landownership.
2. Alternative 2 –WWSP-funded Intensive Planting. This alternative predicts future mature canopy composition, height, and density based on Ash Creek Forest Management's (Ash Creek, planting contractor) planting plans for MRSP. Alternative 2 assesses thermal benefits of intensive native species plantings planned in MRSP.

These alternatives are intended to provide an estimated range of shading and thermal conditions resulting from planned or proposed vegetation restoration actions in the MRSP floodplain.

Vegetation Mapping

W2r's canopy cover mapping for the lower Molalla River from 2019 was used as baseline streamside vegetation cover for the mainstem Molalla River (Legg et al. 2019). This dataset was developed using high-resolution aerial photography, canopy height models, LiDAR, and field mapping by Ash Creek as detailed in W2r's 2019 memo.

W2r conducted additional vegetation canopy composition and density mapping in September and October 2021 in MRSP to coarsely map cover in floodplain areas outside of the immediate streamside zone. These data, in concert with canopy mapping provided by Ash Creek, were used to inform expected mature canopy densities for proposed vegetation restoration actions.

In both alternatives, land cover was classified by dominant species, height, and density, using DEQ land cover codes from the 2008 Molalla River Temperature Total Maximum Daily Load shown in Table 1 (Williams and Bloom 2008).

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Table 1. Streamside DEQ Land Cover Types in Molalla River State Park

Landcover Code	Landcover Type	Height (ft)	Density (%)
87	Natural Shrub	15	25
208	Black Hawthorn, Hedgerows, Brushy Fields	26	75
222	Willow	28	25
224	Willow	43	25
226	Willow	28	75
228	Willow	43	75
301	Water	0	0
400	Light Duty Roads	0	0
403	Barren Ag. Road	0	0
875	Natural Shrub	15	75
932	Christmas Tree	10	75
999	Gravel & Sand	0	0
4634	Ash, Cottonwood: Bottomland Pasture Mosaic	93	25
4636	Ash, Cottonwood: Bottomland Pasture Mosaic	33	75
4638	Ash, Cottonwood: Bottomland Pasture Mosaic	93	75

In alternative 1, mapped streamside populations of Japanese knotweed and Himalayan blackberry were replaced with predicted mature canopy cover, modeling the potential outcomes of the treatment and replacement of invasive species. Predicted landcover types were selected based on adjacent existing landcover types.

In alternative 2, WWSP-funded planned planting areas were mapped, and mature canopy cover was predicted based on planting plans provided by Ash Creek (see Attachment 2). Planting areas were classified as either 'willow' or 'standard' planting areas. Using heights of species which would dominate the canopy strata in each area, canopy densities measured in Fall 2021, and input from Ash Creek, DEQ landcover codes were assigned for these areas as outlined in Table 2.

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Table 2. DEQ Landcover Assignments for WWSP-funded Planting Areas

Attributes of plantings				Assigned DEQ Landcover			
Planting Type	**Dominant species to be planted**	**Maximum mature height of dominant species (ft)**	**Average measured canopy density for forest type (# measurements in MRSP)**	**Landcover Code**	**Landcover Type**	**Height (ft)**	**Density (%)**
Willow	*Salix lasiandra* *Salix scouleriana*	45[1] 35[2]	78% (n=2)	228	Willow	43	75
Standard	*Populus trichocarpa* *Fraxinus latifolia*	150[3] 80[4]	76% (n=5)	4638	Ash, Cottonwood: Bottomland Pasture Mosaic	93	75

[1] U.S. Department of Agriculture Natural Resources Conservation Service 2022.
[2] Anderson 2022.
[3] Niemiec et al. 1995a.
[4] Niemiec et al. 1995b.

Shade-a-lator Model Input Development

Using the existing and predicted vegetation mapping described above as inputs, W2r developed Shade-a-lator model inputs using the TTools geospatial toolbox (Michie 2019). Shade-a-lator model inputs were developed assuming that shade modeling efforts will use Heatsource Version 9 (Boyd et al. 2019). TTools were run separately for each alternative. The coordinate system for all data used is NAD_1983_2011_StatePlane_Oregon_North_FIPS_3601. Each TTool requires a series of data inputs; key input parameters are documented below.

Tool 1 – Segment Stream

This tool generates a feature class of model nodes along the stream centerline.

Key input parameters include:

- Node spacing (node_dx) of 50 meters.

Tool 2 – Measure Channel Width

This tool measures stream width at each node using input feature classes of left and right banks.

Key input parameters include:

- Left and right banks define the approximate bankfull channel.

Tool 3 – Sample Elevation Gradient (Array)

This tool measures stream slope at each model node.

Key input parameters include:

- Elevations of nodes sampled from water surface elevation captured in 2014 LiDAR (Metro).

Tool 4 – Measure Topographic Angles

This tool measures angles to adjacent terrain that allow for calculation of topographic shading.

Key input parameters include:

- USGS DEM (~10 m resolution) dataset used to sample terrain elevations extending at least 10 km from the project area.

Tool 5 – Sample Landcover (Point Method)

This tool samples landcover types and parameters from the various datasets described above in this memo. Note the version of Tool 5 using the Zone Method was not used.

Key input parameters include:

- Sampling transects were defined at 8 directions (N, NE, E, SE, S, SW, W, NW; "trans_count") with 18 samples out along each direction ("transsample_count") at a spacing of 4 meters ("transsample_distance"). This set of parameters creates a maximum sample distance of 72 m from the channel centerline.

- For each alternative, canopy density was represented by a "CanopyCover" raster, and canopy height was represented by a "CanopyHeight" raster. To generate these rasters, predicted mature canopy polygons were mosaiced with the USGS DEM.
    - For alternative 1, mapped invasive species polygons were mosaiced with the DEM. Canopy density and height attributes of the predicted mature canopy type expected following invasive species treatment and native species replanting were assigned to these areas.
    - For alternative 2 WWSP-funded planting areas were mosaiced with the DEM. Canopy density and height attributes of the predicted mature canopy type outlined in Table 2 were assigned to these areas.

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Data Provided with Memo

- Geospatial data layers input to and output from TTools
- TTools scripts with saved input values for both alternatives
- Landcover data tables for both alternatives which will serve as inputs to the Shade-a-lator model

References

Anderson, Michelle D. 2001. Salix scouleriana. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). <https://www.fs.fed.us/database/feis/plants/tree/salsco/all.html> [2022, March 11].

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Legg, N., Bowers, E., Rudolph, J. 2019. Technical Memorandum: Existing Condition Canopy Mapping and Shade-a-lator Model Vegetation Inputs.

Michie, R. 2019. TTools 9.0.0 (beta) <https://github.com/rmichie/TTools>.

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Niemiec, S. S., Ahrens, G.R., Willits, S., and Hibbs, D.E. 1995b. Hardwoods of the Pacific Northwest. Research Contribution 8. Oregon State University, Forest Research Laboratory. < https://owic.oregonstate.edu/oregon-ash-fraxinus-latifolia>.

U.S. Department of Agriculture Natural Resources Conservation Service. Pacific Willow Plant Guide. <https://plants.usda.gov/DocumentLibrary/plantguide/pdf/pg_salul.pdf>. Accessed March 11, 2022.

Williams, Karen Font, and Bloom, James. 2008. Molalla-Pudding Subbasin Total Maximum Daily Load and Water Quality Management Plan – Chapter 2: Temperature. 2008.

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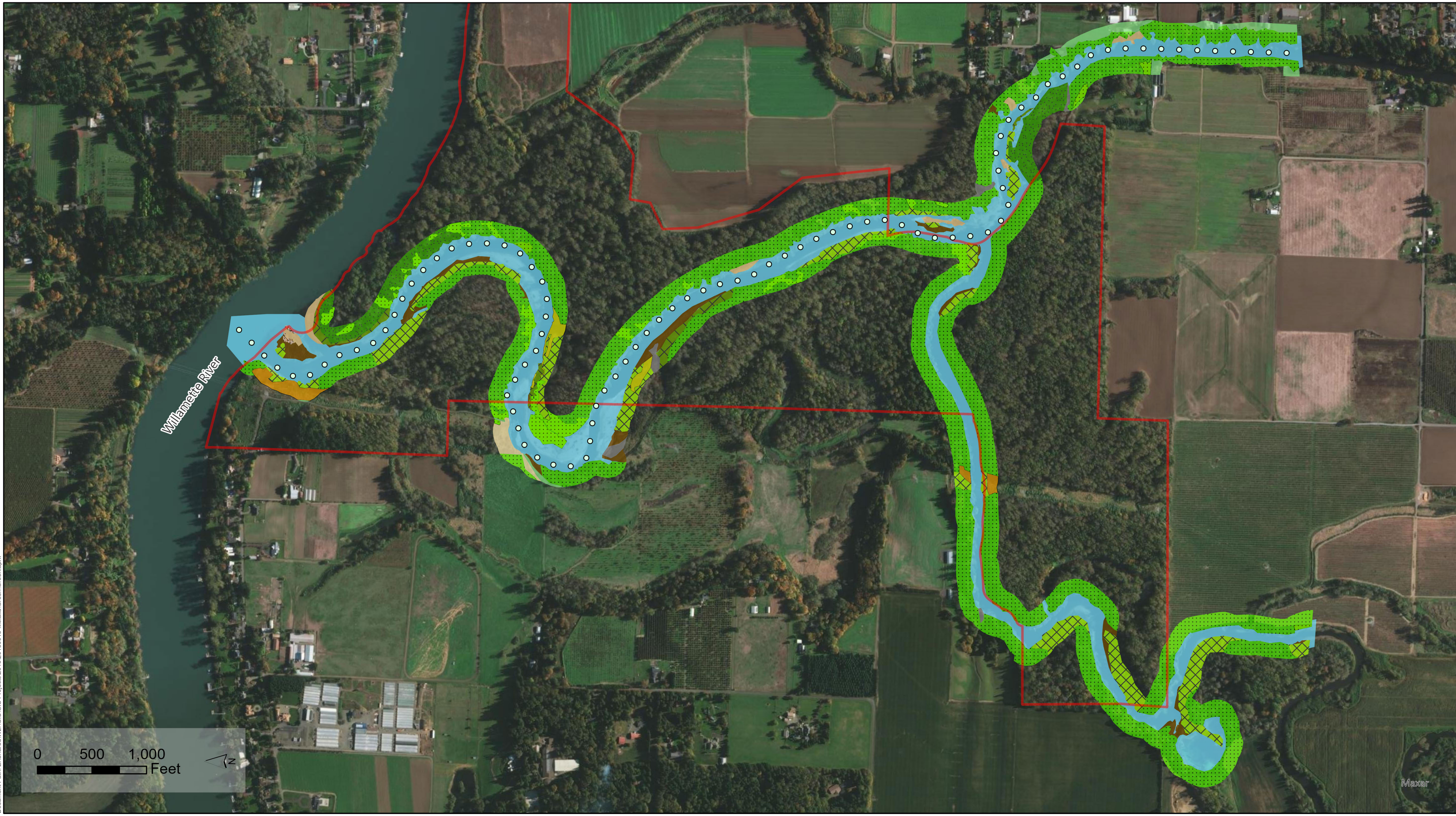
Attachment 1: Alternative Maps



Canopy Cover Type

- Natural Shrub - 87
- Bare/fallow - 88
- Black Hawthorn, Hedgerows, Brushy Fields - 208
- Willow - 222
- Willow - 224
- Willow - 228
- Water - 301
- Light Duty Roads - 400
- Barren - Ag. Road - 403
- Natural Shrub - 875
- Gravel & Sand - 999
- Ash, Cottonwood: Bottomland Pasture Mosaic - 4634
- Ash, Cottonwood: Bottomland Pasture Mosaic - 4636
- Ash, Cottonwood: Bottomland Pasture Mosaic - 4638
- Japanese Knotweed Monoculture - 8752
- Himalayan Blackberry Monoculture - 8754

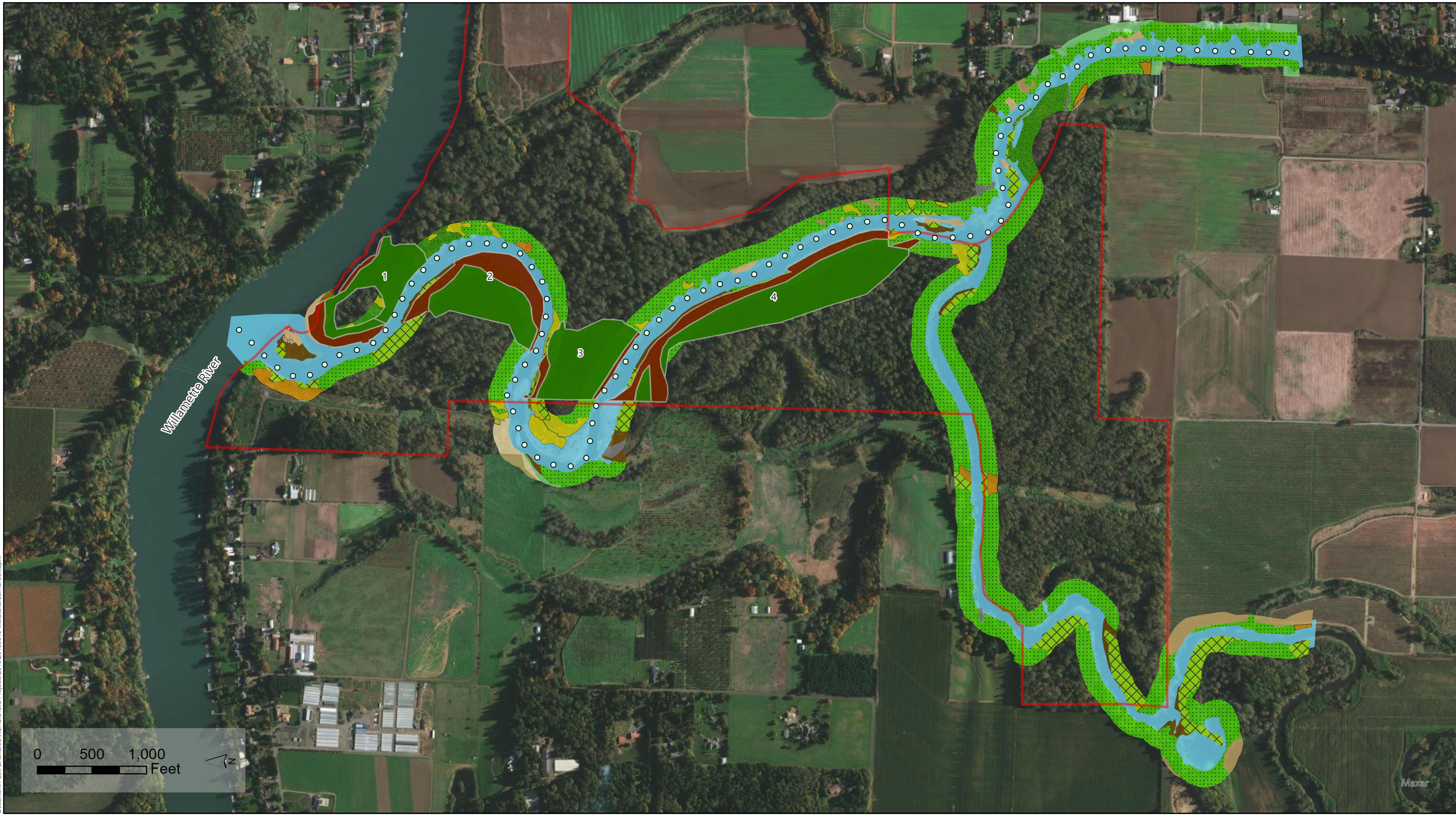
- Molalla River State Park Boundary
- Shadolator model nodes (50 m increments)

Molalla River State Park

Shade Model Inputs - Alt 1

Wolf Water Resources

Molalla River Watch Watershed Council



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Molalla River State Park

Shade Model Inputs - Alt 2

Canopy Cover Type

- Natural Shrub - 87
- Bare/fallow - 88
- Black Hawthorn, Hedgerows, Brushy Fields - 208
- Willow - 222
- Willow - 224
- Willow - 228
- Water - 301
- Light Duty Roads - 400
- Barren - Ag. Road - 403
- Natural Shrub - 875
- Gravel & Sand - 999
- Ash, Cottonwood: Bottomland Pasture Mosaic - 4634
- Ash, Cottonwood: Bottomland Pasture Mosaic - 4636
- Ash, Cottonwood: Bottomland Pasture Mosaic - 4638
- Japanese Knotweed Monoculture - 8752
- Himalayan Blackberry Monoculture - 8754

- Molalla River State Park Boundary
- Shadolator model nodes (50 m increments)
- Planting Areas
- Willow planting
- Standard planting

WOLF WATER RESOURCES

Molalla River WATCH WATERSHED COUNCIL

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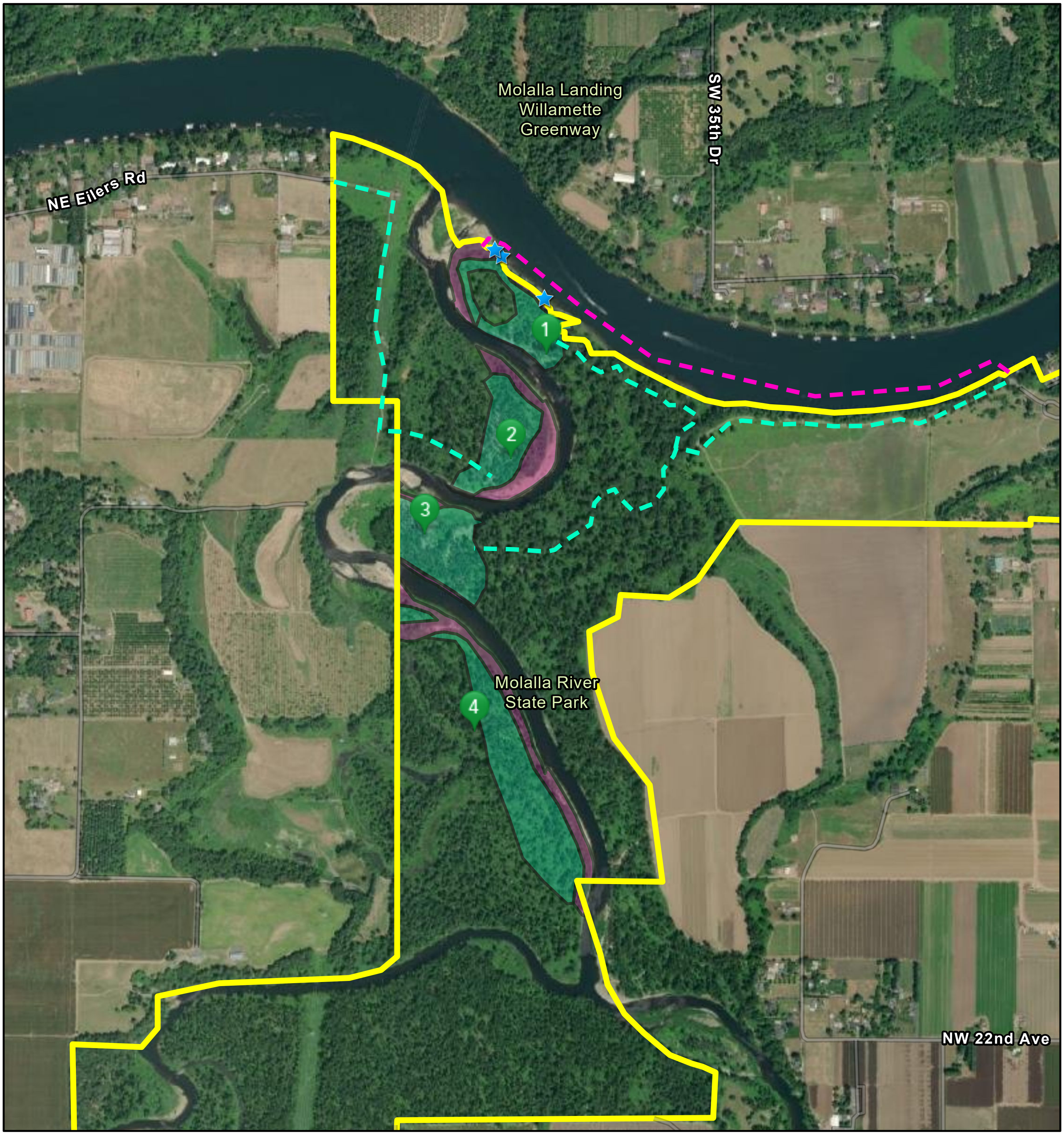
Attachment 2: Molalla River State Park Planting Areas and Plans

Molalla River Planting Entries



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Molalla River State Park - Field Notes (Points)

- Area 1
- Area 2
- Area 3
- Area 4
- Boat Landing

Molalla River State Park - Field Notes (Lines)

- Site Boundaries
- Aquatic Entry
- Foot Entry

Molalla River State Park - Field Notes (Areas)

- Willow Planting
- Standard Planting

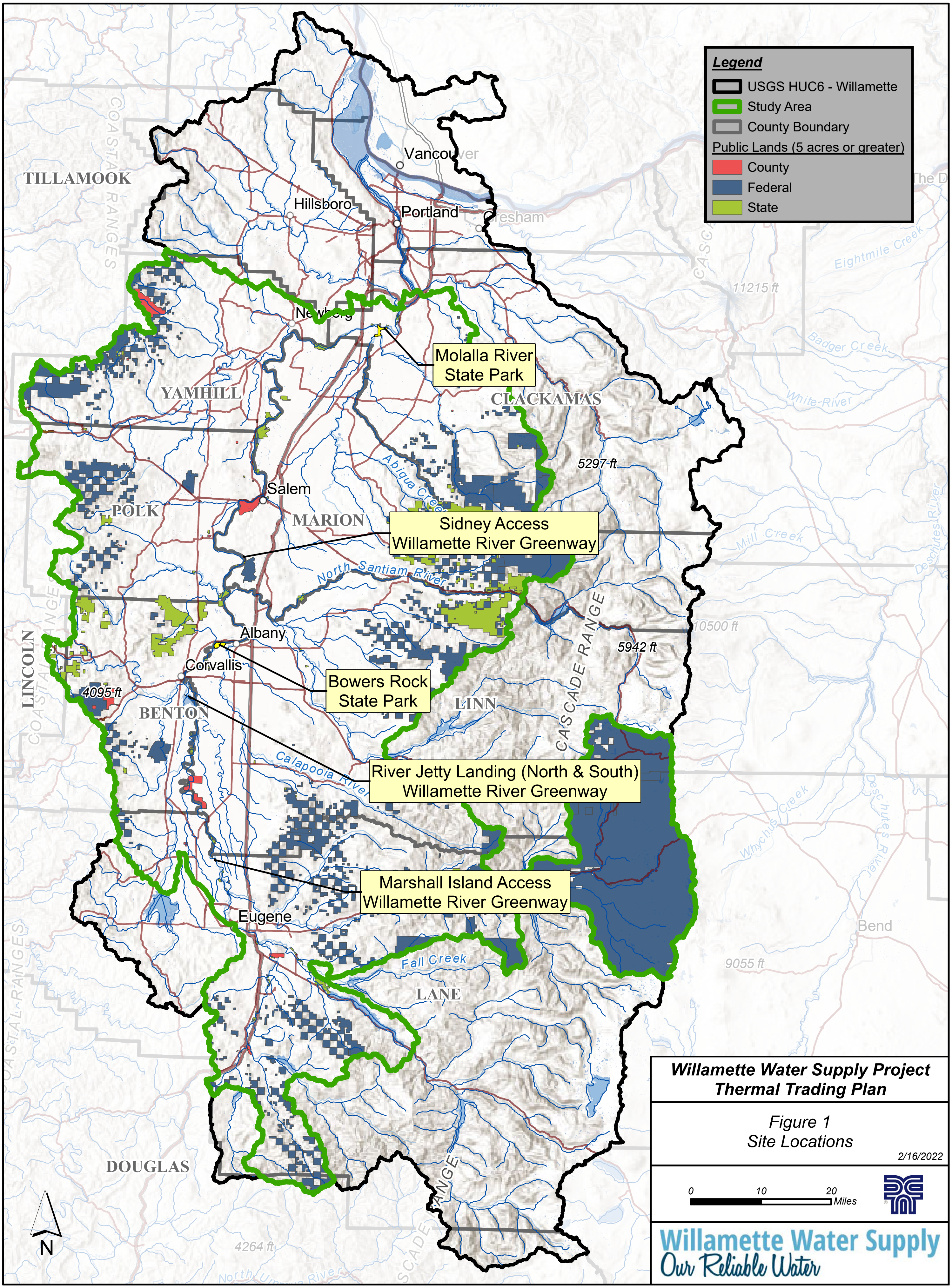
Oregon Metro, State of Oregon GEO, Esri Canada, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc., METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA, Earthstar Geographics

Ash Creek Forest Management - Molalla River State Park planting plan

Bare-Root						Zone 1		Zone 2		Zone 3		Zone 4		
Species	**Common Name**	**Bag Label**	**Type**	**Location**	**Stock Type**	**Amount**	**Planted**	**Amount**	**Planted**	**Amount**	**Planted**	**Amount**	**Planted**	**Remaining**
Acer circinatum	Vine Maple	ACE CIR	Shrub	Shade	bare-root	**250**				**500**		**250**		1000
Cornus nuttallii	Pacific Dogwood	COR NUT	Tree	Shade	bare-root	**100**		**250**		**400**		**250**		1000
Cornus serica (stolonifera)	Red Osier Dogwood	COR SER/COR STO	Shrub	All	bare-root	**1000**		**1000**		**2000**		**1000**		5000
Euonymus occidentalis	Western Wahoo	EUO OCC	Shrub	Shade	bare-root	**250**		**250**		**250**		**250**		1000
Fraxinus latifolia	Oregon Ash	FRA LAT	Tree	All	bare-root	**100**		**100**		**500**		**300**		1000
Lonicera involucrata	Black Twinberry	LON INV	Shrub	All	bare-root	**250**		**500**		**750**		**500**		2000
Mahonia nervosa	Dull Oregon Grape	MAH NER	Shrub	Shade	bare-root					**750**		**250**		1000
Oemleria cerasiformis	Osoberry	OEM CER	Shrub	Shade	bare-root					**750**		**250**		1000
Physocarpus capitatus	Pacific Ninebark	PHY CAP	Shrub	All	bare-root	**250**		**250**		**250**		**250**		1000
Populus trichocarpa	Black Cottonwood	POP TRI	Tree	All	bare-root	**100**		**100**		**550**		**250**		1000
Prunus virginiana	Choke Cherry	PRU VIR	Tree	All	bare-root			**100**		**500**		**400**		1000
Rhamnus purshiana	Cascara	RHA PUR	Tree	All	bare-root			**100**		**500**		**400**		1000
Rosa gymnocarpa	Bald Hip Rose	ROS GYM	Shrub	Shade	bare-root	**250**		**500**		**750**		**500**		2000
Rubus spectabilis	Salmonberry	RUB SPE	Shrub	Shade	bare-root	**250**		**500**		**750**		**500**		2000
Sambucus racemosa	Red Elderberry	SAM RAC	Shrub	Shade	bare-root	**250**		**500**		**750**		**500**		2000
Spiraea douglasii	Douglas Spiraea	SPI DOU	Shrub	Sun	bare-root	**250**		**500**		**750**		**500**		2000
					Totals	**3300**	**0**	**4650**	**0**	**10700**	**0**	**6350**	**0**	25000

Cuttings						Zone 1		Zone 2		Zone 3		Zone 4		
Species	**Common Name**	**Bag Label**	**Type**	**Location**	**Stock Type**	**Amount**	**Planted**	**Amount**	**Planted**	**Amount**	**Planted**	**Amount**	**Planted**	**Remaining**
Cornus serica (stolonifera)	Red Osier Dogwood	n/a	Shrub	All	Cutting	**500**		**250**		**0**		**250**		1000
Salix lasiandra	Pacific Willow	n/a	Tree	Sun	Cutting	**2500**		**2500**		**1000**		**4000**		10000
Salix piperi	Piper Willow	n/a	Tree	Sun	Cutting	**2500**		**2500**		**1000**		**4000**		10000
Salix scouleriana	Scouler Willow	n/a	Tree	All	Cutting	**1000**		**2000**		**500**		**500**		4000
Salix sitchensis	Sitka Willow	n/a	Shrub	All	Cutting	**1000**		**2000**		**1000**		**1000**		5000
					Totals	**7500**	**0**	**9250**	**0**	**3500**	**0**	**9750**	**0**	30000

Appendix C: Additional Potential Restoration Opportunities



Willamette Water Supply Project
Thermal Trading Plan

Figure 1
Site Locations

2/16/2022

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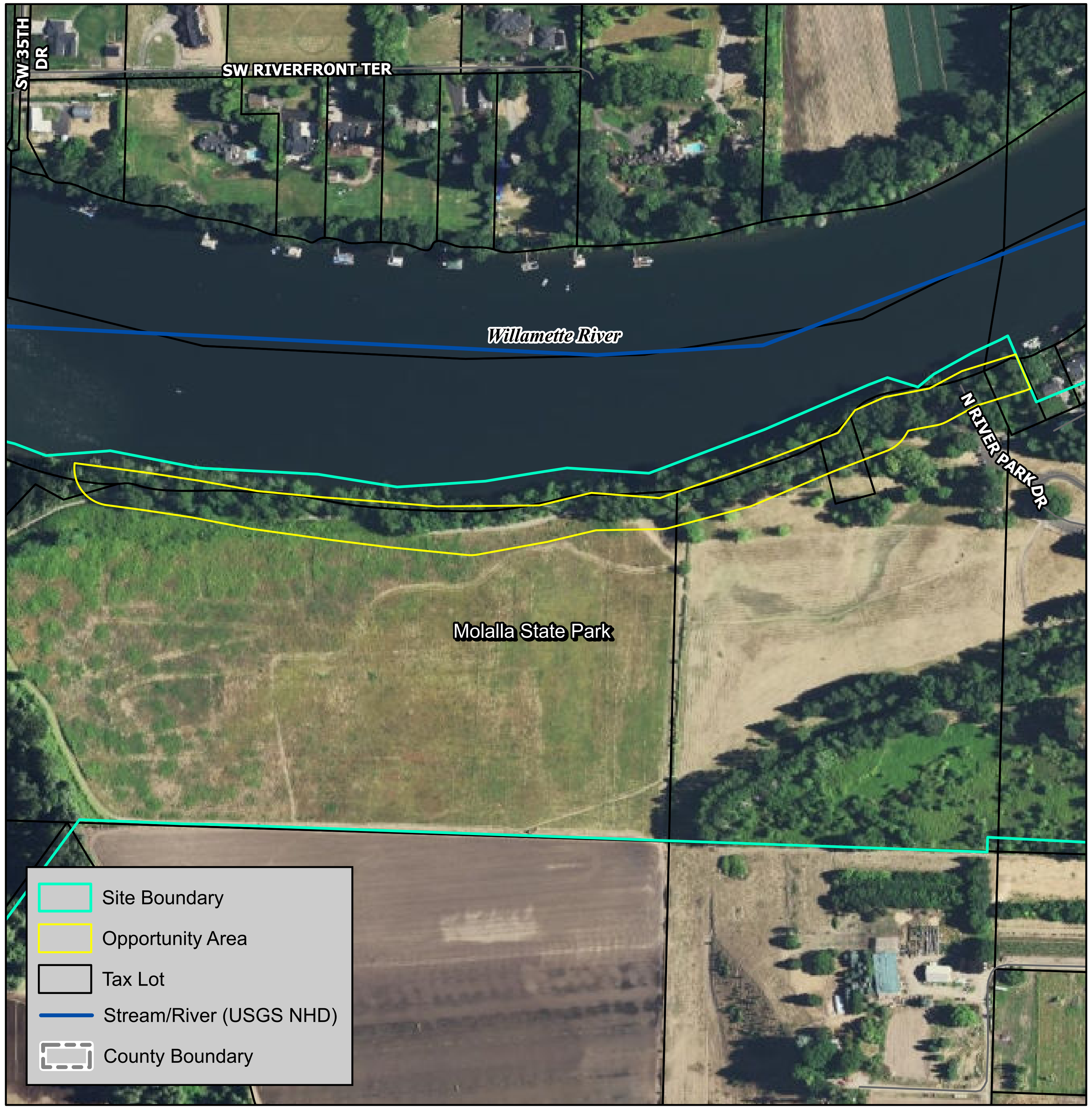

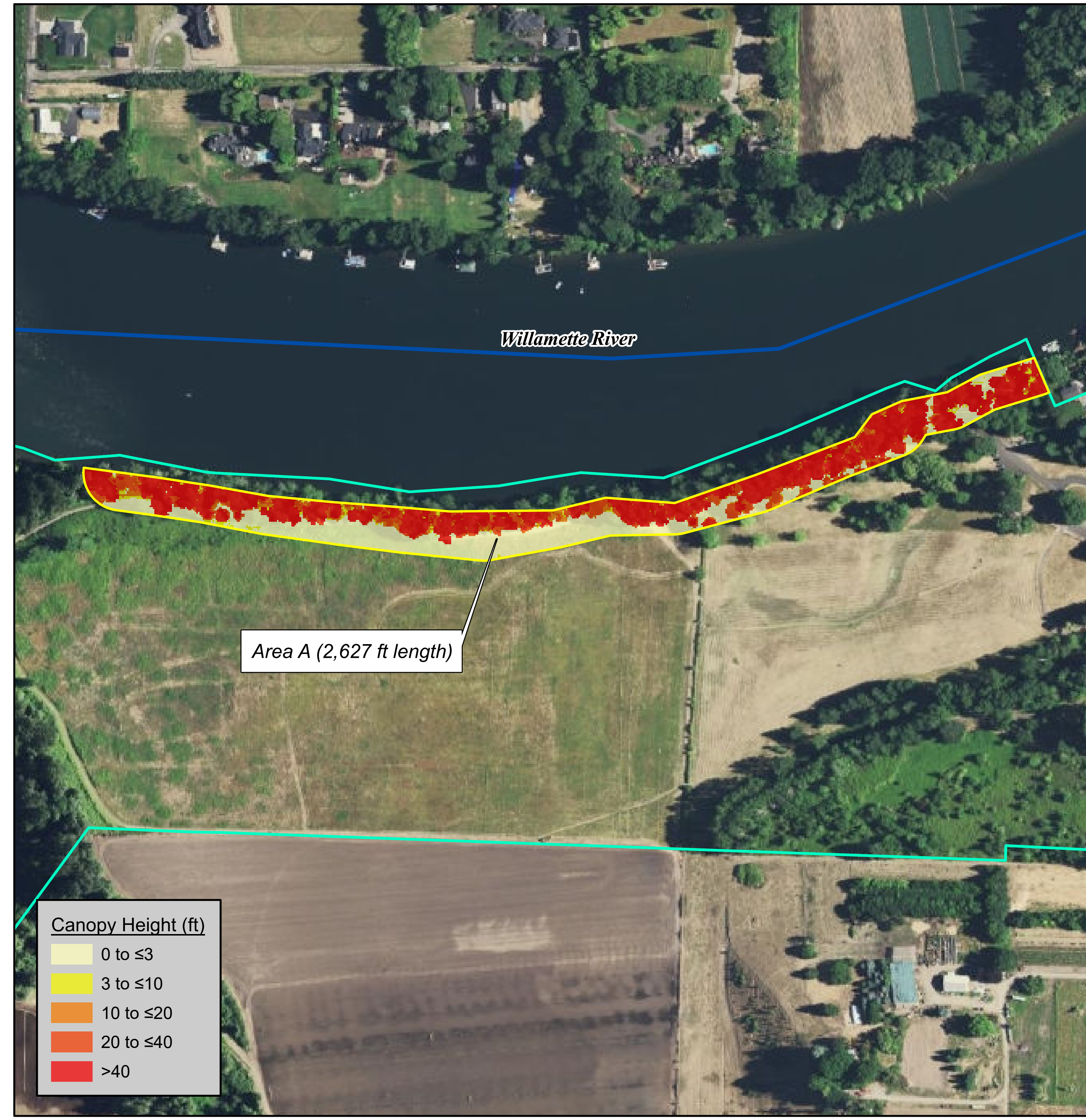

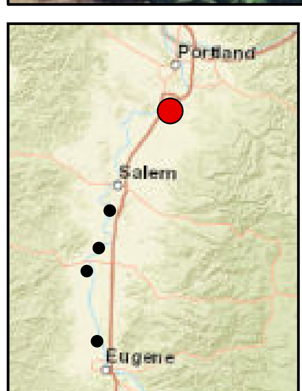

Background imagery: Oregon State Aerial (OSIP) 2019

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Canopy Height in Acres	≤ 3ft	> 3ft to ≤ 10ft	> 10ft to ≤ 20ft	> 20ft to ≤ 40 ft	> 40 ft	Total
Molalla River State Park	2.08	0.1	0.24	0.67	3.15	6.24

Information shown is based on publicly available GIS data, including LIDAR derived canopy height (source: DOGAMI). Information is for planning purposes only.

Willamette Water Supply Program
Thermal Trading Plan

Potential Shade Credit Opportunities
Molalla State Park

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2/22/2022

Willamette Water Supply
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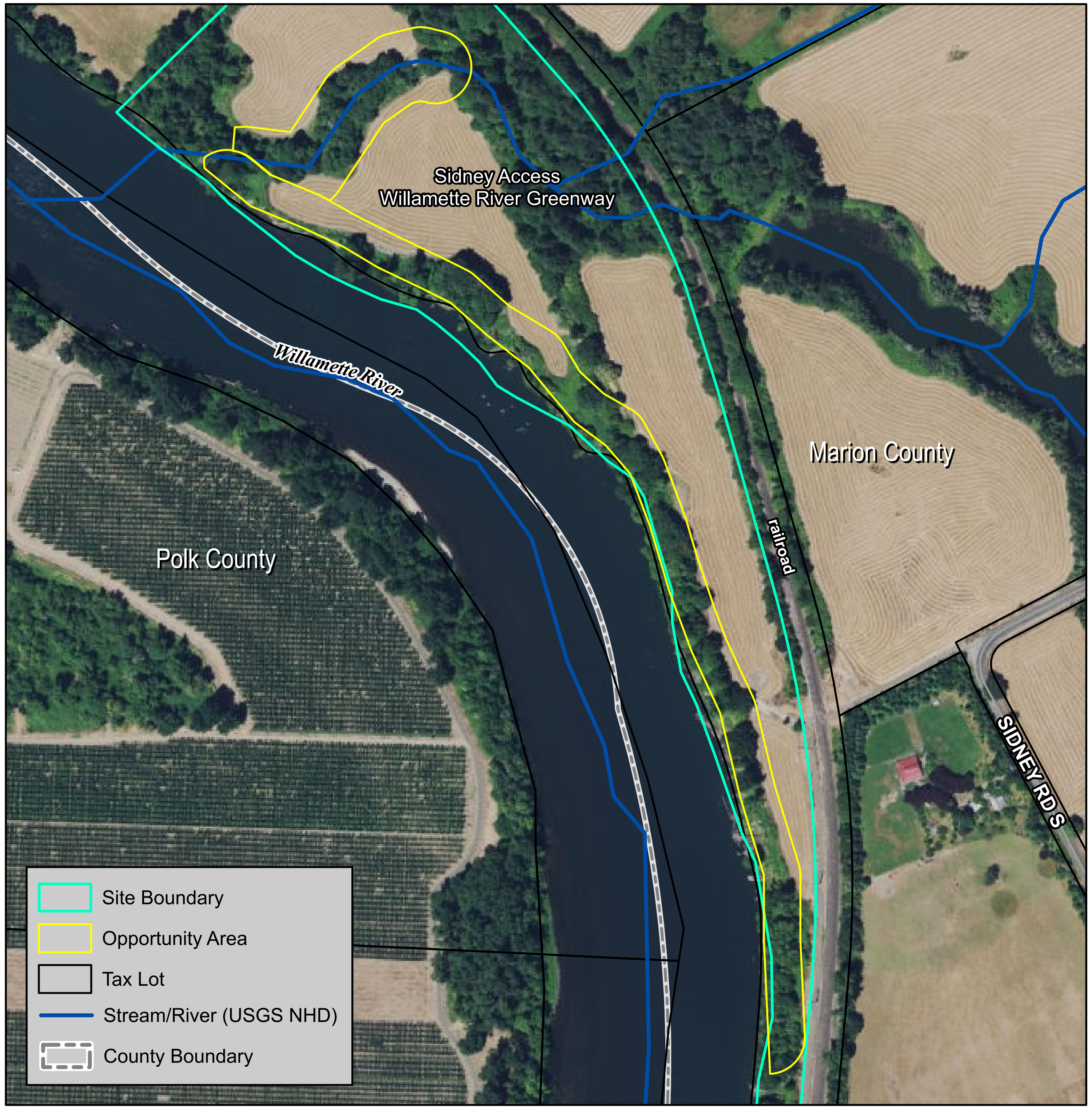

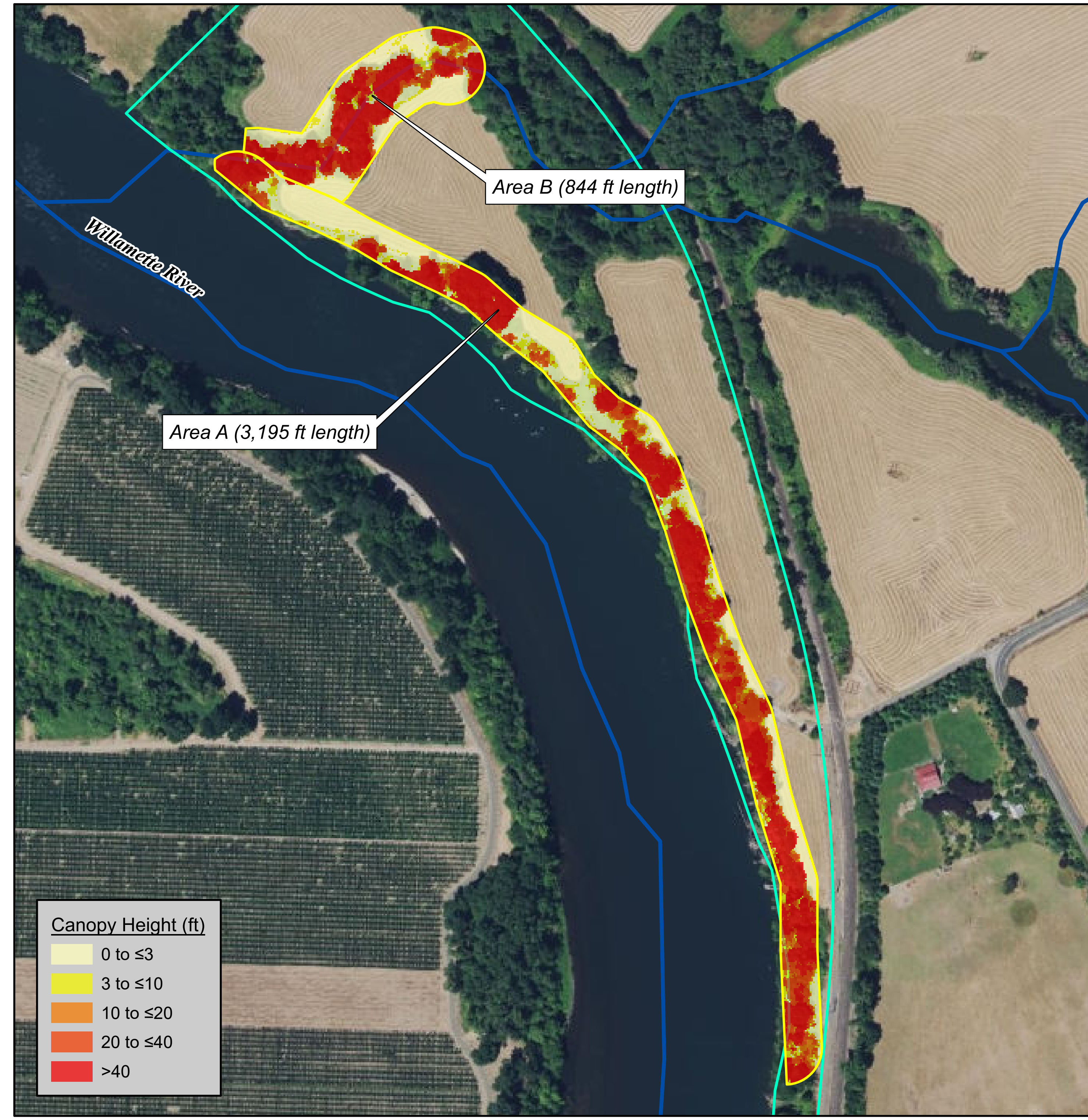

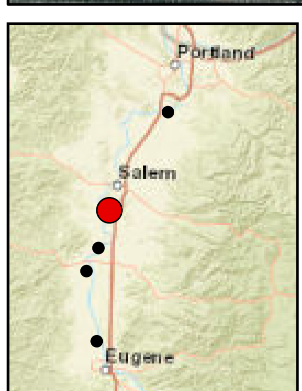

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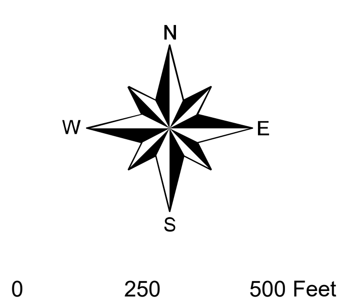

Canopy Height in Acres	≤ 3ft	> 3ft to ≤ 10ft	> 10ft to ≤ 20ft	> 20ft to ≤ 40 ft	> 40 ft	Total
Sidney Access Willamette River Greenway Site A	2.46	0.37	0.47	1.11	3.03	7.44
Sidney Access Willamette River Greenway Site B	1.16	0.12	0.08	0.34	1.38	3.08
Site Total	3.62	0.49	0.55	1.45	4.41	10.52

Information shown is based on publicly available GIS data, including LIDAR derived canopy height (source: DOGAMI). Information is for planning purposes only.

Willamette Water Supply Program Thermal Trading Plan

Potential Shade Credit Opportunities
Sidney Access
Willamette River Greenway

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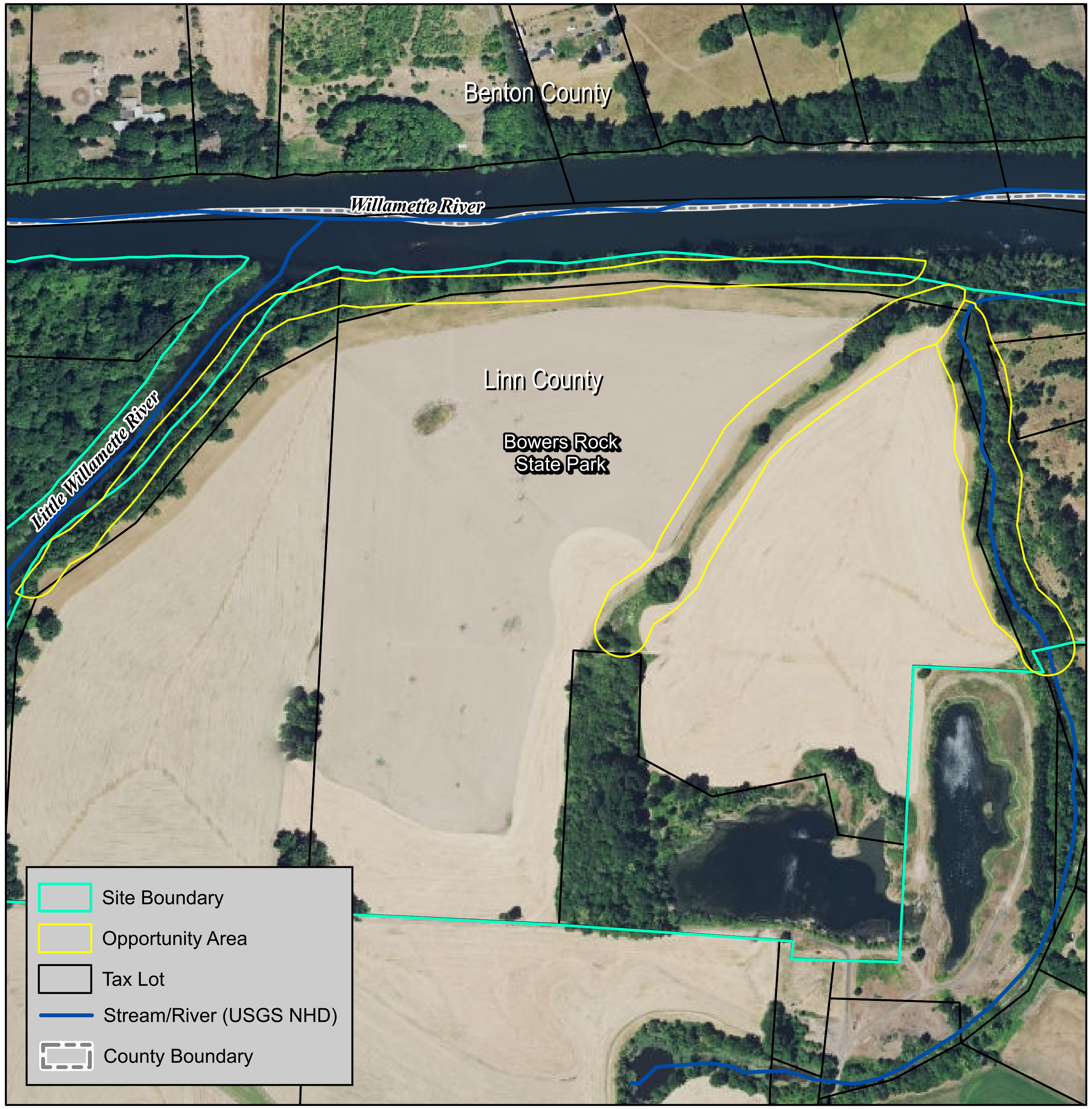

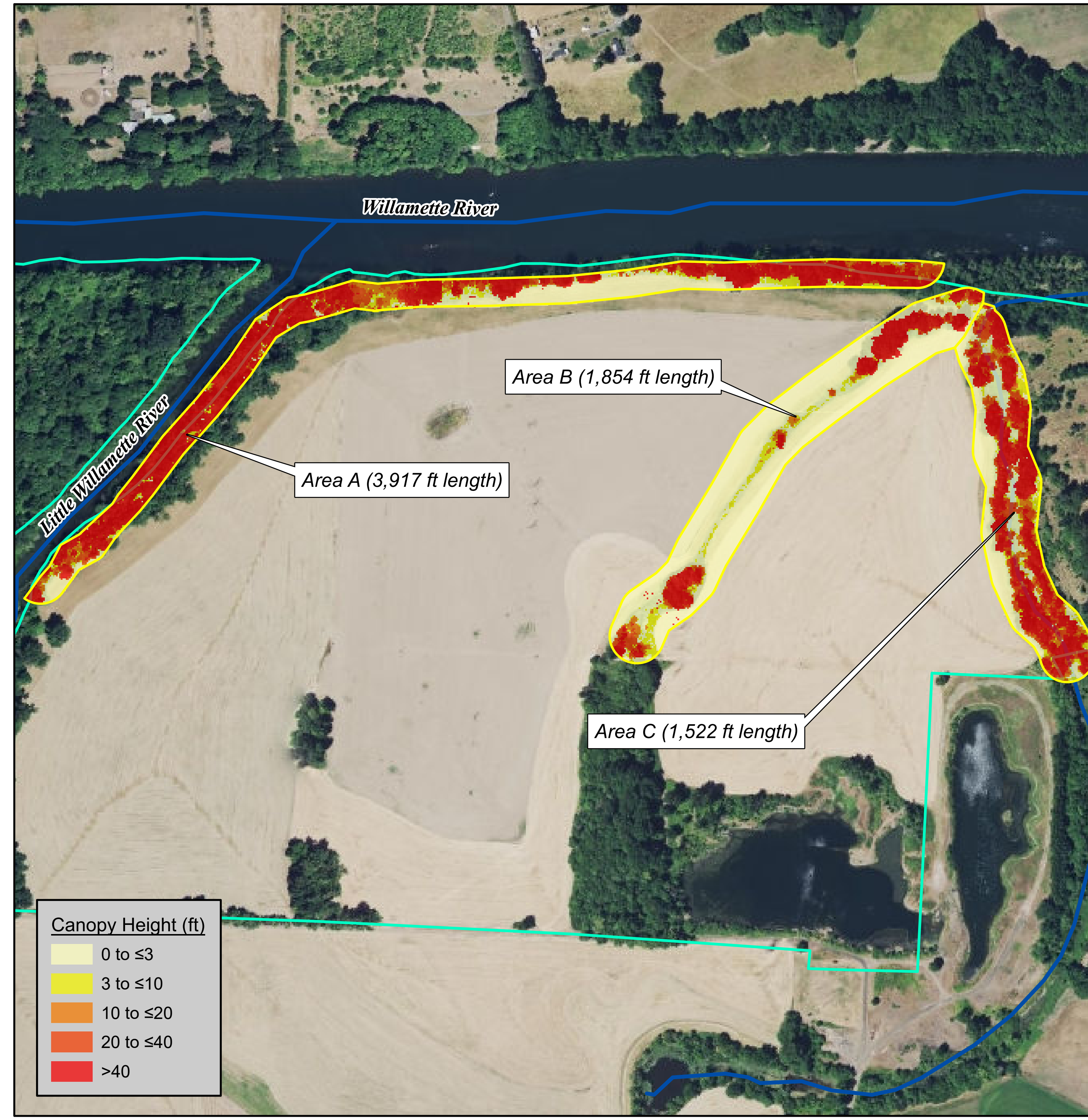

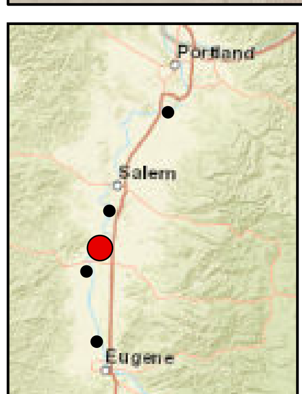

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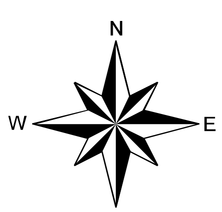

Canopy Height in Acres	≤ 3ft	> 3ft to ≤ 10ft	> 10ft to ≤ 20ft	> 20ft to ≤ 40 ft	> 40 ft	Total
Bowers Rock State Park Site A	6.5	0.32	0.19	0.28	1.17	8.46
Bowers Rock State Park Site B	2.01	0.37	0.43	0.77	5.18	8.76
Bowers Rock State Park Site C	1.93	0.3	0.38	1.07	2.77	6.45
Site Total	10.44	0.99	1	2.12	9.12	23.67

Information shown is based on publicly available GIS data, including LIDAR derived canopy height (source: DOGAMI). Information is for planning purposes only.

Willamette Water Supply Program
Thermal Trading Plan

Potential Shade Credit Opportunities
Bowers Rock State Park

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Willamette Water Supply
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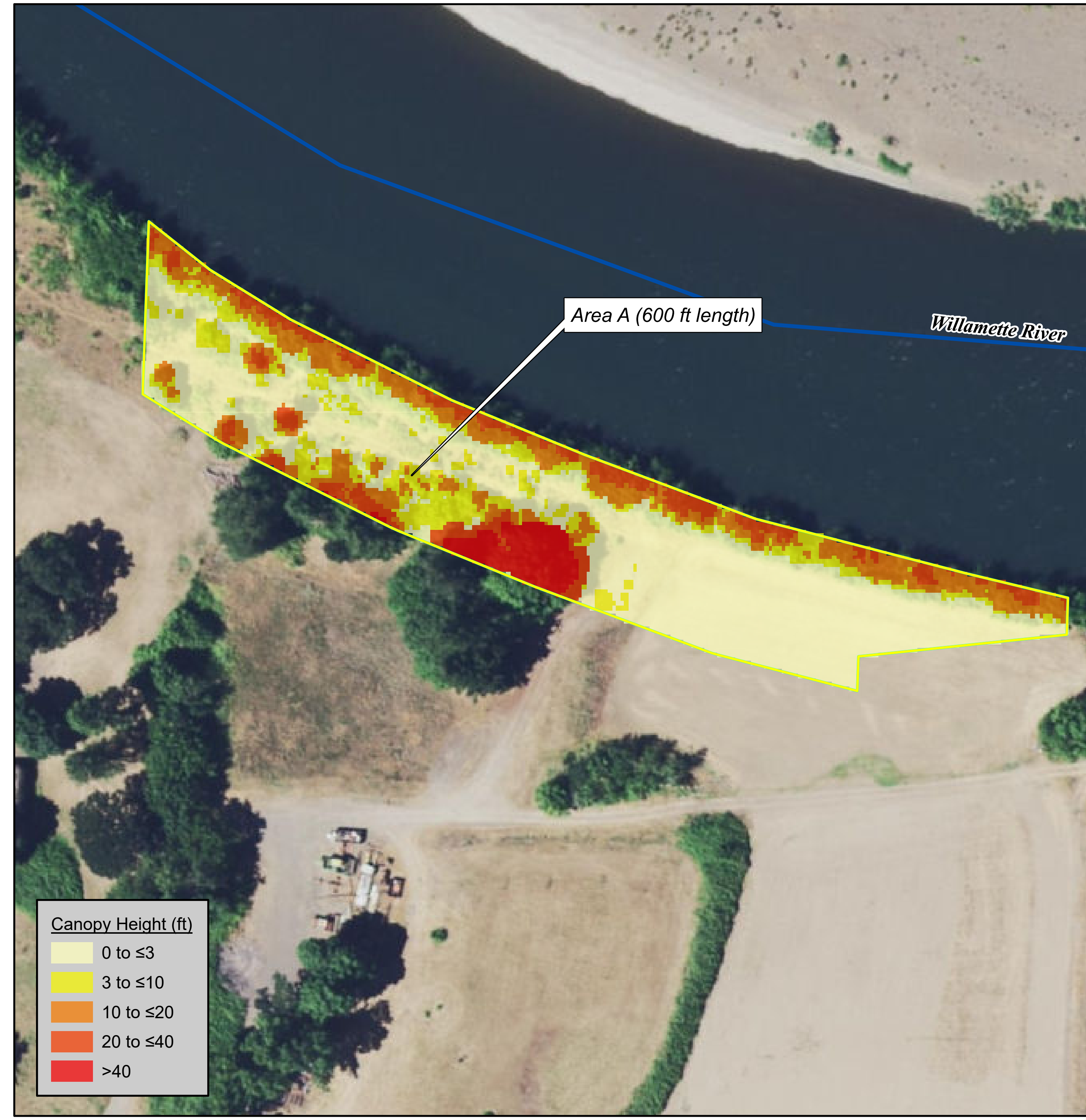

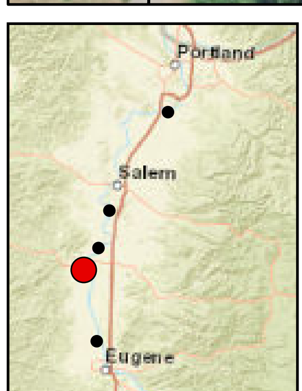

Background imagery: Oregon State Aerial (OSIP) 2019

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Canopy Height in Acres	≤ 3ft	> 3ft to ≤ 10ft	> 10ft to ≤ 20ft	> 20ft to ≤ 40 ft	> 40 ft	Total
River Jetty Landing (North) Willamette River Greenway Site A	0.84	0.19	0.23	0.12	0.07	1.45

Information shown is based on publicly available GIS data, including LIDAR derived canopy height (source: DOGAMI). Information is for planning purposes only.

Willamette Water Supply Program Thermal Trading Plan

Potential Shade Credit Opportunities
River Jetty Landing (North)
Willamette River Greenway

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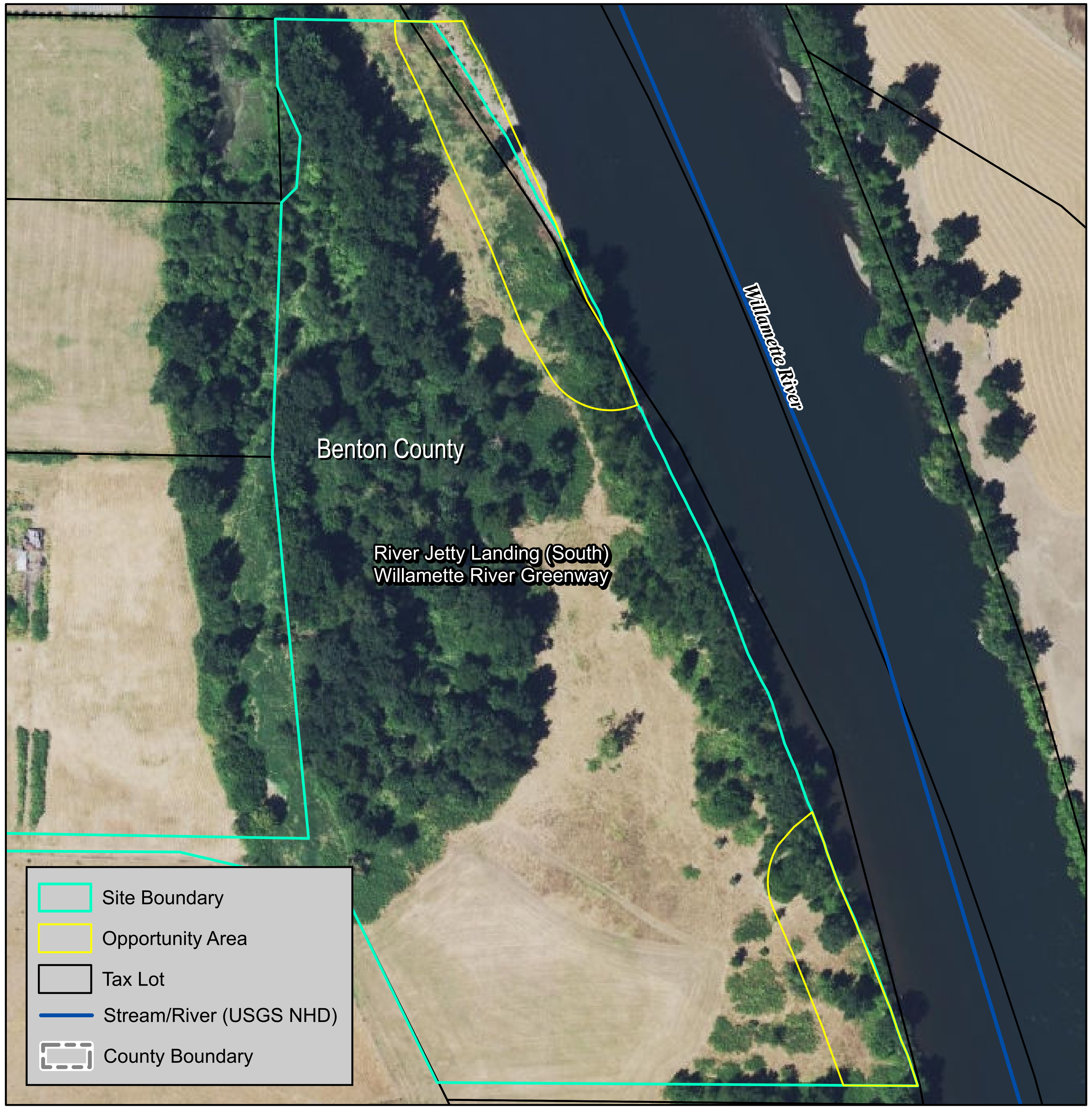
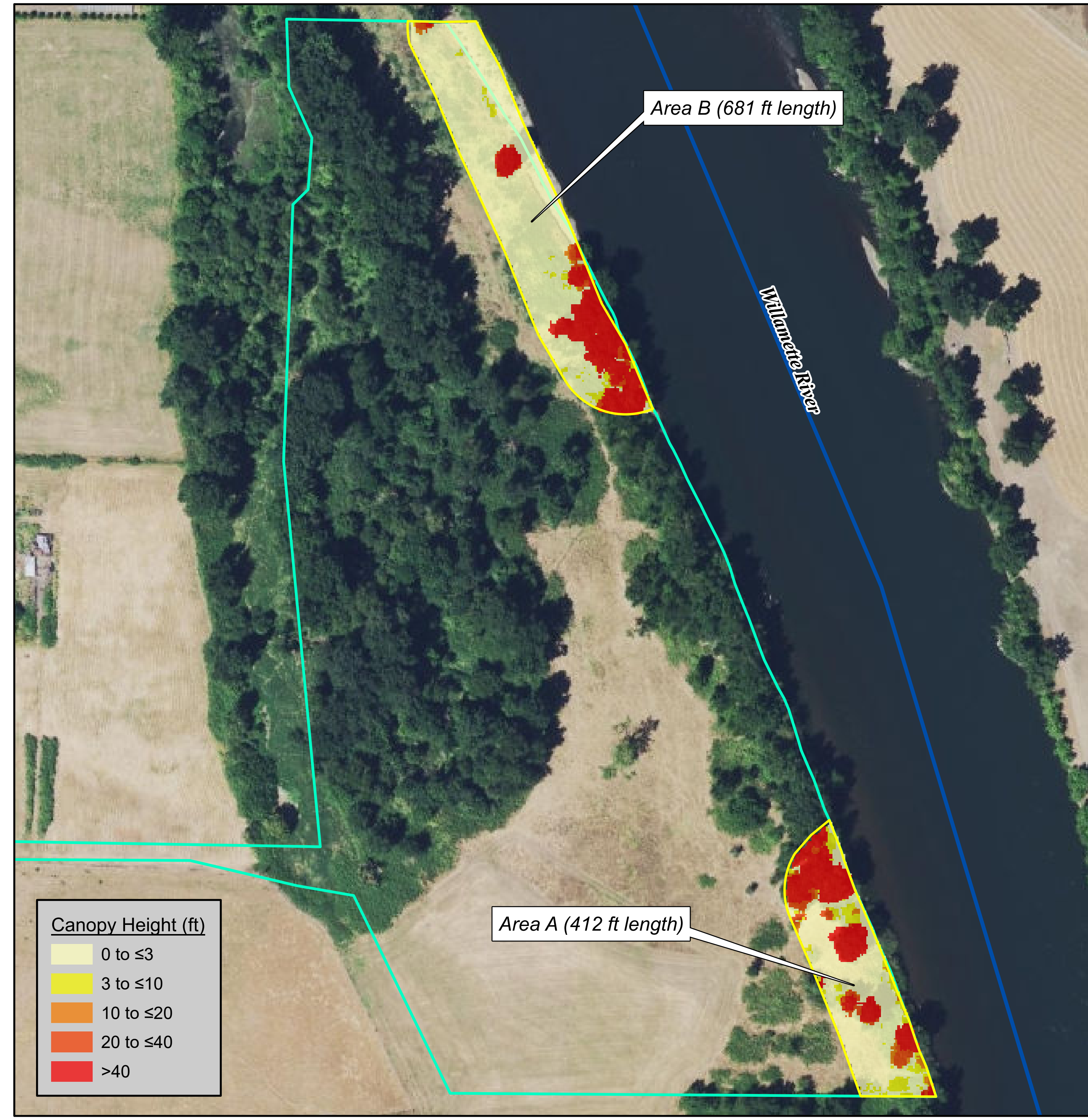
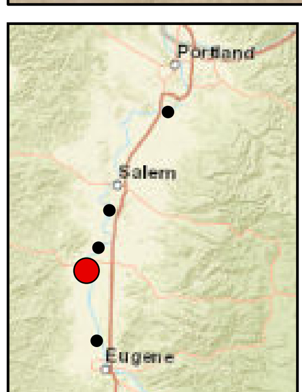
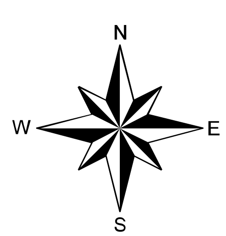
Willamette Water Supply
Our Reliable Water







Background imagery: Oregon State Aerial (OSIP) 2019



0 250 500 Feet

Canopy Height in Acres	≤ 3ft	> 3ft to ≤ 10ft	> 10ft to ≤ 20ft	> 20ft to ≤ 40 ft	> 40 ft	Total
River Jetty Landing (South) Willamette River Greenway Site A	0.49	0.06	0.02	0.05	0.24	0.86
River Jetty Landing (South) Willamette River Greenway Site B	1.05	0.02	0.01	0.03	0.28	1.39
Site Total	1.54	0.08	0.03	0.08	0.52	2.25

Information shown is based on publicly available GIS data, including LIDAR derived canopy height (source: DOGAMI). Information is for planning purposes only.

Willamette Water Supply Program Thermal Trading Plan

Potential Shade Credit Opportunities
River Jetty Landing (South)
Willamette River Greenway

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Willamette Water Supply
Our Reliable Water

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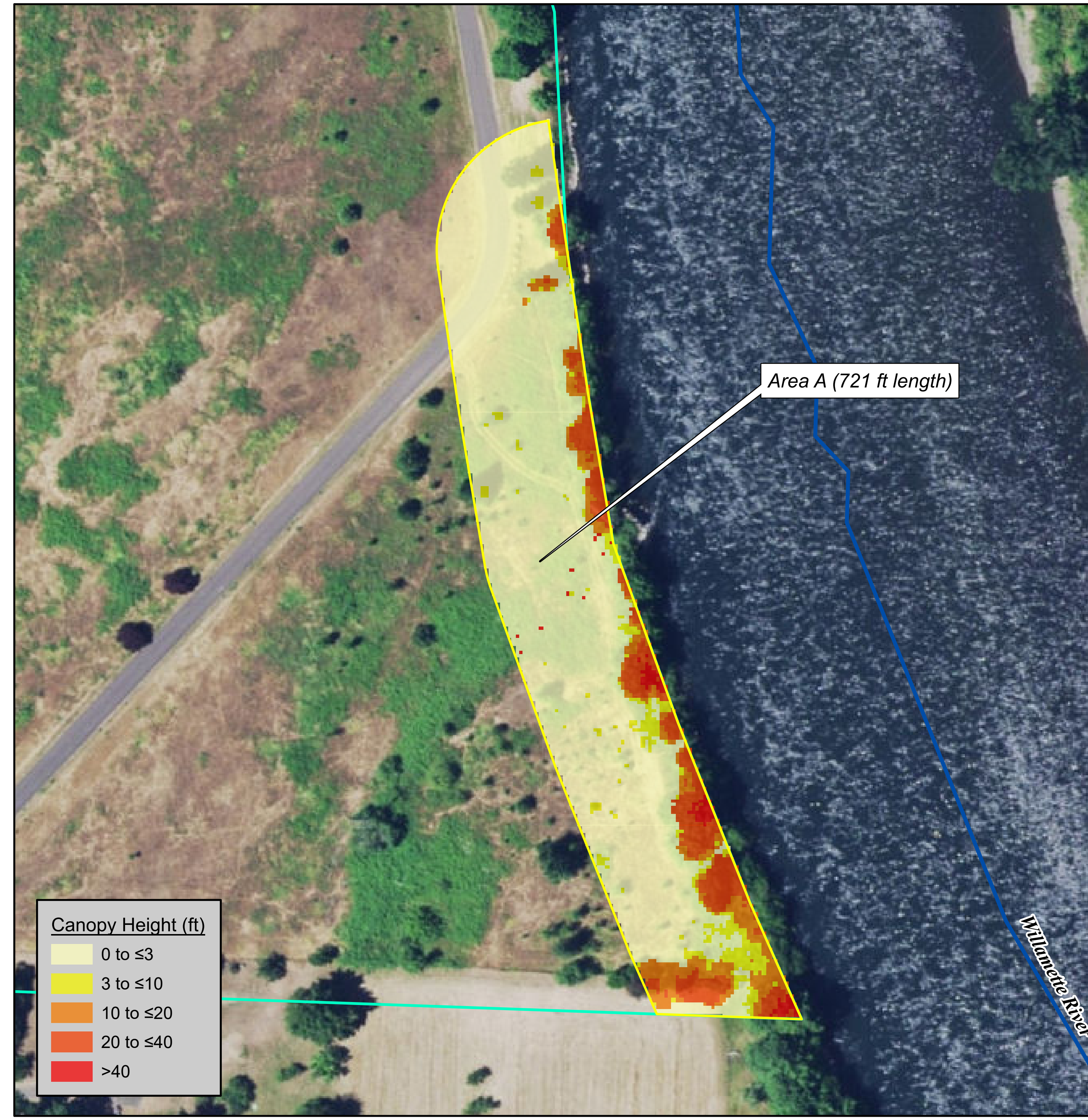

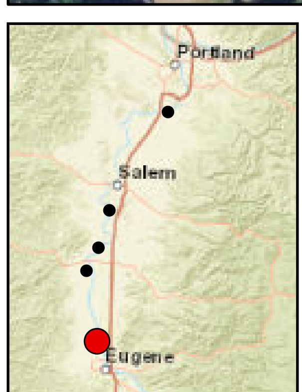

Background imagery: Oregon State Aerial (OSIP) 2019

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Canopy Height in Acres	≤ 3ft	> 3ft to ≤ 10ft	> 10ft to ≤ 20ft	> 20ft to ≤ 40 ft	> 40 ft	Total
Marshall Island Access Willamette River Greenway	1.25	0.06	0.12	0.14	0.02	1.59

Information shown is based on publicly available GIS data, including LIDAR derived canopy height (source: DOGAMI). Information is for planning purposes only.

Willamette Water Supply Program Thermal Trading Plan

Potential Shade Credit Opportunities
Marshall Island Access
Willamette River Greenway

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Willamette Water Supply
Our Reliable Water

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