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Subterranean in Seattle

The Washington State Department of Transportation is preparing to bore the world's largest-diameter tunnel

The camera stalls, for just a moment, at the southern edge of downtown Seattle. It faces north, toward the time-worn and earthquake-damaged Alaskan Way Viaduct, a double-deck highway that has spanned the downtown waterfront for nearly 60 years.

With portions of the viaduct slated for demolition in less than two years, the view here is about to change.

But the camera is no longer trained on the horizon. Instead it is set to plunge

underground to trace the future path of the viaduct's replacement: the world's largest-diameter bored tunnel. It begins its steady descent. The viaduct's foundations, vulnerable to seismic activity like the rest of the structure, are visible in the soils to the east as the frame moves deeper and to the north, past a tangle of utilities, pilings and other buried structures. Above and to the west, the waters of Elliott Bay lap against a seawall that supports the downtown waterfront and the ground on which the viaduct stands.

Other tunnels appear in the distance, signs that tunneling, though challenging, is neither impossible nor unprecedented in Seattle. Slowly the objects drift upward, away from the camera,

until it is surrounded by mostly native glacial soils, nearly 200 ft beneath the city, somewhere between the viaduct's much-studied past and a future that will forever transform Seattle's waterfront and the region's transportation system.

As journeys go, it is a fascinating one, an unusual opportunity to peek at the normally unseen spaces and objects beneath Seattle. But for those who are entrusted with replacing the viaduct, these are not idle fascinations—they are reminders of the great care that must be taken in delivering one of the most important infrastructure projects in Washington state history.

And this is not reality, at least not yet. It is a computer rendering that lets the public see just what lies in the soils through which a five-story boring machine could—pending environmental review—begin tunneling in 2012.

The rendering is itself an impressive feat, a convergence of extensive geotechnical research and the latest in graphical technology that allows illustrating the

project in ways that were not previously possible. Technology, too, is central to the proposed tunnel project, with the rapid progression of tunnel-boring technology enabling it to get off or—as the case may be—under the ground.

Expected to open to drivers near the end of 2015, the State Rte. 99 bored tunnel would be approximately 54 ft in diameter. At almost 2 miles long, with entrances to the north and south of downtown Seattle, it would be one of the longest highway tunnels in the U.S. Its double-deck configuration would allow for four lanes of traffic, matching the number of lanes traveling through downtown on today's viaduct. Precast elements, to be assembled as the tunnel progresses beneath the city, would enable crews to build a quality product while meeting an expedited construction timeline.

Going public

More important than any technical achievements are the project's benefits to Washington state, King County and

the city of Seattle. The bored tunnel, combined with a series of other improvements, would create 9 acres of new public space on Seattle's waterfront while greatly improving mobility in and through the S.R. 99 corridor. Of the 70 options considered, it would cause the least disruption during construction, because the viaduct can remain open to traffic while crews work beneath downtown.

The project's biggest driver is public safety. The 2-mile-long viaduct was built in the 1950s. Once a paragon of modern design, it has since succumbed to decades of wear and tear. Its foundations, particularly at the south end, rest in unstable fill soil that is prone to liquefaction.

By the mid-1990s studies showed the structure was nearing the end of its useful life. Early discussions about replacement were jolted in 2001, when the 6.8-magnitude Nisqually earthquake shook the Puget Sound region. Damaged but not beyond repair, the viaduct was temporarily closed in the aftermath. The 110,000 or so vehicles that use the structure each



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day dispersed onto city streets, giving Seattleites a taste of what traffic would be like should a future quake require the viaduct to be permanently closed before a replacement is built.

Fortunately, the viaduct had sustained only minor damage. Crews made repairs and began monitoring the structure regularly, as they continue to do today, to ensure it remained safe. Knowing that a bigger quake could cause the structure to collapse, the Washington State Department of Transportation (WSDOT) and the Seattle Department of Transportation began examining options for replacing both the viaduct and the nearby seawall.

A variety of elevated, surface and tunnel options were studied. Engineers and planners balanced a number of important, sometimes competing, interests along the way. The replacement, whatever it was to be, would need to move people and goods, allow the city to reclaim its historic waterfront, limit construction disruptions and be fiscally responsible.

Waist of the hourglass

Seattle's unique geography presented a challenge. The city limits are shaped like an hourglass, with downtown occupying its narrowest point between Puget Sound and Lake Washington. Along with I-5 to the east, S.R. 99 is one of the city's two main north-south arteries. As a result, maintaining traffic on the route is critical.

The importance of the S.R. 99 corridor extends beyond the needs of general-purpose traffic. The ability to move freight quickly along the city's working waterfront is equally crucial to the health of state and local economies. The port of Seattle's main shipping terminals flank the mouth of the Duwamish River, at the south end of downtown, and the land surrounding these facilities is bustling with manufacturing and industrial activity. Likewise, the city's marine industrial center sits to the northwest of the city's core. Keeping freight moving on S.R. 99, which serves as a vital link between these facilities, will keep the economy moving as well.

A balanced solution

By 2006, the various replacement options had been narrowed to two: a new elevated structure or a cut-and-

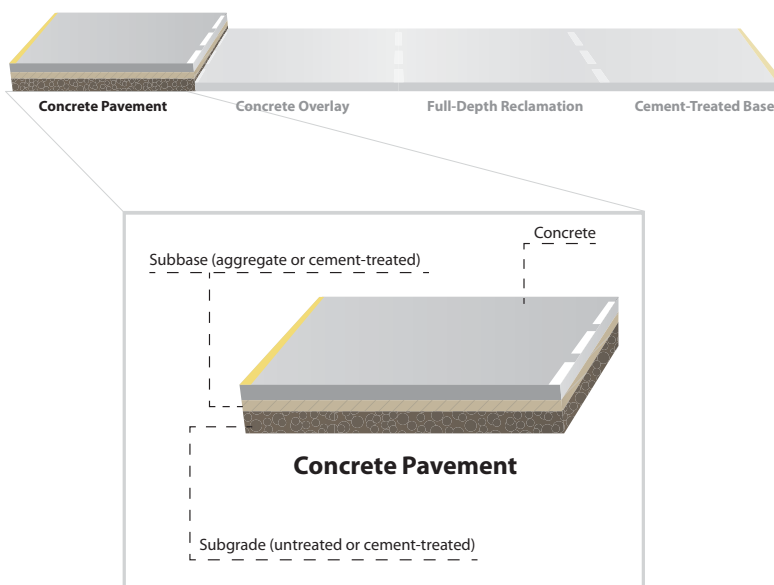
cover tunnel. The city and state favored the cut-and-cover tunnel, but the plan would have cost more than the available funding. Intent on reclaiming its historic waterfront from the shadows and noise of the viaduct, the city turned to voters.

Residents were presented with both options, but they weren't required to choose one over the other; instead they were asked to vote yes or no on each separate option. The result was a

nonbinding advisory vote that rejected both options and sent state and local leaders back to the drawing board.

As they searched for a way forward, leaders realized the two rejected options had a number of common factors—in particular, components at the north and south ends of the corridor—that virtually no one opposed. They agreed to move these elements forward. Doing so would allow them to replace almost half

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of the viaduct while they continued to re-examine how to replace the section on the downtown waterfront. It also offered an opportunity to take a more holistic approach to improving the downtown transportation system, with the S.R. 99 replacement to serve as its centerpiece.

An extensive public-outreach effort was launched, including the formation of a 29-member stakeholder group to provide feedback on potential options. After 13 months of in-depth study, two options emerged: an elevated bypass and a surface and transit solution. Waiting in the wings was a twin bored tunnel concept that seemed to meet all of the criteria desired in a solution except one: cost.

Starting construction at the south end will significantly improve an area that serves a variety of needs.

Not convinced that a bored tunnel was infeasible, stakeholders asked that its costs be analyzed further. Leadership agreed to the idea, and a wider group of tunnel experts was brought in to examine construction and cost-estimate assumptions.

Getting bored?

The question was this: A twin bored tunnel was too expensive, but could a single bored tunnel suit the project's needs? The answer, tunnel experts agreed, was a resounding yes. Rapid advances in tunnel-boring technology had enabled larger-diameter boring machines, better ground control and improved reliability. Boring machines can now safely excavate under almost any type of soil, rock or groundwater conditions. Tunnels also have proven themselves over time in seismically active areas, making the bored tunnel a good match for earthquake-prone Seattle. Convinced by further study, state and local leaders, with widespread support from business, labor and community interests, made the decision in January 2009 to move forward with a single bored tunnel.

Before the boring begins

The decision, of course, was just the beginning. The project is now under environmental review, with a supplemental draft environmental impact

statement available for review. The document builds on previous environmental analysis and looks at how the transportation system functions as a whole, with a focus on the bored tunnel.

In October, two design-build teams submitted proposals for the main tunnel contract, with a winner to be selected early next year. As their proposals take shape, the technical work continues. WSDOT has met with tunneling experts from around the world and is studying other tunnels, including those that faced construction challenges or exceeded their budget, to minimize risk and maximize the safety and cost effectiveness of the project.

Effective tunneling requires extensive planning and understanding of ground conditions. WSDOT has taken soil samples from locations approximately every 100 ft along the tunnel's path. Conditions in the area vary, but nothing has been found to indicate that a tunnel could not be successfully bored. WSDOT is meeting with those who own property above the tunnel route to discuss how construction would affect them. The agency will take an active role in monitoring and responding to indications of ground movement, and the contractor will follow specific requirements for monitoring activities and equipment operation. A team of experts will be on hand to review excavation and ground data and take mitigation measures, if needed.

Like safety, cost remains at the forefront. The tunnel is estimated to cost \$1.96 billion, which includes the tunnel-boring machine, the interior roadway, tunnel systems, operations buildings and portal connections. The estimate is based on WSDOT's cost-estimate validation process for large projects. The process was developed in 2002 and uses outside experts to help establish a more realistic budget at the early stages of a project and identify risks that need to be actively managed. And make no mistake: failure to account for the inherent risks involved

in this kind of project—along with things like unforeseen design changes, mitigation and inflation—is the main culprit when tunneling projects exceed their budget. That fact is continually reinforced in studying other projects, and as a result WSDOT has built a healthy contingency into its budget—\$415 million, or about 21% of the project's total estimated cost—for risk and inflation.

The bigger picture

Although it is the most prominent part of the viaduct replacement, the tunnel is just one component of a larger solution. Planners examined the transportation system as a whole to see how a tunnel could potentially affect traffic in downtown and on all surrounding routes. This research allowed the agencies to identify city-street and transit improvements that would greatly improve the operation of the new tunnel. For instance, city-street projects will improve two major east-west corridors at the north and south ends of downtown. These will improve street grid traffic distribution, providing benefits to drivers who want to enter downtown directly instead of using the tunnel as a bypass.

To accommodate future growth as well as improve the environment, the plan also includes transit investments designed to provide more travel choices into downtown. Leaders agreed to assign these projects to the appropriate state and local jurisdictions, making each responsible for their own projects' management, environmental work, design and construction. The total cost for the viaduct-replacement program, including the transit, city-street and waterfront improvements, is \$4.2 billion. The port of Seattle also is funding a portion of the replacement, having committed to contribute \$300 million to the effort earlier this year.

Meanwhile, major construction is under way to replace the southern mile of the viaduct with a side-by-side roadway. Designed to connect to any replacement for the viaduct along the waterfront, the project also includes a number of freight-mobility, nonmotorized and city-street improvements at the southern edge of downtown.

Starting construction at the south

end will significantly improve an area that serves a variety of important needs, including key freight facilities and two major sports stadiums. It gives WSDOT an opportunity to turn its hard work and preparation into tangible benefits for the public, while proving it is capable of delivering projects of great magnitude.

Even so, Seattleites and Washingtonians, like the camera in the underground simulation video, remain focused on the soils beneath the city. WSDOT's focus is there, too, but it also is on the major construction at hand and the hard work that remains before the boring machine can begin turning soil. It won't be easy. But the agency is confident in its approach and the partnerships it has built with multiple agencies and the public. Together, everyone involved will emerge successful at the other side.

Update: WSDOT received two bids on Thursday, Oct. 28, to design and build the S.R. 99 bored tunnel to replace the seismically unsafe Alaskan Way Viaduct. Both bids were at or below the contract price limit. The submittals were from two teams of national and international tunneling firms, who spent months of design work and cost analysis to produce the extensive proposals.

"After 10 years of debate, 90 alternatives and eight studies today we are returning the waterfront to the people of Seattle and keeping our economy moving," said Washington Gov. Chris Gregoire. "We can't afford to wait. Replacing the Alaskan Way Viaduct is a critical public-safety project. The bored tunnel preserves capacity, is essential to our state's commerce and keeps traffic moving through the entire construction process. We owe it to the families and businesses who will spur our economic recovery to complete this project. Today's bids meet our needs while being on budget and on time to protect the state's taxpayers."

Representatives from WSDOT, the Seattle Department of Transportation, industry experts and the viaduct-replacement program's Strategic Technical Advisory Team will participate in the proposal evaluation. The evaluation will award credits for certain areas

where the teams offer creative ideas and different ways to accomplish WSDOT's goals and minimize disruptions to the community. In December when the bids are opened, the technical credits will be subtracted from the price to identify the apparent best value. Since the evaluation is confidential, any additional information will be available after the review is complete.

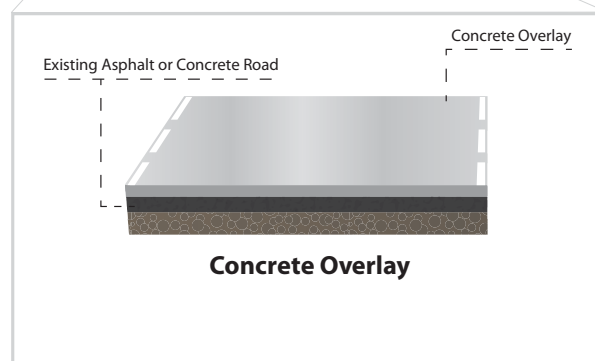
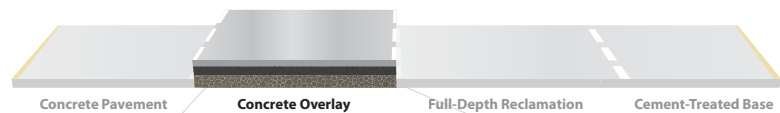
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Alaskan Way Viaduct and Seawall Replacement program, visit www.alaskanwayviaduct.org. **R&B**

Paananen, of WSDOT, is the administrator of the Alaskan Way Viaduct and Seawall Replacement Program. For more information visit www.alaskanwayviaduct.org.

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