EXHIBIT 21
CUP16-02

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MEMO

To: **City of Camas**

From: Jeremy Fick, PE
John Baldwin, PE
Robertson Engineering, PC

Date: February 7, 2017

Re: **Lacamas Heights E.S. Off-Site Road Improvements – 50% Design Summary**

Robertson Engineering is designing a new public roadway in association with the proposed Lacamas Heights Elementary School. The 40-acre school site is located northeast of the intersection of NE 232nd Avenue and NE 9th Street. Both 232nd Avenue and 9th Street are identified as future 3-lane arterials in the City of Camas's (City) Comprehensive Plan with 232nd Avenue as a local access road and trail south of 9th Street. The new road is being designed as the first phase (Phase 1) of the future 3-lane urban arterial planned by the City. The purpose of this memo is to provide the City with the information necessary to evaluate and approve the preferred alignment and basic design criteria used for the road design.

The 40-acre site has several documented wetlands and Oregon white oak trees, and is partially wooded in the SW quadrant where the new public roadway is planned. The new elementary school will be approximately 73,500 s.f. in size, and serve 700 students. It is estimated that the school will generate an average daily trip count of 774 during school days. The goal of the project is to provide the school with appropriate access via a new two-lane road that will function on an interim basis. The new roadway will be expanded and extended in the future by others to a 3-lane urban arterial. As such, the new interim (Phase 1) roadway will be designed to accommodate future expansion and to meet design standards for the urban arterial where feasible.

All of the land south of the proposed north right-of-way line (37 ft. offset from the proposed future arterial centerline) is proposed to be dedicated to the City as right-of-way. This area totals approximately 236,377 square feet (5.43 acres). Dedicating this entire area allows for potential future improvements, such as road widening, local access, trailhead, wetland mitigation, and stormwater treatment and detention.

This 50% Design Summary Memo addresses the following:

- Typical roadway cross-section.
- Horizontal alignment for future urban arterial through the site (to be used as basis for Phase 1 roadway design), and right-of-way required for urban arterial
- Vertical alignment for construction of Phase 1 roadway and future urban arterial through site.
- Intersection layout at NE 232nd Ave. and at school entrance.
- Sight distance compliance for roadway and intersections.
- Preliminary stormwater management strategy.

CROSS-SECTION

The proposed cross-section of the Phase 1 roadway is designed to meet site topography demands and to plan for widening with minimal reconstruction. The paved roadway is slightly larger than half of the future 3-lane arterial, as shown in City of Camas Standard Detail ST5. The roadway pavement will be a minimum of 26 ft. wide, providing for two 13 ft. lanes of traffic. The north side of the road will have curb and gutter, a 6 ft. public utility easement, and a landscape planter (where appropriate). Rather than a typical sidewalk between the planter and P.U.E., the project will incorporate a meandering 10 ft. wide mixed use trail through the woods and pasture north of the project to provide pedestrian connectivity. It is unclear at this time how the ownership and maintenance responsibilities will be divided for the trail component. The south side of the Phase 1 roadway will consist of an edge of asphalt and a 2 ft. gravel shoulder. The Phase 1 roadway will have a shed section, sloping towards the curb and gutter at 2% cross-slope.

Some modifications to the typical section and 4:1 max. side-slope (shown in Standard Detail ST5) are proposed to minimize impacts to existing mature trees. For approximately 240 lineal feet of the north side of the road, the typical section excludes the street trees, and proposes a 2:1 side-slope. These are reflected in the provided roadway drawings. While the modified cross-section eliminates the street trees where implemented, it maintains more of the existing large trees in the forested area. These two modifications save approximately 17 large established trees.

HORIZONTAL ALIGNMENT

The new roadway departs from NE 232nd in a sweeping curve, transitions to a tangent heading SE towards NE 9th St., then curves to an east-west tangent ending near the eastern property line. In Phase 1, a new school access road will tee into the new road with a commercial driveway, providing passenger car, bus, and service truck access to the new elementary school. Connectivity between the new road and NE 232nd will be maintained by the addition of a new connector road.

The preferred alignment presented (design alignment) will be the centerline of the future urban arterial roadway. The design alignment generally runs 3.0 ft. north of the south edge of pavement of the Phase 1 roadway. The Phase 1 roadway is being designed to allow for final build-out of the urban arterial while limiting reconstruction. The Phase 1 roadway will conform to the same geometrical standards and design speed as the built-out urban arterial. Upon future build-out, the Phase 1 roadway will be sawcut at the centerline of the Phase 2 roadway. All features north of the sawcut will remain, and everything south of the sawcut will be reconstructed.

The preferred alignment was determined by physical site constraints and geometrical design standards. The road is constrained by a wetland to the south and will impact a forested area north of the wetland. The preferred alignment skirts the northern boundary of the wetland, with no soil disturbance within the wetland both now in Phase 1 and the future widening (only indirect wetland impact due to soil disturbance inside the wetland buffer). Keeping the roadway close to the wetland helps to limit White Oak tree removal, large diameter fir tree removal, and earthwork quantities. One Oregon white oak tree is proposed to be removed, as it is in direct conflict with the connector road. All indirect wetland and white oak impacts for this project will be included in the school's on-site mitigation plan.

The 2011 AASHTO Green Book was used to determine horizontal and vertical design standards. The City expressed in preliminary discussions that their preferred design speed for urban arterials is 35 mph or 40 mph. The design speed is assumed equal to the proposed posted speed. Horizontal curve alternatives were considered for 35 and 40 mph, with and without a superelevation of 2%. Minimum curve radii were applied at the inside of the controlling traffic lane in the final build-out stage. See the following table for resulting minimum curve radii:

HORIZONTAL GEOMETRY CRITERIA

Based on 2011 AASHTO Green Book

35 MPH

CROWN W/2% SLOPES	Min. Horz. Curve Radius*	510'	Inside of southbound lane
	Resulting C/L Radius	504'	
2% SHED (SUPERELEV.)	Min. Horz. Curve Radius*	408'	Inside of northbound lane
	Resulting C/L Radius	426'	

* Min. curve radius from AASHTO Table 3-13b.

40 MPH

CROWN W/2% SLOPES	Min. Horz. Curve Radius*	762'	Inside of southbound lane
	Resulting C/L Radius	756'	
2% SHED (SUPERELEV.)	Min. Horz. Curve Radius*	593'	Inside of northbound lane
	Resulting C/L Radius	611'	

* Min. curve radius from AASHTO Table 3-13b.

A design speed of 35 mph was used for the preferred alignment. The smaller curve radius results in significantly less impact to existing trees and the lower speed presents a safer condition along the frontage of an elementary school. The preferred alignment assumes a crowned section when fully built-out, and utilizes a minimum centerline radius of 504 ft. for the first (and largest) horizontal curve. Though a superelevated section results in a smaller required radius, and less impact to trees, it was not feasible because of geometric constraints at the new intersection with NE 232nd Ave and the new connector road. A uniform crown section is preferred in final build-out for its simplicity and for easier access from the south (where the terrain is lower), and for consistency with other local urban arterials. The second horizontal curve has a radius of 756 ft.

The roadway was shifted in February, 2017 in order to minimize or eliminate direct wetland impacts when the roadway is built out in Phase 2. This shift was made possible by changing the sidewalk to an off-line trail.

VERTICAL ALIGNMENT

The vertical alignment was dictated by significant site grades, efforts to minimize earthwork and impacts to trees, and AASHTO vertical curve standards. The AASHTO Green Book specifies the following minimum K values for vertical curves based on stopping sight distance:

- 35 mph Sag Vertical Curves: Kmin. = 49
- 35 mph Crest Vertical Curves: Kmin. = 29

The profile requires two curves, a sag vertical curve with a significant algebraic difference and a gentler crest vertical curve. The proposed sag vertical curve has a length of 625 ft., and K value of 49.0. The proposed crest vertical curve has a length of 250 ft., and K value of 43.5.

A maximum grade of 6.75% is proposed in order to best match the existing topography. Camas Municipal Code Section 17.19.040(B)(12) states that "Grades shall not exceed six (6) percent on major and secondary arterials." We are requesting an exception to this requirement because meeting the 6% limit would result in:

- Excessive cut and/or fill.
- Challenging vertical connectivity at the new intersection and the school access road.
- Challenging vertical connectivity at other properties at final build-out (as much as 10 feet of cut at existing driveways).
- More impacts to existing trees and wetlands.

As a comparison, Clark County design standards allow for grades up to 8% in rolling terrain.

CONNECTOR ROADWAY ALIGNMENT

The new connector roadway is designed assuming a 15 MPH design speed for both horizontal and vertical curvature, as drivers are either stopping or slowing as they move through the tee intersection. The horizontal radius is proposed at 100 ft., which is double the minimum required 50 ft. radius. The crest vertical curve is proposed at a K value of 5.1, greater than the minimum of 3. The sag vertical curve is proposed at a K value of 7.8, which is less than the minimum of 10 for 15 MPH, but will be mitigated with an additional street light near this part of the connector roadway so drivers will have sufficient sight distance when it is dark.

The vertical profile design was updated in February 2017 to accommodate the future 2% crown to minimize reconstruction of the connector roadway.

INTERSECTIONS

An intersection has been designed to provide access to NE 232nd south of the new road. Vehicles travelling south on NE 232nd will turn right onto the new connector road and continue south without stop or yield control. Vehicles approaching the site from the south on 232nd will be diverted onto the new connector road with a tee intersection at the new road. The south leg of the tee (new connector road) will be stop controlled. The connector road is designed for Phase 1, and may be reconfigured in final build-out. Northbound drivers on the new road can access the southern leg of 232nd via the new connector road.

The new elementary school will have a commercial driveway intersection with the new Phase 1 roadway. Existing properties south of 9th Street will continue to access their lots off of 9th Street until the arterial is further developed in the future.

Both of these new intersections were designed with radii and lane widths that support a school bus, SU-40, and fire engine truck with no conflicts. If additional vehicles are required, additional analysis can be performed.

SIGHT DISTANCE - Alignment

The preferred alignment is designed to provide a safe stopping distance for vehicles, as calculated using the AASHTO Green Book. AASHTO Table 3-1 specifies a stopping sight distance of 250 ft. on level roadways for 35 mph. For a downgrade of 6.75%, the maximum grade used for the new roadway design, the stopping sight distance is 275 ft. (inferred from AASHTO Table 3-2). Sight distance was evaluated at the horizontal curves in the new roadway and considered the cut slope on the inside of the curve. The horizontal geometry of both the Phase 1 and final build-out condition provide sight distances greater than 275 ft., unobstructed by roadway geometry or the side slope. The 275 ft. sight line will cross the inside of curve, where the P.U.E., street trees (where proposed) and cut slopes are located. Profiles along sight lines were evaluated to ensure that the cut slopes will not block the required sight distance. Sight distance through street trees will be managed by tree location, selection, and maintenance (limbing).

The Phase 1 preferred alignment has a sag vertical curve and a crest vertical curve. The sight distance for sag vertical curves is typically determined by the visibility provided by a vehicle's headlights, projecting 1-degree upward from a height of 2 ft. Calculated in this manner, the vertical curve has a sight distance of 250 ft. Vehicles entering the vertical curve from the SE begin on a downgrade of 6.75% and require a stopping sight distance of 275 ft. During the day, the sight distance will not be controlled by headlights and will exceed 275 ft. Street lights are being installed as part of the project, and will illuminate objects in the roadway. This will effectively extend the sight distance beyond the headlight distance at night. Therefore, the sag vertical curve length of 625 ft. is adequate to provide the required stopping sight distance with installation of street lights.

Sight distance on crest vertical curves is typically determined by the line of sight unobscured by the curve itself. The proposed crest vertical curve has a length of 250 ft., and a corresponding sight distance of 305 ft. The curve provides adequate sight distance that is greater than the required 275 ft. stopping sight distance.

SIGHT DISTANCE - Intersections

At intersections, greater sight distance than stopping sight distance is required so that drivers entering traffic can evaluate an appropriately sized gap in traffic. There are two stop controlled intersections on the new road: at the new connector road to NE 232nd Ave., and at the school access road driveway. Recommended sight distances were determined using the AASHTO Green Book, Chapter 9 - Intersections.

The new connector road intersects perpendicularly with the new road to create a tee intersection, with a stop sign and stop bar on the connector road. Sight distances were evaluated for a passenger car stopped at the stop sign for the Phase 1 condition. The minimum recommended sight distance to the right is controlled by making a left-hand turn onto the new road (AASHTO Case B1). The minimum sight distance to the left is controlled by making a right-hand turn onto the new road (AASHTO Case B2). Recommended sight distances for this intersection were calculated, using AASHTO Equation 9-1, to be 460 ft. to the right and 370 ft. to the left. The 370 ft. sight-line to the left is an unobstructed view across roadway pavement. The 460 ft. sight-line to the right crosses the inside of the horizontal curve of the new road. A profile of the sight-line confirmed that the view is unobstructed by cut slopes or natural topography.

The new school access road intersects perpendicularly with the new road at a commercial driveway forming a tee intersection, with a stop sign and stop bar on the access road. Although there will initially be no significant traffic west of the intersection in Phase 1 (since it is a dead-end street with no access), sight distances were analyzed for the final built-out condition for a school bus stopped at the stop sign. Recommended sight distances for this intersection were calculated, using AASHTO Equation 9-1, to be 490 ft. to the right and 440 ft. to the left. The 490 ft. sight-line to the right is unobstructed by roadway geometry or slopes. The 440 ft. sight-line to the left crosses a cut slope inside the horizontal curve on the new road. Using roadway corridor modeling and profile analysis this area will be designed to maintain the 440 ft sight-line that will be required in the future.

STORMWATER

The project area currently drains to a wetland at the southwest corner of the property. Stormwater flows out of the wetland southerly through a 30" culvert under NE 9th Street. The Phase 1 roadway adds greater than 5,000 square feet of impervious surface, making the project subject to all Minimum Requirements for stormwater management.

Minimum Requirement #7 is flow control. A geotechnical investigation was performed throughout the project property. The borehole closest to the proposed roadway was tested for infiltration, revealing an infiltration rate of 0.2 inches/hour (5 ft. depth). An infiltration facility is deemed infeasible as a means of stormwater disposal and flow control. Because the entire roadway project drains to one low point and the relatively steep grades, an end-of-line detention facility (underground) is proposed between the roadway and the wetland south of the roadway. The proposed location of the facility is under the southbound lane of the future built-out arterial. The facility can be maintained and expanded in the future to accommodate detention of stormwater run-off from the future condition.

Washington State Department of Ecology (DOE) requires that wetlands receive the same flow from the developed condition as the existing condition. Therefore, the existing condition is modeled as the land lies today (pasture and forest), as opposed to all pre-European settlement (forested). Additionally, a french drain will intercept water from north of the roadway (off-site flow) and convey it under the road to the wetland, bypassing the new road's stormwater system.

Curb inlets will collect runoff from asphalt pavement, landscape planter, and sidewalk (where adjacent to roadway). Collected roadway stormwater will be conveyed to the underground detention facility. A stormwater control manhole within the detention facility will dispense water from the facility to the wetland at a controlled rate. The detention facility will be designed to accommodate flows from the Phase 1 condition only. Full build-out of the roadway will require expansion of the facility or creation of a secondary facility.

Minimum Requirement #6 requires the treatment of stormwater runoff from pollution generating surfaces (and from other runoff that is collected in combination with polluted runoff). Runoff from the roadway will need to be treated to the Basic Treatment level. The project is also located within the area above the dam at Round Lake, which requires treatment for phosphorous. WSDOE approved methods for treating stormwater for phosphorous include large wetpond, sand filter, and filtration by an approved mechanical treatment device.

The proposed design incorporates mechanical treatment, downstream of the underground detention facility. This option was selected because of the large space required by wetpond and sand filter facilities, putting them in conflict with the future build-out of the road and/or directly impacting the wetland. The mechanical treatment vault will be located outside of future roadway limits. The facility will be designed to accommodate Phase 1 water quality flows. The fully built-out arterial will require expansion of the treatment facility, possibly through an additional vault.

The stormwater collection and conveyance system will be designed for the 10-year, 24-hour storm event, as prescribed in the City's stormwater manual (for contributing drainage areas less than 40 acres). The collection system will be designed to accommodate future expansion of the roadway to logical limits determined by geography. The assumed northern limit is the creek located 230 ft. north of the Phase 1 limit of construction. The roadway north of the creek continues uphill, and will drain to the creek (separate point-of-compliance than the on-site wetland). The eastern boundary is assumed to be the high point of a crest vertical curve in the future roadway, approximated to be 150’ east of the eastern property line.

MILESTONES

Since these improvements will be dedicated to the City as public improvements within newly dedicated right-of-way, it is our intent to design these improvements in coordination with City staff. This memo and supporting drawings represent a 50% design. Additional milestones where City review and input is anticipated are at 90%, and 100%.