C-040-091

roadway in this positive light, the SDEIS fails to admit the damage and then fails to evaluate alternatives as required.

All of the water area in Portage Bay is public land used for recreational purposes. The expansion of SR520 will cover a new area at least equal to the area now covered by the bridge. Some of the bridge will rest on land owned by Montlake Playfield Park, discussed below, some will rest on land owned by WSDOT, which we will discuss later , see: (14) Portage Bay Park Area in SR 520 Right of Wa**y**

The WSDOT lands are public lands used for recreation and wildlife. Putting new highway on these lands represents a 4(f) taking of these lands. The amount taken permanently as well as for construction bridges is not identified in the SDEIS, but it is acres.

The SDEIS fails to evaluate ways to avoid this taking. There are two issues here, the first is how the bridges are being built and the second is how big the bridges will be. I use the plural here because the plan is to build a new north bridge and put the existing traffic on it. Then tear down the existing bridge and build a new south bridge. The two new bridges will then be described as the new bridge with east and west directions. This construction plan makes the North Bridge capable of handling all current traffic. Creating a twin give us capacity to transport double current traffic levels. That is probably why the extra lanes for access to the express lane on I5 appeared. It appears that the way the bridges are being built automatically creates excess capacity. Changing the size of the first bridge to 4 lanes with shoulders offers the potential to make the north bridge perhaps slightly wider than planned and then not replace the other bridge and not build a second bridge. The problem with selecting the wide bridge option is that then it has to go through the Roanoke Park area and create the carnage discussed above.

- The SDEIS fails to evaluate alternatives which would minimize the damage.
    - The SDEIS Chapter 5 page 5-66 says that the quality of the Portage Bay landscape unit "would not change as a result of the Portage Bay Bridge, but views in the vicinity of the new bridge would be more open. …The greater column spacing (from 100 feet on center currently to as much as 250 feet apart) would open up views under the bridge, especially looking northward from the south side of the bridge." However, this is a subjective assessment that does not acknowledge that the new columns are much larger than the old. In addition, the option is shown without noise walls in the referenced Exhibit 5.5-2 page 5-67. And the primary cause of changed view from the water's edge is the planned increased height of the bridge. This height increases the bulk and the distance noise travels. Most people view this as an adverse change.

- The SDEIS proposals for mitigation are inadequate.

C-040-091
- SDEIS proposes noise walls along the north side of SR 520 from the 10th and Delmar lid to the Montlake Lid and along the south side of SR 520 from 10th and Delmar lid to Montlake Boulevard. (Chapter 5 page 5-105.) There is no commitment to these walls, and the SDEIS does not demonstrate that they have adequately evaluated other alternatives that would benefit Portage Bay users or neighbors.
- Noise walls make the visual aspect of the bridge worse by greatly increasing its apparent mass. Thus, one is caught trading one blight for another, perhaps demonstrating that noise mitigation is not possible. The SDEIS fails to acknowledge the harm SR 520 is creating with increased noise may in fact not be able to be mitigated.

C-040-092

(13) Montlake Playfield Park and (12) South Portage Bay Park

The SDEIS Description: Chapter 4 page 4-29. Also described Attachment 6 page 32.

Montlake Playfield Park is a major city park bordering Portage Bay, with activities ranging from sports, to bird watching and canoeing and kayaking. It is a 27 acre regional park used for football, baseball, soccer and track. It also holds a community center used for classes and events.

South Portage Bay Park is considered by the Park Department to be a part of Montlake Playfield Park. It is mentioned separately here to emphasize the non-playfield orientation of this area, in which residents are following a master plan to develop the shoreline. The goal is to enhance access and quality of the shoreline resource. A small boat launch has recently been added.

The proposed expansion of SR 520 would impact Montlake Playfield Park and South Portage Bay Park:

- The parks will be adversely impacted by noise and visual blight. The higher structure and increased traffic will generate more noise over a longer distance.
- Submerged lands would be taken by the proposed expansion. This is not acknowledged in any detail in the SDEIS.
- The construction impact on Montlake Playfield was identified as small and temporary, arguing that the taking was in an unused section of the park. But in fact that area is a highly used area abutting the Bill Dawson Trail. These lands have been enjoyed by all users of this trail, creating the parkland atmosphere of that trail. Further this area has been actively used by wildlife and now is proximate to a beaver lodge which is enjoyed by Montlake Playfield wildlife enthusiasts. This taking is part of the taking associated with the Bill Dawson Trail. The loss is significant and does not qualify for the "temporary" exclusion the SDEIS is claiming.

C-040-093

SDEIS: Noise & Visual Blight at Montlake Park

C-040-093

The SDEIS does not discuss the adverse impact increasing the height of the east half of the Portage Bay Bridge will have on Montlake Playfield Park. The current bridge is easily blocked by trees, and the sound transmission is much less than will occur at the planned new height. The noise modeling results say that there are no noticeable noise changes with Option A, but no receivers were put in Montlake Playground Park. (SDEIS Exhibit 5.7-1 Ch5 page 5-103)

The SDEIS fails to evaluate alternatives which would avoid or minimize this damage, and fails to propose adequate mitigation.

- There are no commitments to sound mitigation for the new bridge. It is a significant failure for the SDEIS not to quantify this adverse impact on Montlake Playfield Park, a serious 4(f) impact.
- The SDEIS treats the South Portage Bay Park area as part of Montlake Playfield Park, to which it is adjacent. This fails to understand the impact of the expansion plans on the park wetland and wildlife as well as on the community of park volunteers and users.

C-040-094

SDEIS: Submerged Lands not acknowledged as parkland

The SDEIS does not identify how much submerged land will be taken from Montlake Playfield Park, and, in most exhibits, does not acknowledge that any of its land is being taken temporarily or permanently. (See for example, Exhibit 44 page 98 of Discipline Report Attachment 6: Draft Section 4(f) 6 of Evaluation which states for Montlake Park: "no permanent acquisition.) However, elsewhere that report (page 33) acknowledges that it will take some Montlake Playfield Park lands but doesn't identify where or how much. It also deliberately does not identify the submerged lands as parkland on any of its otherwise detailed maps. The standard map that it uses for Montlake Playfield doesn't include submerged lands at all: See Exhibit 4.2-1, Existing Land Use in Seattle, Chapter 4, page 12. Also see also Exhibit 4.4-1, Chapter 4 page 4-27, see also Exhibit 4.13-1, see also Exhibit 5.1-15 and Exhibit 5.2-2,page 5-34, and Exhibit 6.4-1 Construction Effects on Parks, page 6-39, and Exhibit 5.6-4 which maps the historic boundary of Montlake Playfield Park. See also Exhibit 53 Section 5(f) Effects for Options A, K and L which uses the same graphics for Montlake, i.e. no submerged lands. See Exhibit 54, Preliminary Least Harm Analysis by Section 4(f) Property which says there is no Section 4(f) use (indicating no lands taken). The latter ties to Exhibit 10, page 23, Attachment 6 IBID, Properties with a Section 4(f) use where Montlake Park is not shown.

The exception to describing Montlake Park as only solid ground comes in Exhibit 6.4-3, Chapter 6, page 6-41 where for the only time park property is shown as coming up to the south edge of existing WSDOT right of way. Property north of SR 520 is not shown in that exhibit and is never shown in the SDEIS.

C-040-095

The SDEIS asserts that the taking of Montlake Playfield Park lands permanently as well during the construction period is not of consequence and therefore it is not covered by 4(f):

C-040-095 "Montlake Playfield originally extended north of the current SR 520 alignment. Because of the rising water level of Portage Bay, however, 6.8 acres of the original playfield (not included in the 27-acre usable site) are now submerged in Portage Bay. A portion of the submerged land would be acquired from the City of Seattle for the 6-Lane Alternative options. However, the affected submerged land is not currently used for recreational purposes, is not accessible to the public for recreational use, and is not designated as parkland on the Seattle Park Guide (City of Seattle 2006). In addition, there are no formal plans for its recreational use in the future. As a result, the affected submerged lands are not protected by Section 4(f)." Source: SDEIS Attachment 6 Page 33.

Contradicting the above, in another section, the SDEIS says that Attachment 6, page 63, States Option A "would not entail a permanent incorporation of Montlake Playfield property. SR 520 would be widened to the north into NOAA Northwest Fisheries Science Center property and away from Montlake Playfield." This appears as deliberately sowing the impression that expansion to the north of the existing right of way is only on NOAA lands and not on Montlake Parkland when in fact both areas are being impacted.

Chapter 5 page 34, Table 5.2-2 says that the expansion will require 2.2 acres of new right of way in Portage Bay. It shows graphically where the land will be taken, so it is possible to determine that the land taken over water is largely submerged land taken from Montlake Playfield Park.

This quoted paragraph above regarding submerged land has several errors:

A. The statement that the lands "originally extended" north of the current SR 520 alignment implies incorrectly that they no longer do. SR 520's current acres of right of way across Portage Bay came out of Montlake Playfield Park holdings which now lie on both the north and south sides of WSDOT right of way.

B. The argument that the land became submerged and therefore useless is false. It was always submerged. And its "submerged" value was recognized when concern arose about the amount of the lake's surface being taken over by moorage and houseboats. This land was valued as preserving open water and valuable shoreline at the time of its acquisition in addition to its offering space for playfields.

C. While some of the ball playing area and track was expanded using fill, the objective was to increase the height and thereby drainage of the fields which were well inside the bounds of the wetlands. The actual wetland edge of the park remained unchanged according to park history. In any event filling of wetlands ceased everywhere, stopped some 50 years ago with the recognition by both citizens and the park department that all wetlands had value. When Forward Thrust funds were used in 1968 to expand Montlake Playfield Park to

C-040-095 the west, preservation of wetlands for wildlife was part of the master plan for that expansion, a mission being enhanced by years of work on the South Portage Bay Park area, planting more native vegetation and creating access paths and a canoe and kayak launch site.

D. The argument that these lands are not used is a SDEIS deception, as is the SDEIS' failure to show these parklands on the parkland maps provided of the area (see examples above.) The water portion of the park is used extensively both visually by thousands of people per day, and on the surface by various forms of water recreation, and by wildlife.

E. The SDEIS argues that the Seattle Park Department thinks only of the solid land area of Montlake Playfield Park as being park land. It quotes the Park Department's 27 acre size statement as covering only the solid ground area; seeking to imply that the Park Department does not consider significant the submerged land ownership. However, preliminary calculations indicate that one can only describe the park as being 27 acres by including the 6.8 acres which the SDEIS claims are the non-usable submerged lands. Thus, Seattle Parks appears to have included the underwater area in its statement of the Park's size. (Park Department confirmation is being requested.) But that argument carries no weight regardless of the acreage because the lands are park lands accessible to the public and used for recreation, wildlife and other park purposes.

The historic and continued efforts of the Park Department to facilitate preservation and access to these areas, with the creation of South Portage Bay Park and long planned improvements to Montlake Playfield Park, clearly demonstrate the "submerged lands" deserve 4(f) status. The SDEIS is disingenuous at best in not describing in the Discipline Report on 4(f) the acreage of additional right of way that WSDOT will need to take from Montlake Park for new Right of Way. The taking of just one acre would legally require full review (See http://environment.fhwa.dot.gov/4(f) /4(f) mparks.asp). A comparison of Existing vs. Planned ROW is shown in Attachment 6 Draft 4(f) /6f Evaluation, Exhibit 28, Effects on Montlake Playfield. It is easy to see that more than an acre of land will have to be taken under Option A. A different part of the SDEIS implies the permanent taking will be on the order of 2.3 acres (See Discussion in Item (13) Montlake Playfield Park above.)

C-040-096

SDEIS: Land used for construction at Montlake Park

The construction effect on Montlake Playfield is said to be limited to a tiny area to be used on land on the north east corner, 0.3 acres. SDEIS Table 6.4-1 page 6-38. However, in addition to land purchased for permanent right of way over the water, there will be need for additional lands to handle "temporary" bridge construction, taken from Montlake Playfield Park (See Chapter 6, Exhibit 6.2-2). The acreage for this additional need has not been identified.

C-040-096 The construction activity of demolishing the existing bridge and building the temporary bridge and the new bridges will all take their toll on Montlake Playfield Park and represent constructive use which is not described in the SDEIS. The total construction time for the Portage Bay Bridge is 6 years.

As described above, the submerged lands represent a taking of parklands. Montlake Playfield Park with its South Portage Bay park represents a multiple use public recreational facility. In such case significance is rated by the particular use. The wetland and water focused section of the park represents about 20 percent of the park or about 6 acres. The taking of two acres of this section of the park by the expansion of SR520 represents a significant taking of that portion of the park.

The lands taken for construction use in the northeast section of the park, adjacent to the Bill Dawson Trail are significantly public lands highly used as part of the Bill Dawson Trail.
Access to that area will be cut off for 3 years. This is a significant taking of Montlake Playfield park lands and interferes with its activity and function. This area is close to the beaver lodge which the park wildlife enthusiasts enjoy. As described below, Montlake Playfield Park is adjacent to public areas of WSDOT right of way which are used for public park purposes and therefore are also deserving of 4(f) status. Exhibit 6.4-3, Chapter 6, page 6-41, clearly shows that part of the Montlake Playfield track is on WSDOT right of way. It is also very probable that the kayak launching site next to the track is on WSDOT right of way, emphasizing that from everyone's point of view that WSDOT property, not used by SR 520 is being used as park land and deserves 4f status.

The SDEIS fails to acknowledge 4(f) status of Montlake Playfield's submerged lands and therefore it has failed to performed the analysis required for the substantial, adverse taking these water parklands, a taking adverse to both recreational and wildlife usage and to the peace and quiet and wild-land experience offered by the wetland and water of Montlake Playfield Park. For example, both kayakers and beavers use the channels the beavers cut through the lily pads during the summer, channels cut above the "submerged" lands which the SDEIS describes as of no value. There is an active beaver lodge at the south east end of SR 520. In addition to the general public, both Seattle Yacht Club and Queen City Yacht Club use the Montlake Park lands north of the current SR 520 right of way in their recreational activities as well.

This water-parkland is also an integral part of the visual experience of being in Montlake Park, or the east side of Capitol Hill and all the parks there, including West Montlake Park.

The SDEIS has acknowledged that Montlake Playfield Park has 4(f) status because there will be construction occupation of a portion of the park. However, it dismisses this qualification by saying the use is "temporary." However, neither the task nor the time

C-040-096 fit the 4(f) temporary classification. Building a new access bridge to be used to remove and replace the SR 520 off ramp does not fit the nature of a temporary use. Building a major haul route on park land is a significant use. The time of 3 years also does not fit temporary use. Further, this is a combination of forest and wetland used as a wild life refuge that will be significantly adversely impacted during construction and, because of the clearing done for that construction, after construction. The beaver colony living there is not likely to survive the experience. This is an example of current use of Montlake Playfield that will be adversely impacted by this taking. Further, this area of the park, bordering on the Bill Dawson Trail, is heavily used and the park like setting is part of what gives the trail its interest and why people like the trail.

What we have here is a combined constructive use of both Montlake Playfield park lands and the Bill Dawson Trail. Before the constructive use, both were enjoyed together. With the closing of the area neither are to be enjoyed and the cause, removal and construction of SR520 is the came. This section of the park offered wildlife viewing an increasing interest for Montlake Playfield and South Portage Bay Parks. The taking has to be seen in the context of the amount of shoreline in the park that is easily accessed and in this case this is normally a high traffic area. The taking lessens one of the uses of Montlake Park as an wildlife and open space area that is interesting to walk through. The closing of this areas to access and turning it into a major haul road not only turns off interest in that specific area but to the much larger associated area. That corner of the park will need to be avoided for three years. In addition, these lands and the WSDOT land on which this bridge is also being constructed are a mix of forest and wetland and are in fact being damaged by this construction use, impairing their recreational and wildlife use for both the construction period and thereafter. This is a significant loss in one of the attributes of the park, providing interesting wildlife viewing in mature vegetation along the shoreline and will harm its growing reputation as an interesting place for birders for the construction period.

In sum, the SDEIS fails to recognize the significance of the taking of Montlake Park lands, both submerged lands and non-submerged lands because it used logic that did not fit the circumstances. But taken together it is very clear that Montlake Playfield park is having a taking of parklands and its environment is being lessened as a result of the expansion of SR520. The SDEIS was not sensitive to these concerns but Montlake Playfield and South Portage Bay Park users are and so is the Seattle Park Commission, see Appendix X Letter From Park Commissioners.

Avoidance, Minimization, Mitigation at Montlake Park

- The SDEIS failed to evaluate alternatives which might permit avoiding this use. The key element here is whether the change in alignment is necessary, and whether the new bridge to the north needs to be so far north. A change in the size of the Portage Bay Bridge to 4 lanes might permit moving the bridge south enough to avoid taking a significant quantity of Montlake Playfield parklands.

C-040-096 See discussion elsewhere of potential for fewer lanes and therefore smaller Portage Bay bridge.

- The SDEIS fails to evaluate alternatives which would minimize the damage.
- See prior discussion of option to reduce noise.

- The SDEIS omits proposals for mitigation.
- The key point here is avoidance so that mitigation is not necessary.

C-040-097

(14) Portage Bay Park Area in SR 520 Right of Way

The existing SR 520 right of way for the Portage Bay Park Area comes out of Montlake Playfield Park property and comprises 4.7 acres. The existing bridge is 60 feet wide and the section of land that the city provided is some 1400 feet long, suggesting that bridge now covers only 2 acres of the lands it bought from Montlake Playfield Park in the late 50's. This leaves 2.7 acres uncovered and not used by the bridge. This land lies primarily to the south of the bridge. Since SR 520 was built, this land has been used by the public and by wildlife as open space, qualifying it for 4(f) status. See also above discussion of Montlake Park activity being carried out on those lands. As described in the Portage Bay section the use of these lands for a bridge represents a 4(f) use. The proposed construction plan will use these lands for both temporary construction bridges and also for the new permanent bridge. The SDEIS avoided detailing water coverage in Portage Bay, so we do not know these acreages. Construction of the Portage Bay bridge will take some 6 years and will utilize a process which takes a lot of heavy equipment and makes a lot of extreme noise and vibration. For the land taken for permanent use, there is a clear 4(f) taking. Given the length of time and the magnitude of the use there is clearly a constructive use of the lands used for construction even if they are not to be used permanently to support the bridge. Those lands used for a construction bridge, for example, are not available for the normal recreational activities of those lands for that period. I would expect the area to be fully posted with no trespassing signs.
One can expect that the lands closed for construction will be a significant part of the lands owned by WSDOT in Portage Bay, making construction use a significant use of that property.

The proposed bridge will double the amount of water covered, impacting the waters used by the public and by wildlife. Under Option A, the water acreage being covered by the bridge is being more than doubled (at the narrowest middle part of the bridge its width is only being increased 83 percent, but the road flares much wider toward both ends.) The SDEIS omits the calculation of current water coverage vs. the options being considered.

C-040-097 Some of these waters are technically SR 520 right of way and the balance is Montlake Playfield Park. **Given the use patterns of these lands for the last 45 years, recreation, wildlife, scenic beauty, buffer for SR 520, etc., all of the expansion of SR 520 will be over parkland deserving 4f status. Similar lands exist in the Arboretum area: see the R.H. Thompson Lands described below. The SDEIS failure identify the extent of 4f lands within the SR 520 right of way and to provide for all of them the avoidance and mitigation analysis required is an extremely significant error.**

The lands owned by WSDOT, but not actively covered by the bridge are
The SDEIS does not acknowledge the significance of the Portage Bay Area in the WSDOT right of way as a parkland. As a result:

- The SDEIS fails to evaluate alternatives which avoid this damage.
- The SDEIS fails to evaluate alternatives which would minimize the damage.
- The SDEIS omits proposals for mitigation.
- In addition for the use of Montlake Playfield's land near the Bill Dawson Trail, the SDEIS incorrectly regards that taking as a temporary use and therefore one not requiring avoidance and if not avoidable, mitigation.

C-040-098

(15) Bill Dawson Trail (a bike and pedestrian trail)

SDEIS Description Chapter 4 page 4-29. SDEIS Description Attachment 5 page 33.

The Bill Dawson Trail connects Montlake Playfield Park on its west boundary to Montlake Boulevard via a path under and along SR 520. The SDEIS notes that all of the land is publicly owned and the primary purpose is recreation regardless of land ownership. Therefore, the Bill Dawson Trail is subject to the provisions of Section 4(f) if the SR 520, I-5 to Medina Project would result in a use of this recreational resource. It also acknowledges that the trail is heavily used.

The SDEIS attachment 6 page 65 argues there is no 4(f). However, the trail is being taken in its totality for 3 years because the trail is being destroyed with the destruction and replacement of SR520; it will have to be relocated after the new SR520 is built. The scope of work is about as big as it can get. The temporary classification only fits if the scope of work is minor and the magnitude of the changes to the resource are minimal. That doesn't fit this case. Further the use does not qualify as temporary because the trail is shut down. It only exists to do a specific task over a relatively short distance. The purpose of this trail is a speedy access from the end of Montlake playfield to the bridge side of Montlake Avenue, bypassing a lot of long traffic lights and traffic and two freeway on ramps. That quick bypass option ceases to exist with the closure of the trail, a complete "interference with the activities or purpose of the resource," another indication that this closure doesn't fit the "temporary" classification the SDEIS is seeking to use. In addition, the impact is significant: the detour suggested is 1500 feet longer and through the construction zone, a freeway entrance and very long traffic lights. The

C-040-098 trail is completely gone. Walkers and cyclists are left back with city streets they had before the trail was established. Saying that is a detour that "rejoins the trail" is totally misleading because the detour bypasses the trail completely (See Position Paper - Section 4(f) Applicability Temporary Occupancy, Harold J. Brown, Nov 4, 1988). The task and the time for which this property will be used, building a whole new bridge, taking 2.5 to 3 years (See SDEIS Attachment 6 page 65) is not appropriately called a "Temporary Use." The Bill Dawson trail now passes through a section of interesting wetlands with mature vegetation. After construction the area will look greatly different.

- The SDEIS does acknowledge that the Bill Dawson trail qualifies for 4(f) review.

The SDES may be correct that there was no way to keep the trail open, but alternatives must be evaluated.

- The SDEIS failed to acknowledge that there was a constructive use taking of this trail. Its arguments that the taking was temporary in spite of the taking lasting three years do not meet federal standards.

- There is need for mitigation other than saying that one can go back to the way things were before the trail existed. There will be fewer people passing through Montlake Playfield as a result of this change. They will bypass the park instead or will choose other routes to avoid the construction congestion that will be occurring there because without the trail the will not be able to avoid it.
- Because this is a heavily used pedestrian and bicycle trail, it must be replaced with an equivalent trail.

C-040-099

(16) The Washington Park Arboretum. (16) LAKE WASHINGTON Blvd.

See SDEIS description Attachment 6 page 37
*SDEIS description of Lake Washington and Montlake Boulevards as Olmstead Boulevards Chapter 4 page 4-32. SDEIS Description Chapter 4 page 4-30. See also SDEIS Foster Island and Marsh Island Chapter 4, page 4-30.*Lake Washington Boulevard is also adversely impacted by the taking of Canal Lands which balanced that Park Boulevard's entrance at Montlake.

Arboretum land (0.6 acres) is being taken by the expansion of SR 520, particularly on Foster Island. Also, the Arboretum has planned to use MOHI for office space and will therefore lose that facility.

In the Arboretum WSDOT already has a lot of right of way so the small take from Arboretum lands does not indicate the impact of the doubling of the footprint of the new SR520 in that area. Some of these lands are submerged and some are not. All are used for recreation and wildlife purposes and as such deserve 4(f) protection starting with taking steps to avoid use.

A very serious use of the Arboretum by SR520 now and in any expansion mode is the use of Lake Washington Boulevard as an on and off ramp to SR520 and the adverse

C-040-099 impact of increased traffic and increased noise and increased visual blight. See Letter from Park Commissioners Appendix X.

SDEIS under mitigation for "adverse effects that cannot be avoided or minimized (page 5-64) says that WSDOT is working on suitable replacement land (not identified) and other devices as well.

C-040-100

(17) West Montlake Park

The Bill Dawson Trail now leads via Montlake Boulevard to West Montlake Park. This park will be impacted by noise and visual blight by the expansion of SR 520.

C-040-101

(18) Ship Canal Trail

SDEIS Description of Ship Canal Waterside Trail Chapter 4 page 31; see also Attachment 5 page 35.

The Ship Canal Trail connects Foster Island and the Arboretum. It is a National Recreational Trail with special 6(f) status. (See also on same page Burke-Gilman Trail.) The trail will be blocked by the project and mitigation will be provided.

C-040-102

(19) McCurdy Park

SDEIS Description of McCurdy Park Chapter 4 page 4-30. See also Attachment 6 page 34. Confirmation these are 4(f) sites.

McCurdy Park is a 1.5 acre park adjacent to MOHAI and SR 520. It will be taken by this project, and City of Seattle will receive equivalent parkland in exchange. The R.H. Thompson lands have been targeted as the land to be exchanged. However, to the extent the R.H. Thompson lands are understood to be already parkland, they may be found to be an unacceptable exchange under the law because there would be a net reduction of public park land in the exchange and therefore the required mitigation would not be provided.

SDEIS Description of Potential Lids in Montlake Boulevard Area includes Option A's proposal of using a lid over SR520, east of Montlake Boulevard to link Arboretum land south of SR 520 with East Montlake Park, the lid helping the crossing over of the remains of McCurdy Park (taken by WSDOT for waste water treatment). This lid would contain the road that would enter, as it has historically, in front of MOHI which will cease to exist as part of this project because WSDOT needs that right of way.

C-040-103

(20) East Montlake Park

SDEIS Description of East Montlake Park Chapter 4 page 4-29.
SDEIS Description of East Montlake Park and McCurdy Park Attachment 6 page 34.

C-040-103 East Montlake Park is 7.1 acres. The western one third is owned by Seattle Parks and the eastern two thirds are owned by the Washington State Department of Natural Resources. All is managed by Seattle Parks Department.

The proposed expansion of SR 520 will take much of this park, but the balance will remain a park. A land exchange is being arranged with R.H. Thompson Lands proposed for the exchange. See discussion of this exchange under McCurdy Park and below under R.H. Thompson Lands.

C-040-104

(21) Arboretum Waterfront Trail

*SDEIS Description of Arboretum Waterfront Trail Chapter 4 page 4-*31

This trail connects to Marsh Island and Foster Island and then to the rest of the Arboretum. Land and Water Conservation Funds were used in the creation of this trail giving it a very special protected status.

Use is being halted during the construction period creating constructive use and the need for mitigation. Closure of this type of trail for 6 months creates an automatic Constructive Use requirement for mitigation, the provision of equivalent land providing the equivalent experience.

C-040-105

(22)The R.H. Thompson Lands

This area is a WSDOT right of way in the Arboretum. It has been used as parkland for the last 50 years and is totally surrounded by parkland. It is also a very actively used area with a nice parking lot for easy access. Few, if any users of the parking lot and the walking area would perceive that this land was any different from Arboretum land and paths and trails interconnect. This land lies in direct view of the entrance sign to the Arboretum. It is maintained by Seattle City Parks.

Because of its public access and park and wildlife use, probably all of the area within the WSDOT right not now used directly for highway use qualifies for 4(f) status and needs to be treated that way. The SDEIS here (as elsewhere) erroneously treats WSDOT right of way as not protected by 4(f). Additional examples include the water under SR 520 as well as the water south of Marsh Island. This Marsh Island area is heavily used by canoes coming to and from the Arboretum. That water area lies within the WSDOT right of way, but has been used for recreational purposes for 45 years. This land will be used by the proposed highway. (See Ch 5 page 5-60.) The SDEIS incorrectly assumes that expansion using WSDOT right of way in this area does not create the need for 4(f) harm evaluation and the requirement to minimize use of those lands as well as land established as park.

C-040-105 **The SDEIS failure identify the extent of 4(f) lands within the SR 520 right of way and to provide for all of them the avoidance and mitigation analysis required is an extremely significant error.**

The SDEIS Attachment 2, Agency Correspondence, un-numbered first page states that WSDOT plans to exchange the R.H. Thompson property as part of the mitigation. The SDEIS Chapter 7 page 24 says that "Unlike the experience of past years, however, today's transportation improvement projects include mitigation in the form of replacement parkland. No permanent loss in total park area would result from the proposed 6-Lane Alternative in combination with Medina to SR2012 project, Sound Transit's north Link, and East Link for light rail projects and other planned transportation improvement and land development or redevelopment projects." **This is making the argument that land taken will be replaced by other land equally suitable for park use. It pre-supposes a non-park use of the land being exchanged. However, the land in question, the R.H. Thompson Land is already park land as defined by 4(f), making the R.H. Thompson exchange questionable. Exchanging parkland for parkland may be acceptable to the owners, but it is not consistent with the objectives of federal law.**

The City of Seattle's Parkland Exchange Policy is quoted in SDEIS Chapter 7 page 7-25. Ordinance 118477 states that all park land must be preserved or mitigated by providing replacement "land or a facility of equivalent or better size, value, location and usefulness in the vicinity, serving the same community and the same park purpose." The intent is to see to it that "no long-term adverse effect on parkland and recreational resources would result from construction of the proposed project.

- The SDEIS fails to acknowledge that the WSDOT lands in the Arboretum area and elsewhere are publicly accessible park lands used for wildlife and recreation and therefore requiring 4(f) treatment.
- The SDEIS fails to evaluate alternatives which would avoid harm to these lands.
- The SDEIS fails to evaluate alternatives which would minimize the damage.
- The SDEIS has no proposals for mitigation

The use of open land for highway construction takes it over physically, with mass, shadow and noise. The new highway is to be higher than the old, increasing the impact on surrounding lands by increasing the distance the sound will travel, and also increasing the amount of noise with higher speeds. Open space used for recreation and wildlife is and subsequently taken for highway use is marred by that use, the attributes and functions of the land so taken are diminished, it becomes a less pleasant place for people and wildlife. Lands occupied by highways don't act and feel like parks. Doubling the size of this highway definitely increases the harm that is being done to the foot print area and beyond. There are also pollution issues and health issues of those who recreate or spend time next to highways. Small particulate emissions found close to

C-040-105 highways are hazardous to our health. All of this is to say that the taking of public recreational lands for highway use is a significant adverse taking.

C-040-106

(23) University Canal Lands

The University Canal Lands lie just to the north of SR 520 between Montlake and MOHAI. They have mature and very beautiful landscaping, and offer a very important visual continuity to the trees which line Lake Washington Blvd, emphasizing that one is entering into Arboretum Lands. Visually they provide an east-west continuity with McCurdy Park trees and help create a feeling of entering park land as one approaches MOHAI, East Montlake Park and McCurdy Park. The lands have been owned by the University of Washington for nearly 100 years. They are called Canal Lands because they front on what was once the canal through which logs were floated in the portage that gave Portage Bay its name. On the north side of this significant tract of land there is a significant grassy area with a picnic table, extending the park like setting to the contributing historic homes across the alley. The land has been a buffer between these residences and SR 520 for the last 45 years.

SDEIS shows that these lands will be taken for right of way Exhibit 5.2-3 Chapter 5, page 5-35.

Description of University lands as qualifying for 4(f) status is in Attachment 6 page 37, but this specific holding is not identified and only the University holdings north of the cut are described. The SDEIS shows, however, that the homes adjacent to this site contribute to the historical district.

These are publicly owned lands used as open space to support three adjacent parks: The Arboretum with its Lake Washington Boulevard Parkway park land is across SR 520 to the south, McCurdy is directly east, and this parcel serves as a gateway to East Montlake to the north. In addition, these lands on Montlake Boulevard set the tone of entering University Open space used for park type activities. I believe these lands qualify for 4f protection.

The loss of these lands will be a significant loss to Lake Washington Blvd and should be identified as a 4(f) loss for that reason as well as the other reasons that have been identified. The impact of widening SR 520 at Montlake Boulevard is severe because of the magnitude of the widening. It creates a major challenge to recreating an attractive entrance way to the Arboretum and to East Montlake Park because real trees can't be grown on lids.

- The SDEIS fails to acknowledge that these University Lands publicly accessible park lands used for recreation and wildlife and therefore require 4(f) avoidance if

C-040-106 possible. In this case with parkland on both sides of SR520 avoidance can only happen with reduced foot print, a smaller road. This is the critical assessment The SDEIS fails to evaluate alternatives which would avoid harm to these lands.

- The SDEIS fails to evaluate alternatives which would minimize the damage.
- The SDEIS has no proposals for mitigation

It is not clear to me what will be left of these lands and how that remainder will be used. Preserving the green belt here is particularly important given its many links to other green areas.

C-040-107

Notes on the Proposed 10th Avenue to Delmar Lid

Exhibit 3-6, Chapter 3, page 3-12 shows the location of retaining walls supporting the proposed lid between 10th Avenue and Delmar. Given the required height clearance of the roadway and height of the 10th and Delmar bridges and given the steep slope of the adjacent hillsides, it is clear that these walls will be above ground for a lid which is described as dropping from surface level on 10th Avenue to surface level on Delmar Street, making it a twisted plane. For the lid to be attractive, the contour of the hill should be re-established as it once was by filling in behind its walls. But that will take design of the walls integral to the lid such that the walls can hold back earth. If not, the walls will collect ivy and graffiti. In the above Exhibit, the limits to construction are what the SDEIS thinks is WSDOT right of way, but that right of way actually includes the clear patches in the photo. Thus, the landscaping should run from that verge to Roanoke Street in a nice slope which would act to integrate Roanoke Park, Bagley Viewpoint and Interlaken Park and further re-integrate the historic Roanoke neighborhood, with pedestrian connections to the now dead-end Federal Avenue East, to Interlaken at 11th Avenue East and to Bagley Viewpoint.

The purposes of the lid have been described in the SDEIS, but not in a cohesive fashion which establishes both that this is mandatory mitigation and that the mitigation must be done in a way that achieves not just sound mitigation but also mitigates damage to the adjacent parks and historic neighborhoods. In addition the SDEIS fails to describe the need in this high traffic area to not have exposed and ugly barrier walls that would restrict movement and create maintenance headaches.

SDEIS claims a noise reduction relative to current levels throughout the corridor but says "The addition of lids and landscape features over the highway would be the primary reasons for the reduction in noise levels." Chapter 5 page 5-170.

SDEIS Exhibit 5-4-1 Permanent Park Acquisition at Bagley Viewpoint CH 5 page 5-54 includes one lid depiction which just covers the highway section and a cartoon artist rendering of the lid. The issues of fitting the lid into the hillside without creating graffiti collecting walls have not been dealt with.

C-040-107 SDEIS, Chapter 5, page 5-44 says that community cohesion would be improved in the neighborhoods in the study area. "They all include landscape lids with pedestrian and bicycle pathways over I-5 at East Roanoke Street, 10th Avenue East and Delmar Drive East and in the vicinity of Montlake Boulevard East. The lids would benefit community cohesion by reconnecting neighborhoods originally bisected by SR 520 and I-5, providing linkages between adjacent and nearby parks, improving views toward the highway from nearby residences, and providing safe passage across i-5 and SR 520 at these locations.

SDEIS, Chapter 5, page 5-53 " Green open spaces, landscaping and pathways planned for the lids at I-5 10th and Delmar and in the Montlake area would provide new area for passive recreation. Trails across these lids would further improve connectivity for bicyclists and pedestrians."

Care needs to be taken to manage the south to north transition of the lid: the transition from 11th and the end of Federal Street and the higher portion of the hill near 10th Avenue as the ground slopes to Roanoke Street. There is no discussion of the south to north transition issues the 10th Avenue to Delmar lid will present although one of the objectives of the lid, besides noise containment, is described as bridging neighborhoods otherwise cut apart by SR 520. The break is most significant north-south because SR 520 lies in an East-West trench with few cross over points. Making that north south connection by using a lid to make a pedestrian connection from Federal Avenue East to Roanoke Park, for example, would be very valuable.

The SDEIS Right of Way description in Exhibit 5.2-1 purports to show WSDOT right of way south of Roanoke Street and East of 10th Avenue Bridge. The actual right of way is further to the south and includes the cleared areas in the photo.

Unfortunately, the SDEIS describes the 10th to Delmar Lid and all other lids as at the discretion of WSDOT, not mandatory remediation. Further, the picture shown is a lid over the actual excavated area of roadway with no backfilling. This 1950's style design would leave walls on the north and south sides which would collect graffiti and ivy and areas for the homeless and leave the slope too steep for use or maintenance.

It is critical that the importance of the connection of Roanoke Park to Interlaken be recognized so that the lid proposed is:
A. Seen as mandatory,
B. Seen as requiring lid design integrated with wall design such that the walls will be able to hold fill stacked up against them (Meaning trees can be planted at the edges of the lid and the walls will disappear at surface level because they have been backfilled.)
C. Constructed so that fill be removed as part of the construction be reserved for placement against those walls so that the hillside can be contoured as it was before SR 520 was built. The excavation material will be beach like sand, perfect for this

C-040-107 application. This will require negligible additional cost and will create usable recreation area equivalent to the current area of Roanoke Park. Keeping the fill near the site of excavation offers the potential to reduce adverse hauling impact on adjacent historical neighborhood as well as reducing excavation cost. Lids have weight constraints such that they are basically tree free. Tying the lid into the hill at lid surface level on an integrated basis will permit trees to grow near the edges of the lid and create a wonderful easily maintainable landscape as well as easy path transitions.

A major failure of the SDEIS is that it fails to acknowledge that under the No Build Alternative the landscaping would be preserved and the degradation of the adjacent park areas by an expanded highway system would not occur. If the decision is to destroy what we have, then that destruction on and off right of way should be identified. That in turn should create a mitigation mandate, not a WSDOT option to mitigate which is what the SDEIS now describes.

SDEIS Overview Maps and Exhibits

- SDEIS Map page 4-27 which shows all parks in affected area including Miller Park and Colonnade Park.
- SDEIS Table 4.4-1 Chapter 4, page 4.28 which lists all Recreation Resources in Project Vicinity.
- SDEIS VIEWSHED and Landscape Units map Chapter, page 4-35 and subsequent descriptions of same. There are 6: Roanoke, Portage Bay, Montlake, Union Bay, Lake Washington and Eastside Viewshed and Landscape Units.
- Historic Properties of Seattle Chapter 4, page 4-43. It is noteworthy how much of the area SR 520 passes through is historical. See also Historical Properties East side Chapter 4, page 4-50.
- Exhibit 4.7-1 Existing Noise Levels in the Seattle Project Area Chapter 4 page 4-52 for Seattle side and page 4-53 for east side.
- Chapter 4, page 4-62 Wetlands in the Seattle Area.
- Chapter 5, page 5-29 Future Trail Connectivity showing link Montlake Playfield Park to Arboretum and back to Montlake West Park.
- SDEIS Table 5.4-1 Permanent Park Acquisitions (acres) Chapter 5, page 5-54. Note that Montlake Park submerged lands are not described.
- SDEIS Table 6.4-1 Construction Effects on Parks (acres.) Chapter 6 page 6-38.
- Properties with a Section 4(f) Use in the Seattle Area Overview Map.
- 4(f) standards Attachment 6 page 57.
- Summary of Potential Section 4(f) Use Impacts Option Attachment 6 page 82.
- See also that the decisions on 4(f) and 6(f) were made by the TWG group. (Attachment 1 page 6) and their conclusions are on page 7. Meeting discussions are listed on Page 21 and might be valuable to get because they discussed 4(f) thresholds for Roanoke Park, the Bill Dawson Trail, the issue of permanent vs. temporary use, etc.

TILGHMAN GROUP
TRANSPORTATION PLANNING

14 April 2010

Jenifer Young
Environmental Manager
SR 520 Program Office
600 Stewart St., Suite 520
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C-040-108 Dear Ms. Young:

I have reviewed the SR-520: I-5 to Medina Bridge Replacement and HOV Project SDEIS on behalf of The Coalition for a Sustainable SR-520 and offer the following comments. My comments fall under four categories:

- Corridor Traffic Operations
- Assumptions
- Needed Clarifications
- Conclusions of the SDEIS

1. Corridor Traffic Operations

A. The SDEIS describes traffic operations on SR-520 and at intersections but gives much less attention to corridor operations on surface streets. While it indicates that congestion occurring at one location may affect others, it does not provide a clear picture of how traffic operates or will operate along corridors such as Montlake Boulevard, NE Pacific Street, E. Roanoke Street, Harvard Avenue E., 10th Avenue E., or Lake Washington Boulevard through the Arboretum. For example:

- The document (SDEIS 4-3) gives only nodding recognition to existing backups on Montlake Blvd. indicating that they "can" extend as far north as NE 25th Avenue rather than saying that those long backups occur daily, and that they often extend further back. The same is true for NE Pacific Street.
- The Transportation Discipline Report (6-24) notes for the No Build option that "Montlake Boulevard southbound would often be congested as far back as NE 45th Street". That is barely different than today's conditions, despite the significant increase in volume by 2030 and longer delays at the intersection of Montlake Blvd/NE Pacific Street. How is that possible?

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C-040-108
- Similarly, for options K & L, "The increased congestion would affect adjacent intersection operations to the north, south, and west" of the Montlake Blvd/NE Pacific intersection (Transportation Discipline Report 6-40). How will the operations be affected? How will travel times be affected? How frequent will back-ups be?
- Option K's turnaround at the new Montlake interchange is projected to operate slowly during both morning and afternoon peak periods. Long queues occur for northbound traffic in the Arboretum during the morning commute now (although they are not discussed in the SDEIS), and volumes on Lake Washington Boulevard are projected to increase significantly with Option K. How will the turnaround's slow operation affect traffic driving through the Arboretum?

C-040-109
B. Pedestrian and bicycle routes are identified for each option but important elements of the user's experience are not discussed. For example:
   - Option A creates a much wider intersection at Montlake Blvd./24th Avenue East. Pedestrians would cross 5, 6 and 7 lanes, where they now cross 3, 4 and 5 lanes. What is the potential effect of wider crossings on pedestrian safety, walking time and pedestrians' willingness to walk?
   - Option A also creates a new signalized intersection on Montlake Blvd. at the 520 westbound ramps with a 5th leg for buses. Pedestrians face additional crossings as well as a wait at the new signal. How does this affect pedestrian safety and walking time along the Montlake corridor?
   - Riders transferring from the new SR-520 westbound bus stop under Option A to southbound local buses would have a new route to reach the southbound bus stop. Currently, riders can use the stairs and underpass to cross Montlake and then have only one lane of traffic to cross to reach the stop. While the new route is a shorter distance, it appears to require waiting at two signalized cross-walks. Would more time be required to make such a transfer than occurs now?
   - The SDEIS (5-28)calls Option A's reduction of volumes on Lake Washington Blvd. a benefit to cyclists and pedestrians but it does not characterize the effect of Option K & L's increases in volumes on cyclists and pedestrians on that road. What would the effect be?

C-040-110
2. Assumptions

A. The area of influence identified for the Montlake interchange does not adequately cover roads and intersections affected by traffic operations south of the interchange. While its influence extends nearly a mile to the north, the south boundary is located at the SR-520 Arboretum ramps. The boundary should extend further south to include 24th Avenue at Boyer, Lake Washington Blvd. at Boyer, 23rd Avenue at Madison, and Lake Washington Blvd. at Madison. Given the identified shifts in volume among the options, their effects on the Arboretum and streets serving it should be fully understood.

C-040-110 On Capitol Hill, the area of influence should extend from the Harvard Avenue E/ I-5 on-ramp south to at least the 10th Avenue E/ Boston intersection. This area experiences almost daily backups from vehicles wanting to enter or leave SR 520.

C-040-111 B. Option A adds a second bridge across the Montlake Cut. Yet, the need for the second bridge is not readily apparent. For instance, traffic performance between the No Build alternative and Option SA (also known as Option A+ as preferred by the Legislative Workgroup) differs only by one letter grade at two intersections. Unfortunately, there is too little information in the SDEIS to indicate whether the LOS results reflect borderline ratings or more significant differences in travel delay. Accordingly, the transportation benefit of the second bridge remains obscure. Yet, its impacts to views, home displacements, and neighborhood character are obvious. How was it determined that additional capacity across the Montlake Cut is required? If it is, indeed, required, are there other options to provide extra capacity that have fewer community impacts?

C-040-112 C. Transit demand modeling relied on an approach "not constrained by transit volume and service forecasts" (Transportation Discipline Report 4-8). This approach produces an ideal but not realistic transit demand forecast. How would a more realistic forecast reflecting transit agencies' service policies differ? To what extent did the unconstrained transit modeling result in a mode shift from general purpose vehicles?

C-040-113 D. Future transit vehicle occupancy assumes an average of 65 passengers per bus (Transportation Discipline Report 4-8) whereas today's buses average just under 30 passengers (derived from information in Transportation Discipline Report 8-3). That assumption exceeds the number of seats on the largest buses currently in service and implies that all peak period bus trips would operate with standing loads. How is such a vast increase in vehicle occupancy a reasonable and appropriately conservative assumption? If the demand forecast is to be believed, then the number of buses has most likely been understated.

C-040-114 E. As the SDEIS notes, elimination of the Montlake freeway transit station will force riders between the University District and Eastside to make transfers. Did the unconstrained transit demand modeling account for the disadvantage of a transfer? If not, what is the effect on transit demand and general purpose traffic of doing so?

C-040-115 F. A number of recently proposed developments in the Montlake area would increase traffic on study area streets. These projects include: University Village Shopping Center expansion; QFC additional recreational facility development at Warren G. Magnuson Park. Traffic volume forecasts used in the SDEIS need to be updated to include these specific projects. It should be noted that the University Village, QFC and Seattle Children's projects alone would account for over half of the SDEIS's background traffic growth on Montlake Blvd. north of NE Pacific Pl.

C-040-116 G. Pedestrian volumes were assumed to remain static (Transportation Discipline Report 4-15). That assumption conflicts with all other assumptions about population and employment growth, transit ridership increases, and traffic volume growth. Since pedestrian volumes at intersection crosswalks affect traffic operations, intersection level of service analysis should incorporate realistically higher pedestrian volumes at crosswalks.

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C-040-117 H. A modified plan for pedestrian access to Sound Transit's light rail station has been proposed by the University of Washington. The proposal calls for a new surface crossing of Montlake Blvd. between NE Pacific St. and NE Pacific Place rather than a pedestrian bridge. If this proposal should be adopted, the SDEIS should be updated to include that crossing in its traffic analysis.

3. Needed Clarifications

C-040-118 A. For all options, it would be very helpful to know the changes in travel time along arterial streets. That is a measure that readers can readily understand in comparing the effects of the options. Comparisons should begin with existing travel times and then estimate future times for all options, including No Build.

C-040-119 B. The analysis of SR-520 provides extensive information about variations in hourly volumes and operations. The analysis of local arterials, however, deals only with the morning and afternoon peak hour. How many hours experience similar levels of congestion now, and how many in the future?

C-040-120 C. How would bridge openings affect future traffic operations? The SDEIS notes that mid-afternoon openings can cause delay through the entire afternoon peak period now, so what would the effects be for each of the options?

D. Under Option A (including SA and A+), with a second bascule bridge, would the duration of bridge openings differ from today's times? If so, how would traffic be affected?

C-040-121 E. Option A claims a reduction in volumes on streets north of the Montlake Cut due to elimination of the Lake Washington Boulevard ramps to SR-520. This seems speculative given that the alternate routes of travel noted in the Transportation Discipline Report entail considerable out-of-direction travel, congestion in the NE 45th Street corridor, and limited I-5 access capacity from NE 45th Street. The volume reductions result in an improvement in LOS at Montlake Blvd NE/NE Pacific Street and at NE Pacific Street/15th Avenue NE over No Build conditions (Transportation Discipline Report 6-33). How realistic is such diversion? And how sensitive are the LOS results to that reduction in volume?

C-040-122 F. Option A is shown to reduce volumes on Lake Washington Boulevard. How far south is that the case? Does that reduction occur because of a diversion to E. Boyer Street and 24th Avenue E. to reach SR-520? If so, what are the consequences for intersections on E. Boyer and on E. Boyer itself?

C-040-123 G. Option A includes an auxiliary lane on westbound SR-520 across Portage Bay. Yet, even with that extra capacity, Option A has less westbound on-ramp throughput than other options. What function does that lane provide? What would traffic performance be for Option A without the auxiliary lane? Why would Option A+ have the auxiliary lane?

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C-040-124 H. Option K would reconfigure Lake Washington Boulevard at the north end of the Arboretum. However, the text and maps do no fully illustrate changes in circulation resulting from that reconfiguration.

- How would the intersection with E. Foster Rd. be configured? What would be its operating quality?
- What is the change in volume on E. Roanoke Street with the one-way local access scheme on Lake Washington Boulevard?
- Volumes with Options K & L increase significantly through the Arboretum. How would they affect the operation of Lake Washington Boulevard/E. Madison Street? And how long would southbound queues be at E. Madison? Queues now frequently extend back to the Japanese Garden in both morning and afternoon peak periods.

C-040-125 I. At E. Roanoke and Harvard Avenue E, the existing PM peak hour level of service is F. Vehicles waiting in queues now do not all clear the intersection on one signal cycle. For all future scenarios, volumes increase at this intersection. Yet, there is no sense of how queues will grow. How long will queues be and how much additional delay will occur on the approaches to this intersection? How will traffic on 10th Avenue E. operate?

4. Conclusions of the SDEIS

C-040-126 A. Exhibit 5-19 in the Transportation Discipline Report compares demand and throughput for the Portage Bay Bridge and the westbound on-ramp. Throughput varies for each Option, ranging from 74% to 86% of demand, substantially less than for No Build. The text, however, obscures this fact by discussing how the build options compare with one another. Had it compared them to No Build conditions, the text would state that the build options make conditions worse. Queues on local streets would be longer than under No Build. The difference in queuing, and not just in intersection LOS, should be disclosed so that the consequences for local traffic operations are clear.

C-040-127 B. The cumulative effects scenario includes regional transportation projects that may not be completed by 2030. Yet, the Transportation Discipline Report (11-15) concludes that, in comparison to the cumulative effects analysis, the SDEIS alternatives analysis "represents a conservatively high estimate of traffic and associated traffic effects". It is misleading, however, to say that the SDEIS is either conservative or high in its projections. The SDEIS and cumulative analysis scenarios are simply different networks with different results. There is no indication that the modeling done for the SDEIS reflects a high projection of traffic demand given the network assumed for the SDEIS alternatives. In fact, as I noted previously, the forecast of bus vehicles appears low. Furthermore, the Transportation Discipline Report (11-7) pointedly tells readers not to compare the results of the cumulative analysis directly with those of the other analyses, saying that they are instead for relative comparisons at the regional level.

C-040-128 C. Operating results for key intersections on Montlake Blvd. show very poor future performance. It is hardly acceptable to say that a particular option's LOS F is better than No Build's LOS F – both represent a system failure and therefore guarantee unwelcome environmental consequences.

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C-040-128 Under those conditions, the build options simply allow more people to share in the poor performance. It would be useful to determine what measures would achieve better results so that decision makers know whether they have realistic choices to improve future operations.

C-040-129 D. Overall, the SDEIS needs to provide a more comprehensive measure of performance on arterial streets, comparable to its measures for SR-520 performance. Indications of travel time, queue lengths, and missed signal cycles would be instructive and for more informative for most readers. Similar measures for local transit trips and for pedestrian and bicycle travel also are necessary to provide a reasonably complete picture of transportation performance resulting from the project's various options.

Thank you for the opportunity to comment on this regionally and locally important project. I look forward to reviewing your responses to these comments.

Sincerely,

Ross Tilghman

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April 14, 2010

Bricklin & Newman
1001 Fourth Avenue, Suite #3303
Seattle, WA 98154

Attention: David Bricklin
Subject: SR-520 SDEIS, Noise Analysis Review

C-040-130 Ladies and Gentlemen:

This report presents review comments pertaining to the Supplemental Draft Environmental Impact Statement prepared by WSDOT for the SR-520 project as it pertains to the west end of the proposed project. I did not take time to review the entire document, but I have reviewed the sections relating to noise (SDEIS Chapters 5.7, 6.7, and the Noise Discipline Report). I have also reviewed the November 24, 2008 final report on Noise Reduction Strategies prepared by the expert review panel. My comments are focused only on the west end of the project, extending from I-5 east to the floating bridge.

Construction Noise

Chapter 6.7 of the SDEIS discusses the issue of construction noise impacts. In the Key Points box it is disclosed that maximum noise levels could be as high as 105 dB at a distance of 50 feet from pile driving. Other sources could be as high as 92 dB at the same distance. These sound levels are 30 to 40 dB higher than any of the measured existing sound levels reported in Exhibit 10 on page 31 of the Noise Discipline Report (Part 1). The construction noise level increase (above the existing ambient noise levels) is not presented in the SDEIS as it should be.

It is stated at the bottom of page 6-64 of Chapter 6.7 of the SDEIS that most construction work could be performed within the limits of the Seattle Noise Ordinance (Table 6.7-2 of the SDEIS) if the work was performed during normal daytime hours. This is almost certainly false as anyone can easily see by comparing the typical construction equipment noise levels presented in Table 6.7-1 with the sound levels presented in Table 6.7-2. I suspect that what was intended by this sentence is that most construction work could be performed within the limits of the Seattle Noise Ordinance (SMC 25.08.425), which

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C-040-130 allows maximum noise levels to be as much as 25 dB higher than the values presented in Table 6.7-1 of the SDEIS. This statement cannot be true if pile driving and demolition work are taken into account. If the noise levels from pile driving are as high as is indicated in this document, this activity would not comply with the Seattle noise ordinance (SMC 25.08.425) in either the daytime or the nighttime. The bigger issue, however, is the noise impacts on the community, not just compliance with the noise ordinance. In order to determine the noise impact on the community the EIS must assess both the existing and predicted future noise levels (both construction noise and operational noise). This comparison cannot be found in the DSEIS.

C-040-131 It should be noted that construction noise within the city limits of Seattle is limited by SMC 25.08.425. As I have stated previously, it is likely that WSDOT will require a noise variance for pile driving operations during the daytime, as well as a noise variance for other activities if construction is expected to continue through the nighttime hours. With the exception of impact sources like pile driving (where compliance is based on the maximum noise level), compliance with the daytime construction noise ordinance is based on a 1-hour average (Leq) noise level. The predicted average construction noise levels at a distance of 50 feet range from 83 to 88 dB as shown in Table 6.7-5 of the SDEIS. The maximum allowable construction noise level (1-hour Leq) during daytime hours in a residential zone is 80 dB (55 + 25 = 80). Since the predicted average (Leq) sound levels presented in Table 6.7-5 are all above the 80 dB maximum allowable noise level allowed by the construction section of the Seattle Noise Ordinance, it seems all too evident that a noise variance would be required for both daytime and nighttime construction activities related to this project. The SDEIS should also present another table similar to Table 6.7-5 that compares the predicted construction noise levels (both Lmax and Leq) with the existing Leq and Lmax at residences that will be in close proximity to the construction activity. The table should show the expected increase in noise level due to construction activity, the duration (times of day and overall extent) of the construction activity, the probability of the noise interfering with normal daily activities (including sleep interference), and the number of residences that will experience this specific noise level increase. This information cannot be found in the current SDEIS. How likely is it that the noise will interfere with their sleep, and to what extent? Will it likely wake them once in a while or will it be so pervasive that people can barely sleep at all? Questions like these need answers if the EIS is to provide the information necessary for an informed decision.

C-040-132 Exhibit 6.7-2 shows the predicted "typical maximum pile driving noise levels" as a function of distance from the source of the noise. While the graph is accurate, the last sentence at the bottom of page 6-68 is misleading because it implies that the graph is a conservative estimate by ignoring the effects of ground attenuation and atmospheric

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C-040-132 absorption. While this is also true, a fair disclosure would note that both of these effects (ground attenuation and atmospheric absorption) are not significant factors for sound transmission over water or pavement and at distances less than 1,000 feet.

C-040-133 Of all of the construction noise issues relating to this project, pile driving will be the toughest to deal with in terms of noise control. Not only does pile driving generate the highest noise levels of all sources, the noise is impulsive in nature which makes it even more annoying and stressful than other types of noise. This critical information is not disclosed in the DSEIS. It should be disclosed prominently.

The contour plots showing the extent of pile driving noise in Exhibit 7.67-3 of the SDEIS clearly show that this noise will be audible over a large area of the city, including the Capitol Hill, Madison Park, Montlake, and Laurelhurst areas. The pile driving noise will be clearly audible anywhere inside the 75 dBA contour, and should also be audible (to a lesser degree) outside this contour. The impact noise levels will be extreme inside the 87 dBA (green) contour. There is very little discussion of noise mitigation in the SDEIS for the pile driving work. There is only brief mention of augering piles (which would be much quieter than pile driving), including a statement that an auger is not likely to be feasible (without any explanation as to why it would not be feasible). There is only a brief mention of coating the piles, using piston mufflers, and using pile pads to cushion the noise of impact, suggesting that these methods are less effective. Clearly, because of the extreme noise levels that are predicted, much more effort should be placed on these and other possible techniques for controlling pile driving noise.

Consideration should also be given to the use of suspended acoustic shields as a technique for reducing pile driving noise. This technique was used successfully in 1998 during the construction of King Street Center in the Pioneer Square district of downtown Seattle (see attached newspaper article and technical report). The piles used in that project were quite a bit smaller than those proposed for this project, so the impact noise levels for this project could be even higher.

C-040-134 Another glaring omission in the SDEIS is the lack of a discussion about a construction noise monitoring program. This will actually be required in order to determine if the project is in compliance with the Seattle Noise Ordinance. This is not something that can be initiated at the last minute. In order to be effective, a properly designed and executed construction noise monitoring program should have baseline ambient noise measurements collected over an extended period of time before construction begins. Without preconstruction noise measurements over an extended period of time, it may be impossible to distinguish construction noise from general environmental noise (with the

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C-040-134 obvious exception of pile driving noise which will be easily distinguished from the general environmental noise in the area).

C-040-135 The construction noise mitigation measures listed on page 6-72 of the SDEIS should be extended to include acoustic shields for pile driving. In addition, unless pile driving work on weekends and holidays is precluded, the EIS should disclose the impact of that noise on outdoor (and indoor) activities likely to be underway during those times.

C-040-136 The restriction of backup beepers during evening and nighttime hours is a good approach, but another step which could be implemented is the use of ambient sensitive beepers (which adjust the level of the beep commensurate with the ambient noise level at the time) or the use of broadband backup alarms which are less annoying than the standard tonal beepers, especially at distances greater than 100 feet from the vehicle.

C-040-137 Page 6-69 and the final paragraph of Section 6.7 of the SDEIS discuss vibration effects. The vibration level mentioned as a likely maximum for distances of 50 to 100 feet is 0.5 inch per second. While this might sound like a low vibration level, it really is not. The threshold of human perception (for a human being standing on the ground or on the floor of a building) is approximately 0.005 inch per second, which is only 1% of the level mentioned. According to ANSI Standard S3.29, the recommended maximum floor vibration level for residences during the daytime hours is equivalent to 0.008 inch per second. The commonly used safe limit for preventing damage to building structures is 2 inches per second, although minor damage has been observed[1] at vibration levels of 1 inch per second. The point here is that the vibration level referenced in the SDEIS looks like a relatively small value, but it is close to the threshold of causing damage to structures, and it is nearly 100 times the threshold of annoyance to private citizens living in their homes close to the construction site. As with the noise impacts, the EIS should disclose this impact in plain English, with a description of its likely effect on humans and structures. The EIS should include information on not only the intensity, but also the duration of these impacts.

C-040-138 It should also be pointed out that Option L will certainly cause a significant increase in construction noise for the residents of the Montlake area, due to its close proximity to the proposed new bridge and roadway around this residential development. The last paragraph on page 6-69 mentions construction noise impacts to the Burke-Gilman trail and the UW campus, but completely ignores the Montlake residential district which would have the greatest noise impact of all (pertaining to Option L).

[1] Handbook of Acoustical Measurements and Noise Control, Third Edition, Cyril M. Harris (editor), page 26.13, McGraw-Hill, 1991.

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C-040-139 One of the important recommendations offered by the Expert Review Panel in their Novervmber 24, 2008 final report was to develop a construction noise plan that "involves substantial and targeted public input". I cannot agree more, and this plan should include noise monitoring stations at carefully selected locations to ensure that the project complies with the Seattle Noise Ordinance and includes the noise mitigation measures agreed to prior to the start of construction.

C-040-140 *Operational Noise*

Chapter 5.7 of the SDEIS discusses the issue of operational noise impacts. In the Key Points box it is noted that the number of residences that are expected to exceed the 67 dB noise abatement criteria (NAC) in 2030 will be less than the No Build Alternative, regardless of which alternative is selected. This analysis is based on the output of the traffic noise model TNM (version 2.5). According to Table 5.7-1, this is not necessarily true for all areas within the project. For example, under the No Build Alternative, 24 of the 83 residences in the Portage Bay/Roanoke area will exceed the NAC, but that number will increase from 24 to 26 for Option A, and the number increases to 27 for Options K and L. Even more disturbing is some of the data that is presented in Exhibit 5.7-1. If you look at the 4 residences (closest to the east end of the Montlake Cut) located in the Montlake district north of SR-520, you will see that they are all marked as green circles for the No Build Alternative and for Option A. The green circle means that the calculated noise level is between 49 dB and 65 dB. If you look at these same 4 residences under Option K (which includes a tunnel under the Montlake Cut, so there is no exposed traffic noise other than the tunnel entrance next to SR-520) you will note that the traffic noise level does not change for the three residences closest to the Montlake Cut, but the one residence closest to the tunnel entrance is expected to change from a green circle to a red circle, which indicates that the traffic noise level will cross over the 65 dB threshold. This conclusion is believable, but the data presented for Option L is not. As one can see from the figure, the three residences closest to the Montlake Cut are still shown as solid green circles (indicating no noticeable increase in noise level), even though a new arterial is passing right next to these homes! The fourth residence is shown as having a 3 to 6 dB decrease in noise level by the introduction of a new arterial that appears to pass directly through the center of the home. This is clearly not believable, and makes me question the validity of other data points in these figures.

C-040-141 The Key Point note on page 5-105 of the SDEIS suggests that noise barrier walls alongside the SR-520 roadway will be the primary method of mitigating the operational noise impacts of this project. The key note goes on to say that quieter pavements cannot be considered for use on this project because these pavements have not been

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C-040-141 demonstrated to meet the required noise mitigation standards in Washington State. While noise barrier walls are well known to be an effective and long-lasting means of reducing traffic noise if properly designed and installed, they are not the only approach that should be considered. In fact, 70% of the Expert Review Panel voted to recommend that open-grated friction course (OGFC) overlays be considered for this project. The remaining 30% voted that additional information should be acquired and assessed prior to making a final recommendation, but none of the expert panel members voted to reject the use of the OGFC pavement overlay as a viable candidate for a quiet pavement for this project. There are two major questions that impact the feasibility of this noise mitigation methodology. One issue is how much noise reduction can be achieved with the quieter pavements, and the second is how long will the noise reducing capabilities last before it must be replaced? Mr. Tim Sexton of WSDOT will be presenting a technical paper on April 19, 2010 at Noise-Con 2010 in Baltimore, MD discussing the results of recent testing on sections of quiet pavement in the Seattle area. According to his abstract, the results show that the "quiet pavement" was not significantly quieter that the control sections after 6 months of use. Reasons for the poor performance are not known, but the use of studded tires on some vehicles, frequent freeze-thaw cycles, and lower surface temperatures during installation are suggested as possible causes. Certainly, no one would want to rely on a noise mitigation method that is expensive and does not work. While it may not be prudent to rely on a technique that has not yet proven to be effective in this region, if WSDOT is eventually able to figure out how to make it work in this area, it could easily be added to the project at a later date. Adding noise barrier walls to the project after the fact would be extremely expensive and virtually impossible in the bridge sections due to structural considerations.

C-040-142 Noise barrier walls are proposed for both sides of SR-520 from the lid at 10th and Delmar all the way down to the Montlake interchange. In addition, there is a noise barrier wall proposed for the south side of SR-520 to protect the Madison Park neighborhood. The SDEIS does not indicate the height of the noise barrier walls (although the presumed heights can be found in the Noise Discipline Report), nor does any document indicate whether or not the barriers are reflective or sound absorptive on the side facing the traffic. This is an important detail that will affect the acoustical performance of the barrier. The EIS should disclose what assumptions were made regarding these items in developing the predictions of the noise reduction effects of the walls.

Presumably, the noise barriers will be designed to meet the WSDOT criteria using the FHWA traffic noise model (TNM version 2.5). The main problem with this is that Version 2.5 of TNM does not even attempt to model acoustic reflections from vertical surfaces, so it will underestimate the traffic noise levels in the Laurelhurst neighborhood because of the reflection off the noise barrier wall on the south side of SR-520 near

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C-040-142 Madison Park. The note on Exhibit 5.7-3 indicates that noise walls were not evaluated for the Laurelhurst neighborhood because the calculated noise levels did not exceed the NAC. Noise levels in Laurelhurst could be up to 3 dB higher than predicted by Version 2.5 of the TNM because of this limitation of the model. SR-520 traffic noise levels could be even more than 3 dB above the TNM predictions when there is a south wind or during certain atmospheric conditions. These metrological effects are not modeled by TNM, but they can be modeled by more advanced noise modeling software programs like CadnaA and SoundPlan, both of which employ the sound propagation models that are documented in ISO 9613-2.

C-040-143 The other problem with Version 2.5 of the TNM, relates to the consideration of parallel noise barriers. When noise barriers are located on both sides of the highway, the effectiveness of the noise barrier is reduced due to multiple reflections between the two vertical barriers. The degradation of the acoustical performance is significant when the ratio of the height of the barriers to the width of the roadway (distance between the barriers) is greater than 10 to 1. Parallel barriers are recommended for all Build options on the Portage Bay bridge, extending from the lid at 10th and Delmar all the way down to the Montlake Blvd. interchange. According to Exhibit 54 in the Noise Discipline Report, the height of these parallel barriers will be 10 feet on both sides of the highway. The width of the roadway would be less than 100 feet for all options, since there will be only 6 lanes of traffic (except for Option A which would have 7 lanes). These roadway dimensions would require an evaluation of the degradation of the acoustical performance of these noise barriers. Version 2.5 of TNM does not do this automatically. Assessing the degradation caused by the parallel barriers requires a special program run and the results have to be manually deducted from the values calculated from the original program run. This was not mentioned in the Noise Discipline Report, so I would assume that this has not yet been done. This effect will result in higher predicted noise levels on both sides of the Portage Bay bridge. The degradation caused by parallel noise barrier walls can be reduced by increasing the height of the noise barrier walls and/or installing noise barriers that are sound absorptive on the side facing the traffic.

C-040-144 One of the best design features of the proposed project (from an acoustic perspective) is the use of lids over the SR-520 roadway in the Montlake and Capitol Hill neighborhoods. Residents in the vicinity of these lids will enjoy significant traffic noise reductions. This is not true of the residences near the entrances and exits of the lids, however. Noise generated by traffic under the lids does not simply disappear. It will radiate out the lid openings, concentrating the traffic noise near the openings that would otherwise be distributed over a wide area. This effect is not modeled by Version 2.5 of the TNM.

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C-040-144 There are two ways to combat this increase in noise level: 1) introduce high noise barrier walls at the entrance and exits of the lids, and/or 2) adding sound absorptive materials to the underside of the lid. The concept of adding acoustical treatment to the inside of the tunnels and lids was something that was recommended by 90% of the Expert Review Panel. Appropriate materials are readily available for this type of application, and they should be incorporated into the project. Unless the project is revised to include full acoustic treatment inside the tunnel and the lidded portions of the project, the noise level projections presented in the EIS in these areas should be adjusted upward accordingly or noted as being lower than the true expected noise levels.

C-040-145 *Summary*

This review has pointed out several major deficiencies in the SDEIS, which can be briefly itemized as follows:

1. Construction noise impacts are not adequately addressed
2. Pile driving noise mitigation was not adequately addressed
3. A construction noise monitoring program was not even mentioned
4. Vibration impacts during construction are not adequately addressed
5. A construction noise plan with community input was not even mentioned
6. The effects of parallel barriers and the resulting noise impacts are not discussed
7. The importance of acoustical treatment in tunnels and lids and on the traffic side of the noise barriers is not discussed

If you have any questions concerning these results, do not hesitate to give me a call.

Very truly yours,
JGL Acoustics, Inc,

Jerry G. Lilly

Jerry G. Lilly, P.E., President, FASA
Member INCE, ASTM, NCAC

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Subject: RE: EIS
From: "UCO Pontoon Contruction Project" <Pontoons@WSDOT.WA.GOV>
Date: Fri, 12 Mar 2010 16:50:32 -0800
To: "Fran Conley" <fran@roanokecap.com>

March 12, 2010

Dear Fran,

Thank you for your interest in the SR 520 Pontoon Construction Project.

The Washington State Department of Transportation (WSDOT) is preparing a draft environmental impact statement (EIS) to evaluate potential effects to the surrounding environment from constructing and storing pontoons. The draft EIS will be released for public and agency comment in May 2010. We look forward to sharing the results of the analysis for public review and comment in the coming months. The final EIS is planned for release in late 2010.

Thanks again for your interest. You may also visit the project Web site for the latest news and project information.

Sincerely,

Suanne Pelley
Communications Manager
SR 520 Bridge Replacement and HOV Program
http://www.wsdot.wa.gov/Projects/SR520Bridge

-----Original Message-----
From: Fran Conley [mailto:fran@roanokecap.com]
Sent: Sunday, February 28, 2010 10:06 AM
To: UCO Pontoon Contruction Project
Subject: EIS

Can you tell me, please, when you will publish the Draft EIS for the pontoon project?

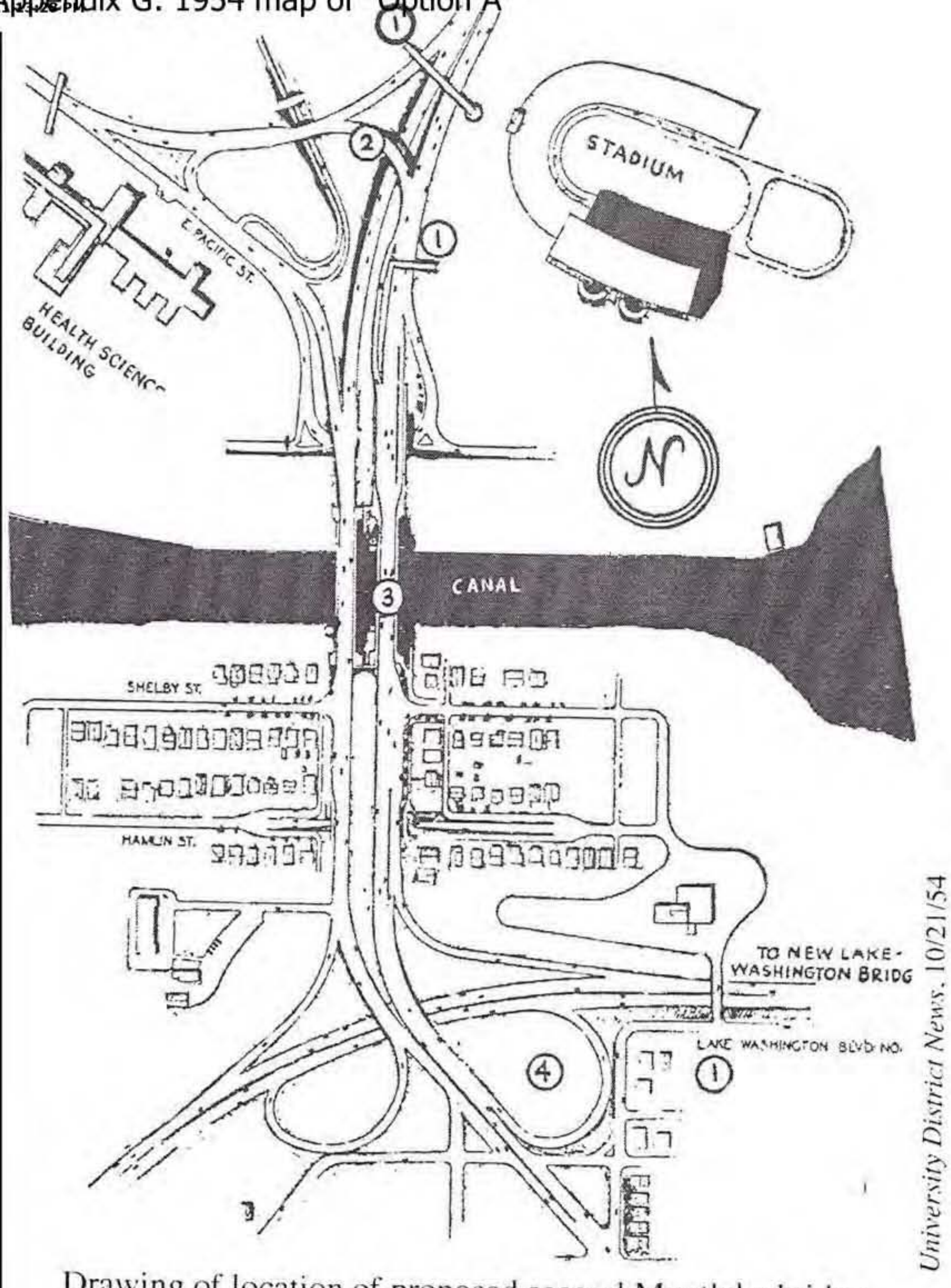
Thanks

Fran Conley

C-040

Appendix G: 1954 map of "Option A"

C-040-147



Drawing of location of proposed second Montlake bridge to accommodate greater volume of north-south traffic

Source :the 1954 plan of the Seattle City Engineer for the exit from 520, as shown in the book by Eugene Smith ('Montlake, an Urban Eden', 2004), page 101.

C-040-148

STATE OF WASHINGTON

February 1, 2010

The Honorable Richard Conlin, Council President
The Honorable Sally Bagshaw, Councilmember
The Honorable Tim Burgess, Councilmember
The Honorable Sally J. Clark, Councilmember
The Honorable Jean Godden, Councilmember
The Honorable Bruce A. Harrell, Councilmember
The Honorable Tom Rasmussen, Councilmember
The Honorable Mike O'Brien, Councilmember
Seattle City Council
600 Fourth Avenue, 2nd Floor
P.O. Box 34025
Seattle, WA 98124-4025

Dear Councilmembers:

Thank you for your January 28, 2010 letter responding to the recommendation made by the SR 520 Legislative Workgroup on the Westside interchange option. Your willingness to work with us to complete the final design process for the SR 520 Bridge Replacement and HOV Program is greatly appreciated.

As you know, last year's Legislative Workgroup is only the most recent step in an extensive public process that began in 1997. We have been very grateful for the substantial public engagement from a diverse array of perspectives that has informed this process. Your offer to commission the Seattle Department of Transportation (SDOT) to engage with the Washington State Department of Transportation (WSDOT) in a technical discussion related to traffic on local Seattle streets, including transit connectivity to the new bridge will contribute greatly to the final design process.

Our primary objectives for any Westside interchange design selected for a new SR 520 are as follows: 1) the design selected must allow the project to be open to drivers in 2014, 2) the design must meet federal and state permitting requirements, and 3) the design must allow the project to be constructed within the $4.65 billion budget.

With regard to the schedule, we very much appreciate your recognition of our plan to open the replacement floating bridge to drivers in 2014. We share your sense of urgency to correct the critical public safety and seismic issues of the existing floating bridge and its approaches. Maintaining the pace of the necessary regulatory milestones is critical to achieving the schedule for opening the bridge to traffic in 2014. This includes the selection of a preferred alternative by mid-April 2010. With 13 years of analysis and hundreds of millions of dollars invested in the corridor replacement, we feel strongly it is time to move forward on this much needed safety and mobility project. Therefore, the joint WSDOT-SDOT technical work and council deliberation must be completed within the objectives noted above and must be substantially completed by April 15th.

Your letter references the legislative direction within which we have worked regarding the number and types of lanes to be incorporated into the SR 520 Bridge Replacement. A six-lane configuration was endorsed by the Washington State Legislature in 2007 and 2008. As part of Engrossed Substitute Senate Bill 6099 approved in 2007, codified as RCW 47.01.405, the legislature stated that:

> *"The state must take the necessary steps to move forward with a state route number 520 bridge replacement project design that provides six total lanes, with four general purpose lanes and two lanes that are for high-occupancy vehicle travel that could also accommodate high capacity transportation, and the bridge shall also be designed to accommodate light rail in the future. High-occupancy vehicle lanes in the state route 520 corridor must also be able to support a bus rapid transit system."*

We have heard that some may wish to revisit the legislative direction regarding the use of the two additional lanes for high occupancy vehicles (HOV). The Supplemental Draft EIS focuses on alternatives based on the four general purpose lanes – two High Occupancy Vehicle (HOV) lanes option resulting from years of previous analyses and public input. Changing the configuration now would require a new environmental process. The office of the Attorney General tells us that revisiting these decisions from several years ago would set the project back at least 18 to 24 months. Our commitment to ensuring public safety does not allow that kind of delay.

The planned four general purpose and two HOV lanes included in the supplemental environmental impact statement best meets the travel needs of this growing region between now and 2030. However, it is important to note that decisions we make now on the design features of the facility do not preclude future options for high capacity transit in the corridor.

Working within the scope of the preliminary work done to date is fundamental to our ability to complete the regulatory steps on schedule. We therefore urge that any recommendations from the SDOT/WSDOT technical discussions that will affect WSDOT's selection of a preferred alternative in mid-April conform to the scope of the Westside interchange alternative recommended by the Legislative Workgroup and past legislative direction. There will be continued opportunities to refine the local elements of Westside interchange option until early fall before WSDOT prepares the final environmental statement.

We know you recognize the budget constraints associated with this project, and share your commitment to making lids and other project features that address impacts on the adjacent community an integral part of the corridor improvements. These improvements are estimated as part of the $4.65 billion project budget and we will continue to advance them through the design and environmental process. Work is already underway to reduce the height of the bridge in response to feedback we have received on the proposed design.

We share your interest to increase transit service in this corridor, and the addition of carpool/transit lanes will improve transit service reliability as demand increases in the future. Forty-five new buses will be added to the SR 520 corridor, made possible by the Urban Partnership Agreement between the WSDOT, King County, Puget Sound Regional Council, and federal government. Also, the second phase of Sound Transit funds 100,000 additional service hours to further develop bus rapid transit in the SR 520 corridor. If additional transit service is needed in the corridor, the Washington State Legislature also approved Second Substitute Senate Bill 5433 in 2009, which gave King County the option of raising its property tax for the purpose of expanding transit service in the SR 520 corridor.

Your expressions of support and offer to help advance our design process are both timely and gratefully received. We look forward to working with you, the Mayor and the SDOT to address the issues associated with the Westside interchange options analyzed in the supplemental draft environmental impact statement. We have asked WSDOT to begin to work with SDOT as quickly as possible to develop a schedule and work plan for this effort.

Sincerely,

Chris Gregoire

Christine O. Gregoire
Governor

Mary Margaret Haugen

Mary Margaret Haugen
State Senator, 10th Legislative District
Senate Transportation Committee Chairman

Judy Clibborn

Judy Clibborn
State Representative, 41st Legislative District
House Transportation Committee Chairman

Attachment

The SR 520 Bridge Replacement and HOV Program

History

Project:

- Built in 1963 and now estimated to have 10-15 year life expectancy remaining. Windstorms and earthquakes pose the biggest risks to the structure.
- 1997: Trans-Lake Washington Study made recommendations for a draft Environmental Impact Statement (EIS)
- 2000: First broad EIS initiated
- 2005 Draft EIS narrows focus to 6-lane replacement options
- 2006: Governor's report 'A Path Forward to Action' identified the 6-lane alternative as the state's preference
- 2007-2008: Mediation groups review and refine project options with technical support from WSDOT
- 2010: Work will begin on pontoon construction. Supplemental Draft EIS released. The public may comment at a February hearing or through the web until March 8th. Options reviewed are 6-lane bridge replacements: Option A, adds a 2nd parallel drawbridge over Montlake Cut; Option K, adds a tunnel under Montlake Cut and Option L, adds a 2nd drawbridge and elevated interchange.

Previous Legislation highlights:

- ESSB 6099 (2007) required an SR 520 project impact plan to be developed with local input through the use of a mediator.
- ESHB 3096 (2008) Required an SR 520 finance plan, created a tolling implementation committee to evaluate tolling issues and survey citizens, and provided a sales tax deferral for the SR 520 bridge project.
- ESHB 2211 (2009) authorized tolling on the SR 520 corridor, set the maximum budget for the project at $4.65bn and created a legislative workgroup to make recommendations on the design of the project.

C-040-150 Appendix J: opposition to re-thinking

file:///C:/Documents%20and%20Settings/fran/Desktop/Appendices/Times%20Gregoire%20no%20rethink.htm
Seattle Times

Gregoire opposes Seattle officials' request to rethink 520 bridge

By Mike Lindblom

Seattle Times transportation reporter

Gov. Chris Gregoire pushed back Monday against Seattle lawmakers who are seeking separate transit lanes, instead of a pair of carpool lanes, for the future Highway 520 replacement bridge.

That change and others suggested by Seattle officials would require up to two more years of studies and delay the project, the governor contended.

Her comments put her at odds with House Speaker Frank Chopp of Seattle, a fellow Democrat. He and five other elected officials declared their support earlier Monday for the transit-only lanes.

"The mayor and the council now stand united against the current plan," Chopp said at a news conference, with marshes and abandoned road ramps in the foreground and the roar of morning traffic over Lake Washington.

Seattle Mayor Mike McGinn, City Councilmembers Nick Licata and Mike O'Brien, Democratic state Sen. Ed Murray and Democratic state Rep. Jamie Pedersen joined him, along with 100 supporters. These include the Cascade Bicycle Club; the Sierra Club; the Washington Park Arboretum Foundation; and the Coalition for a Sustainable SR 520, representing Madison Park, North Capitol Hill, Montlake, Roanoke Park, Portage Bay, Laurelhurst and the boating community.

Last week, the Seattle City Council issued a letter saying a greatly enlarged Montlake interchange and a 30-foot-high floating bridge deck, as proposed, are unacceptable â€" and asked the state for a 120-day period for the two governments to work out a new design maximizing transit opportunities.

State law calls for a toll bridge with two general-purpose lanes and one high-occupancy-vehicle lane in each direction. The governor's letter says in part: "Changing the configuration now would require a new environmental process. The office of Attorney General tells us that revising these decisions from several years ago would set the project back at least 18 to 24 months. Our commitment to ensuring public safety does not allow that kind of delay."

But the letter acknowledges there would be technical discussions with the city before the state Department of Transportation (DOT) states its Montlake interchange choice this fall.

Sen. Rodney Tom, D-Bellevue, a leading advocate for a six-lane bridge as planned, said talks with the Seattle groups have lasted long enough: "To me, every time they turn the corner they come up with a new wrinkle. We have an agreement; let's move forward."

Debates and design research have been under way since 1997 to replace the nearly 47-year-old, four-lane bridge, at risk of sinking in a severe earthquake or windstorm.

....paragraphs omitted...

The $4.65 billion project is at least $2 billion short of funding, and the state has yet to choose a toll strategy to close some or all of that gap.

Mike Lindblom: 206-515-5631 or mlindblom@seattletimes.com

C-040-151

METHODOLOGICAL FLAWS IN TRANSPORTATION ANALYSIS

Summary

The methodology used by the TDR team to evaluate design options may be fundamentally flawed, because it assumes a particular transportation demand model rather than acknowledging the fundamental uncertainties about Seattle demographics and transportation demand in 20 years. In particular, unrealistic assumptions are made that portray 6-lane alternatives in a favorable light. A sound methodology would acknowledge uncertainties and perform robust sensitivity analysis.

Contents

The SDEIS Transportation Discipline Report (TDR, hereafter) portrays 6-lane design alternatives in a favorable light [TDR 2-3]

1. Comparing the No Build Alternative with the 6-Lane Alternative, year 2030 congestion and HOV travel times between I-5 and SR 202 would be reduced between an average of 2 to 8 minutes during the morning peak period and 5 minutes during the evening peak period. However, during the peak of the evening commute period, the completion of the eastbound HOV lane could save both general-purpose and HOV vehicles approximately 40 minutes.

2. Tolling and the completion of the HOV lane with the 6-Lane Alternative would reduce daily vehicle volumes across SR 520 by up to 4,700 vehicles (or 3 percent) compared to the No Build Alternative. Some people would choose to take other modes of travel (such as transit, carpools, vanpools, and bike), change time of travel, or select a different route.

3. Daily person trips across SR 520 would increase by up to 14,400 people (6 percent) because completing the HOV lane system between I-5 and SR 202 and/or tolling the corridor would increase carpools and bus use.

4. General-purpose vehicle trips would decrease by up to 10,000 vehicles per day and general-purpose person trips would decrease by up to 13,500 persons per day.

This seems almost magical: vehicle trips will decrease substantially, with commensurate decreases in greenhouse gas emissions, yet peak transit times will reduce by 40 minutes and 14,400 more people will cross each day!

C-040-151 Methodological flaws

Exhibit 4-4 of the TDR presents the methodology used by the WSDOT team for predicting future traffic flows (steps irrelevant for current discussion omitted):

1. Calibrate existing CORSIM model to match field observations
2. Code future conditions into CORSIM model
3. Summarize results for year 2030 conditions

"The first step in the process was to verify that the simulation model correctly represented existing freeway operations process known as calibration. The team calibrated the CORSIM model against existing WSDOT freeway count data to ensure that the model's output for the morning and afternoon peak periods was accurately representing current volumes and operations of the freeway mainline and ramps. Most locations were calibrated to within 5 percent of actual volumes. The team verified that the congestion and travel times from the model reasonably matched field observations and data from WSDOT loop detectors. Existing data from October of 2008 were used in the calibration effort."

In the terminology of simulation studies, "calibration" refers to adjusting parameters of a model to match a set of observations. However, just as an infinity of curves can match a small number of data points, an infinity of transportation models can fit a small set of observations from October of 2008, and there is no guarantee that whatever parameters selected by the calibration process will fit 2030 Seattle transportation well.

The possibility of a calibration stage fitting a set of observations used for calibration but failing to predict the future well is so likely that sound simulation modeling includes a post-calibration step known as "validation", in which the simulation is used to predict observed transportation data that was NOT used in the calibration stage. [See for example "Discrete-Event System Simulation" (Banks et alia), chapter 10, or most textbooks on fitting of statistical models.] If the predictions do not match these "held-out" observations, the results of other predictions can not be trusted.

But the TDR methodology diagram 4-4 does not show a validation step. This completely undermines the credibility of all simulation results.

Further, step 3 of the TDR methodology, "Code future conditions into CORSIM model", requires some particular future conditions to be

C-040-151 chosen. The TDR states:

The SDEIS 2030 No-Build & Cumulative Effects Definition Technical Memorandum (SR 520 Bridge Replacement and HOV Program 2008) and a supplement to that memo issued by the project office on March 28, 2008, contain detailed information about these travel demand model assumptions. They include all projects that were assumed to be complete by 2030, planned transit service, and other assumptions coded into the project's travel demand model for the No Build Alternative. Adjustments were also made to reflect expected changes in inflation and land use,1 specifically future population and employment growth forecasts, for the year 2030. These elements are major factors that influence travel behavior and patterns.

The last sentence is particularly telling: "These elements are major factors that influence travel behavior and patterns."

In other words, particular assumptions were made about traffic demand and transportation conditions in the year 2030, which strongly influence conclusions. These include untested stated assumptions about human behavior (in particular, that tolls will cause large numbers of people to switch to HOV transport); demand (such as that load remains heavily concentrated at peak periods); transportation infrastructure (particular transport services existing such as light rail across the lake); and many other implicit assumptions such as that citizen pressure does not force HOV lanes to be opened for general use. It would be fantastic if all these assumptions turned out to be exactly true.

Sound method for modeling with suspect assumptions include various forms of either "sensitivity analysis" (testing the change in results for various changes in assumptions to derive confidence bounds) or "worst-case analysis" (testing at the boundaries of plausible futures) or "model averaging" (combining results across a diversity of possible future conditions). But the methodology described in the TDR does not indicate that any of these were performed, and no results presented in the TDR demonstrate any of these were performed.

Misleading presentation of results

The TDR states: "travel demand models are not intended to provide an absolute traffic volume forecast", advising that forecasted traffic flows should be used only for comparison between options, NOT for estimating absolute conditions.

But in many places in the TDR and executive summary, this distinction

C-040-151 has been lost:

"Daily person trips across SR 520 would increase by up to 14,400 people (6 percent) because completing the HOV lane system between I-5 and SR 202 and/or tolling the corridor would increase carpools and bus use."

"General-purpose vehicle trips would decrease by up to 10,000 vehicles per day and general-purpose person trips would decrease by up to 13,500 persons per day."

Clearly, there is great appeal to the idea that the number of vehicles crossing each day will decrease and the number of people crossing will increase, but given that the TDR states only relative values are meaningful, this conclusion should not be drawn and should not be in the report.

Further, it is clear that certain assumptions, especially those surrounding the impact of tolling on usage of the HOV lane, will affect the relative standing of 6-lane vs. 4-lane alternatives. Given that no data has been presented demonstrating such assumptions are reliable, and that no analysis is presented as to the sensitivity of results to these assumptions, conclusions such as the two above are highly suspect and misleading.

Conclusion

It is impossible to conclusively evaluate the methodology used in traffic forecasting even from such a lengthy document as the TDR, given that it is but a summary of a vast amount of work performed by the TDR team. However the statement of methodology presented in the TDR, pointedly omitting any rigorous model validation procedures, suggests the methodology may be flawed and unreliable. And since results do not include any form of confidence bounds or other indication of sensitivity to forecasting and traffic modeling assumptions, they are highly misleading and should not be used for policy decisions and should not have been included in a report for the public.The draft EIS makes predictions about the comparative benefits of the No-Build vs Build options. There are reasons to be concerned about the accuracy and the margin of error of these predictions.

The methodology for the obtaining those predictions is described in the Transportation Discipline Report. The report does not give evidence that errors at various levels in the model have been estimated accurately, so that the forecasts are credible.

C-040-152

1. The simulation model is chosen by PSRC, the model inputs (demographic and land use forecasts) are established by PSRC, the model validation is done by PSRC teams, and the goals for development are also set by PSRC. There is no independent review of this process at any step.

2. Models are calibrated from current data. This process sets the models' internal parameters to values that best align the model predictions with the observed data. The problem is that, for models with many parameters, there can be many different parameter setting that can fit the current data equally well. However, these parameter setting will produce wildly different forecasts for the future, e.g for 2030. The report does not explain how the choice was made.

A standard statistical validation technicque to avoid the catastrophic ambiguity I described above is to test the model predictions on existing data, but to employ for this purpose independent or fresh data, which was not previously used in calibration. The accuracy of the model on the fresh data ris a better estimate of the ability of the model to represent the reality in the field.

3. The inaccuracies in the input variables (demographic, employment, and land use forecasts were not considered). Nor is it explained how these inccuracies, which are unavoidable in any forecast, will propagate through the model and will affect its predictions. In other words, there is no evidence that the model used is "robust" to changes in the input data. For instance, a 10% error in the population growth may well translate into a 100% error in the traffic time estimate. The document does not demonstrate that the errors of this kind have been controlled for.

4. Another source of inaccuracies in the final predictions of traffic time, traffic volume etc are the variations in model parameters. The travel demand model has parameters for each of the 4 steps: trip generation, trip distribution, mode choice, trip assignment. It is the latter two steps that I want to discuss now. Essentially, the travel demand model hsas an internal model for how people will choose to travel in 2030, and by what route. At first glance, all the model parameters are validated by predicting current data. However, the current data is not detailed enough to guarantee that these parts of the model are accurate even for the present. The validation method, as it is explained in the document, only ensures that the model as a whole predicts traffic patterns at certain points and across certain screenlines, but does not guarantee that the model captures correctly

C-040-152 the mechanisms of mode choice and travel assignment that produce these results. It is not known what the margin of error of the traffic forecasts are with respect to such inaccuracies.

In summary, I feel that transportation forecasts produced may be relied upon, only under the unlikely conditions when the economic, demographic and land use forecasts are accurate, when people make their choice in agreement with the model's step 3 and 4 parameters and not otherwise, and when cars, gas consumption, gas prices also evolve as forecasted. But that the current analysis does not cover any other scenario. Thus it does not support the conclusion that the benefits for transportation will continue to exist if the circumstances of the future become different from what was assumed in 2009.

C-040-153 Appendix O: References used in Section III, Traffic Assumptions

References,(incorporated here by reference)

Dargay, J. M. and P. B. Goodwin (1995), "Evaluation of Consumer Surplus with Dynamic Demand Changes." Journal of Transport Economics and Policy, Vol. XXIX, No. 2, pp. 179-93.

Appendix M: Flaws in Model Methodology and Use in the TDR.

Appendix N: Flaws in Simulation Methodology in TDR

Appendix O: -Tilghman Group Analysis of SDEIS

Appendix P: Review of Studies on Generated Traffic and Induced Travel

Lawton, K. (2001), The Urban Structure and Personal Travel: an Analysis of Portland, or Data and Some National and International Data, E-Vision 2000 Conference (www.rand.org/scitech/stpi/Evision/Supplement/lawton.pdf).

Levinson, D. and A. Kumar (1997), Density and the Journey to Work, Growth and Changes,
Vol. 28, No. 2 1997, pp. 147-72

Litman, T (2010) Generated Traffic and Induced Travel Implications for Transport Planning http:www.vtpi.org

Marshall, N.(2000), Evidence of Induced Demand in the Texas Transportation Institutes Urban Roadway Congestion Study Data Set, TRB Annual Meeting (www.trb.org).

Open Space Seattle (2010) http://www.seattlepi.com/local/271365_ncenter24.html

STPP (1998), Do New Roads Cause Congestion?, Surface Transportation Policy Project (www.transact.org); at www.transact.org/congestion/analysis.htm.

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Generated Traffic and Induced Travel

Implications for Transport Planning

19 March 2010

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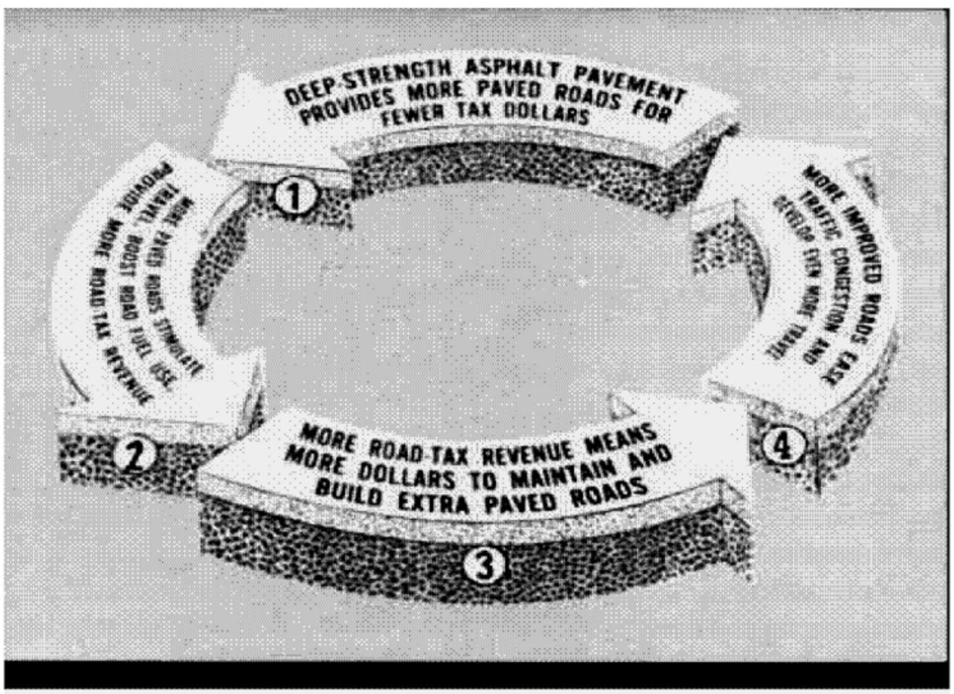
Abstract

Traffic congestion tends to maintain equilibrium. Congestion reaches a point at which it constrains further growth in peak-period trips. If road capacity increases, the number of peak-period trips also increases until congestion again limits further traffic growth. The additional travel is called "generated traffic." Generated traffic consists of diverted traffic (trips shifted in time, route and destination), and induced vehicle travel (shifts from other modes, longer trips and new vehicle trips). Research indicates that generated traffic often fills a significant portion of capacity added to congested urban road.

Generated traffic has three implications for transport planning. First, it reduces the congestion reduction benefits of road capacity expansion. Second, it increases many external costs. Third, it provides relatively small user benefits because it consists of vehicle travel that consumers are most willing to forego when their costs increase. It is important to account for these factors in analysis. This paper defines types of generated traffic, discusses generated traffic impacts, recommends ways to incorporate generated traffic into evaluation, and describes alternatives to roadway capacity expansion.

A version of this paper was published in the *ITE Journal*, Vol. 71, No. 4, Institute of Transportation Engineers (www.ite.org), April 2001, pp. 38-47.

Contents



Roads beget roads: From the cover of *Asphalt Bulletin*, April 1966.

This illustration from a highway builders' magazine shows how expanding roadway capacity tends to stimulate automobile travel and the need for more roads.

Introduction

Traffic engineers often compare traffic to a fluid, assuming that a certain volume must flow through the road system. But urban traffic may be more comparable to a gas that expands to fill available space (Jacobsen 1997). Road improvements that reduce travel costs attract trips from other routes, times and modes, and encourage longer and more frequent travel. This is called *generated traffic*, referring to additional vehicle traffic on a particular road. This consists in part of *induced travel*, which refers to increased total vehicle miles travel (VMT) compared with what would otherwise occur (Hills 1996).

Generated traffic reflects the economic "law of demand," which states that consumption of a good increases as its price declines. Roadway improvements that alleviate congestion reduce the generalized cost of driving (i.e., the price), which encourages more vehicle use. Put another way, most urban roads have *latent travel demand*, additional peak-period vehicle trips that will occur if congestion is relieved. In the short-run generated traffic represents a shift along the demand curve; reduced congestion makes driving cheaper per mile or kilometer in terms of travel time and vehicle operating costs. Over the long run induced travel represents an outward shift in the demand curve as transport systems and land use patterns become more automobile dependent, so people must drive more to maintain a given level of accessibility to goods, services and activities (Lee 1999).

This is not to suggest that increasing road capacity provides no benefits, but generated traffic affects the nature of these benefits. It means that road capacity expansion benefits consist more of increased peak-period mobility and less of reduced traffic congestion. Accurate transport planning and project appraisal must consider these three impacts:

1. Generated traffic reduces the predicted congestion reduction benefits of road capacity expansion.
2. Induced travel imposes costs, including downstream congestion, accidents, parking costs, pollution, and other environmental impacts.
3. The additional travel that is generated provides relatively modest user benefits, since it consists of marginal value trips (travel that consumers are most willing to forego).

Ignoring these factors distorts planning decisions. Experts conclude, "*…the economic value of a scheme can be overestimated by the omission of even a small amount of induced traffic. We consider this matter of profound importance to the value-for-money assessment of the road programme*" (SACTRA 1994). "*...quite small absolute changes in traffic volumes have a significant impact on the benefit measures. Of course, the proportional effect on scheme Net Present Value will be greater still*" (Mackie, 1996) and "*The induced travel effects of changes in land use and trip distribution may be critical to accurate evaluation of transit and highway alternatives*" (Johnston, et al. 2001)

This paper describes how generated traffic can be incorporated into transport planning. It defines different types of generated traffic, discusses their impacts, and describes ways to incorporate generated traffic into transport modeling and planning, and provides information on strategies for using existing roadway capacity more efficiently.

Defining Generated Traffic

Generated traffic is the additional vehicle travel that results from a road improvement. Congested roads cause people to defer trips that are not urgent, choose alternative destinations and modes, and forego avoidable trips. Generated traffic consists of *diverted travel* (shifts in time and route) and *induced travel* (increased total motor vehicle travel). In some situations, highway expansion stimulates sprawl (automobile-dependent, urban fringe land use patterns), further increasing per capita vehicle travel. If some residents would otherwise choose less sprawled housing locations, their additional per capita vehicle travel can be considered to be induced by the roadway capacity expansion.

Below are examples of decisions that generate traffic:

- Consumers choose closer destinations when roads are congested and further destinations when traffic flows more freely. "*I want to try the new downtown restaurant but traffic is a mess now. Let's just pick up something at the local deli.*" This also affects long-term decisions. "*We're looking for a house within 40-minute commute time of downtown. With the new highway open, we'll considering anything as far as Midvalley.*"
- Travelers shift modes to avoid driving in congestion. "*The post office is only five blocks away and with congestion so bad this time of day, I may as well walk there.*"
- Longer trips may seem cost effective when congestion is light but not when congestion is heavy. "*We'd save $5 on that purchase at the Wal-Mart across town, but it's not worth fighting traffic so let's shop nearby.*"

Travel time budget research indicates that increased travel speeds often results in more mobility rather than saving time. People tend to average about 75 minutes of daily travel time regardless of transport conditions (Levinson and Kumar 1995; Lawton 2001). National data indicate that as freeway travel increases, average commute trip distances and speeds increase, but trip time stays about constant (Levinson and Kumar 1997). As a result, traffic congestion tends to maintain a self-limiting equilibrium: once congestion becomes a problem it discourages further growth in peak-period travel. Road expansion that reduces congestion in the short term attracts additional peak-period trips until congestion once again reaches a level that limits further growth. It may therefore be incorrect to claim that congestion reductions save travel time.

Definitions

Generated Traffic: Additional peak-period vehicle trips on a particular roadway that occur when capacity is increased. This may consist of shifts in travel time, route, mode, destination and frequency.

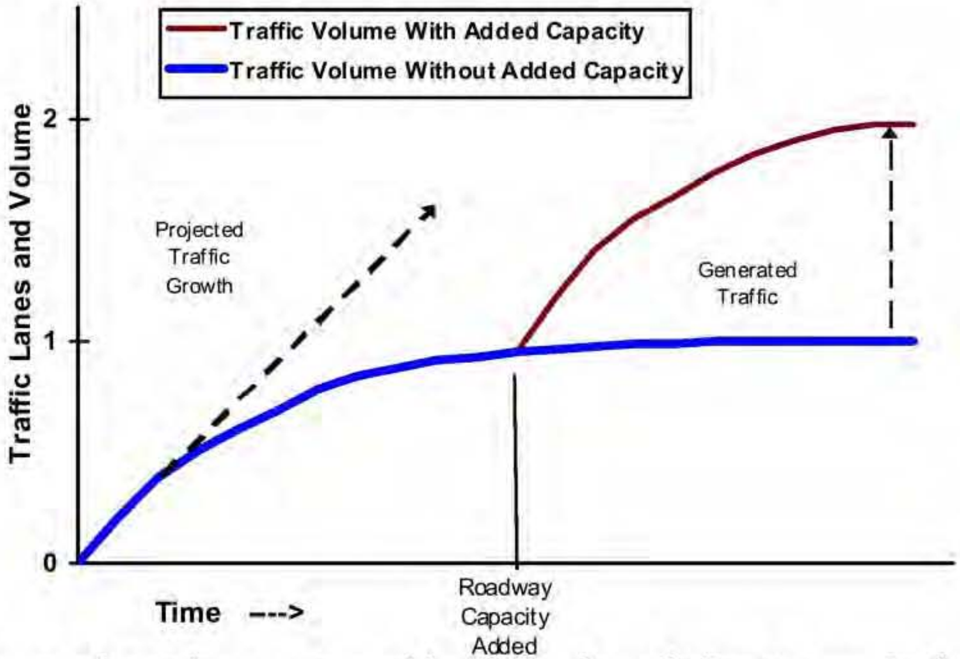
Induced travel: An increase in total vehicle mileage due to roadway improvements that increase vehicle trip frequency and distance, but exclude travel shifted from other times and routes.

Latent demand: Additional trips that would be made if travel conditions improved (less congested, higher design speeds, lower vehicle costs or tolls).

Triple Convergence: Increased peak-period vehicle traffic volumes that result when roadway capacity increases, due to shifts from other routes, times and modes.

Figure 1 illustrates this pattern. Traffic volumes grow until congestion develops, then the growth rate declines and achieves equilibrium, indicated by the curve becoming horizontal. A demand projection made during this growth period will indicate that more capacity is needed, ignoring the tendency of traffic volumes to eventually level off. If additional lanes are added there will be another period of traffic growth as predicted.

Figure 1 **How Road Capacity Expansion Generates Traffic**



Traffic grows when roads are uncongested, but the growth rate declines as congestion develops, reaching a self-limiting equilibrium (indicated by the curve becoming horizontal). If capacity is added, traffic growth continues until it reaches a new equilibrium. The additional peak-period vehicle travel that results is called "generated traffic." The portion that consists of absolute increases in vehicle travel (as opposed to shifts in time and route) is called "induced travel."

In some situations, adding capacity to a network in which all the moving entities rationally seek the most efficient route can reduce the network's overall efficiency, a phenomena called *Braess's Paradox*. In such situations, closing certain roadways can increase average traffic speeds (Youn, Jeong and Gastner 2008).

Generated traffic can be considered from two perspectives. Project planners are primarily concerned with the traffic generated *on the expanded road segment*, since this affects the project's congestion reduction benefits. Others may be concerned with changes in *total vehicle travel* (induced travel) which affects overall benefits and costs. Table 1 describes various types of generated traffic. In the short term, most generated traffic consists of trips diverted from other routes, times and modes, called *Triple Convergence* (Downs 1992). Over the long term an increasing portion consists of induced travel.

Table 1 **Types of Generated Traffic**

Type of Generated Traffic	Category	Time Frame	Travel Impacts	Cost Impacts
Shorter Route Improved road allows drivers to use more direct route.	Diverted trip	Short term	Small reduction	Reduction
Longer Route Improved road attracts traffic from more direct routes.	Diverted trip	Short term	Small increase	Slight increase
Time Change Reduced peak period congestion reduces the need to defer trips to off-peak periods.	Diverted trip.	Short term	None	Slight increase
Mode Shift; Existing Travel Choices Improved traffic flow makes driving relatively more attractive than other modes.	Induced vehicle trip	Short term	Increased driving	Moderate to large increase
Mode Shift; Changes in Travel Choice Less demand leads to reduced rail and bus service, less suitable conditions for walking and cycling, and more automobile ownership.	Induced vehicle trip	Long term	Increased driving, reduced alternatives	Large increase, reduced equity
Destination Change; Existing Land Use Reduced travel costs allow drivers to choose farther destinations. No change in land use patterns.	Longer trip	Short term	Increase	Moderate to large increase
Destination Change; Land Use Changes Improved access allows land use changes, especially urban fringe development.	Longer trip	Long term	More driving and auto dependency	Moderate to large increase, equity costs
New Trip; No Land Use Changes Improved travel time allows driving to substitute for non-travel activities.	Induced trip	Short term	Increase	Large increase
Automobile Dependency Synergetic effects of increased automobile oriented land use and transportation system.	Induced trip	Long term	Increased driving, fewer alternatives	Large increase, reduced equity

Some types of generated traffic represent diverted trips (trips shifted from other times or routes) while others increase total vehicle travel, reduce travel choices, and affect land use patterns.

What constitutes *short*- and *long-term* impacts can vary. Some short term effects, such as mode shifts, may accumulate over several years, and some long term effects, such as changes in development patterns, can begin almost immediately after a project is announced if market conditions are suitable. Generated traffic can also work in reverse; when urban roadway capacity is reduced a significant portion of previous vehicle traffic may disappear altogether (Cairns, Hass-Klau and Goodwin 1998).

Highway capacity expansion can induce additional vehicle travel on adjacent roads (Hansen, et al. 1993) because such projects leverage automobile dependent land use patterns. For example, urban-fringe highway expansion often stimulates more dispersed development. Although these indirect impacts are difficult to quantify they are potentially large and should be considered in transport planning (Louis Berger & Assoc. 1998).

Measuring Generated Traffic

Several studies using various analysis techniques have examined the amount of traffic generated by specific projects (Goodwin 1996). Their findings are summarized below:

- Cervero (2003a & b) used data on freeway capacity expansion, traffic volumes, demographic and geographic factors from California between 1980 and 1994. He estimated the long-term elasticity of VMT with respect to traffic speed to be 0.64, meaning that a 10% increase in speed results in a 6.4% increase in VMT, and that about a quarter of this results from changes in land use (e.g., additional urban fringe development). He estimated that about 80% of additional roadway capacity is filled with additional peak-period travel, about half of which (39%) can be considered the direct result of the added capacity.

- Duranton and Turner (2008) investigate the relationship between interstate highway lane-kilometers and highway vehicle-kilometers travelled (VKT) in US cities. They found that VKT increases proportionately to highways and identify three important sources for this extra vehicle travel: increased driving by current residents, an inflow of new residents, and more transport intensive production activity. They find aggregate city-level VKT demand to be elastic and so conclude that, without congestion pricing, increasing road or public transit supply is unlikely to relieve congestion, and current roadway supply exceeds the optimum.

- Time-series travel data for various roadway types indicates an elasticity of vehicle travel with respect to lane miles of 0.5 in the short run, and 0.8 in the long run (Noland 2001). This means that half of increased roadway capacity is filled with added travel within about 5 years, and that 80% of the increased roadway capacity will be filled eventually. Urban roads, which tend to be most congested, had higher elasticity values than rural roads, as would be expected due to the greater congestion and latent demand in urban areas.

- The medium-term elasticity of highway traffic with respect to California state highway capacity was measured to be 0.6-0.7 at the county level and 0.9 at the municipal level (Hansen and Huang 1997). This means that 60-90% of increased road capacity is filled with new traffic within five years. Total vehicle travel increased 1% for every 2-3% increase in highway lane miles. The researcher concludes, "it appears that adding road capacity does little to decrease congestion because of the substantial induced traffic" (Hansen 1995). Mokhtarian, et al (2002) applied a different statistical technique (matched-pairs) to the same data and found no significant induced travel effect, but that technique does not account for additional traffic on other roads or control for other factors that may affect vehicle travel.

- A study by leading U.K. transportation economists concludes that the elasticity of travel volume with respect to travel time is -0.5 in the short term and -1.0 over the long term (SACTRA 1994). This means that reducing travel time on a roadway by 20% typically increases traffic volumes by 10% in the short term and 20% over the long term.

- The following are elasticity values for vehicle travel with respect to travel time: urban roads, short-term -0.27, long term –0.57; rural roads, short term –0.67, long term –1.33 (Goodwin 1996). These values are used in the FHWA's SMITE software program described below.

- A Transportation Research Board report based finds consistent evidence of generated traffic, particularly with respect to travel time savings (Cohen 1995).

- National Highway Institute concludes that the elasticity of highway travel with respect to users' generalized cost (travel time and financial expenses) is typically -0.5 (NHI 1995).

- Analysis of traffic conditions in 70 metropolitan areas finds that regions which invested heavily in road capacity expansion fared no better in reducing congestion than those that spent far less (STPP 1998). The researchers estimate that road capacity investments of thousands of dollars annually per household would be needed achieve congestion reductions.

- Noland and Mohammed A. Quddus (2006) found that increases in road space or traffic signal control systems that smooth traffic flow tend to induce additional vehicle traffic which quickly diminish any initial emission reduction benefits.

- Cross-sectional time-series analysis of traffic growth in the U.S. Mid-Atlantic region found an average elasticities of VMT with respect to lane miles to be 0.2 to 0.6 (Noland and Lem 2002).

- Small (1992) concludes that 50-80% of increased highway capacity is soon filled with generated traffic, based on a detailed review of previous studies.

- The USDOT Highway Economic Requirements System (HERS) investment analysis model uses a travel demand elasticity factor of –0.8 for the short term, and –1.0 for the long term, meaning that if users' generalized costs (travel time and vehicle expenses) decrease by 10%, travel is predicted to increase 8% within 5 years, and an additional 2% within 20 years (Lee, Klein and Camus 1998; FHWA 2000).

- Cervero and Hanson (2000) found the elasticity of VMT with respect to lane-miles to be 0.56, and an elasticity of lane-miles with respect to VMT of 0.33, indicating that roadway capacity expansion results in part from anticipated traffic growth.

- A comprehensive study of the impacts of urban design factors on U.S. vehicle travel found that a 10% increase in urban road density (lane-miles per square mile) increases per capita annual VMT by 0.7% (Barr 2000).

- In a study of eight new urban highways in Texas over several years, Holder and Stover (1972) found evidence of induced travel at six locations, estimated to represent 5-12% of total corridor volume, representing from a quarter to two-thirds of traffic on the facility. Henk (1989) performed similar analysis at 34 sites and found similar results.

- Modeling analysis indicates that adding an urban beltway can increase regional VMT by 0.8-1.1% for each 1.0% increase in lane capacity (Rodier, et al. 2001).

Table 2 Portion of New Capacity Absorbed by Induced Traffic

Author	Short-term	Long-term (3+ years)
SACTRA		50 - 100%
Goodwin	28%	57%
Johnson and Ceerla		60 - 90%
Hansen and Huang		90%
Fulton, et al.	10 - 40%	50 - 80%
Marshall		76 - 85%
Noland	20 - 50%	70 - 100%

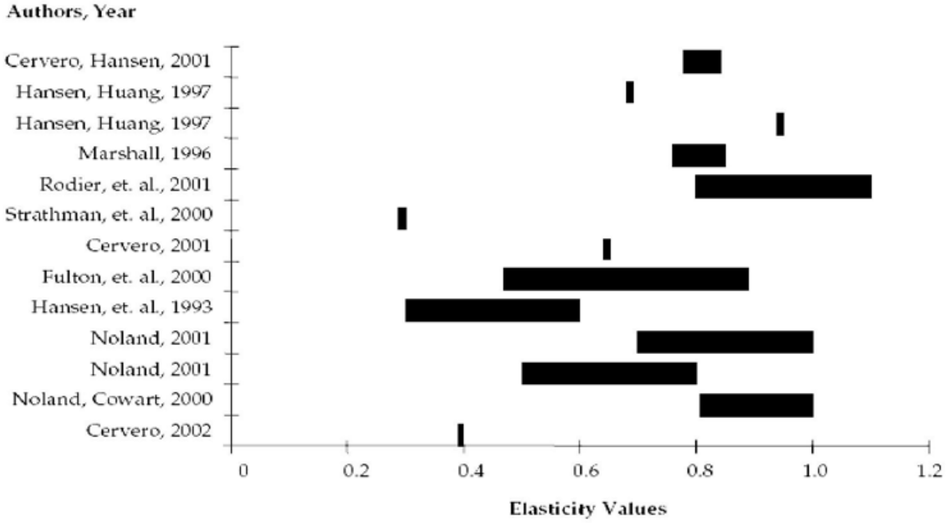
- Yao and Morikawa (2005) develop a model of induced demand resulting from high speed rail service improvements between major Japanese cities. They calculate elasticities of induced travel (trips and VMT) with respect to fares, travel time, access time and service frequency for business and nonbusiness travel.

- Odgers (2009) found that traffic speeds on Melbourne, Australia freeways did not decline as predicted following new urban highway construction, apparently due to induced traffic. He concludes that, "major road infrastructure initiatives and the consequent economic investments have not yet delivered a net economic benefit to either Melbourne's motorists or the Victorian community."

- Burt and Hoover (2006) found that each 1% increase in road lane-kilometres per driving-age person increases per capita light truck travel 0.49% and car travel 0.27%, although they report that these relationships are not statistically significant, falling just outside the 80% confidence interval for cars and the 90% confidence interval for light trucks.

- Schiffer, Steinvorth and Milam (2005) perform a meta-analysis of induced travel studies to identify short- and long-term elasticities of VMT with respect to changes in traffic lane-miles and other variables, as summarized in Figure 2. They predicted the amount of VMT induced by regional highway expansion in the Wasatch Front (Salt Lake City region). They reached the following general conclusions concerning induced travel:
    - *Induced travel effects exist* – The elasticity of VMT with respect to added lane-miles or reductions in travel time is generally greater than zero and the effects increase over time.
    - *Short-term induced travel effects are smaller than long-term effects* – As measured by the increase in VMT with respect to an increase in lane-miles, short-term effects have an elasticity range from near zero to about 0.40, while long-term elasticities range from about 0.50 to 1.00. This means that a 10% increase in lane-miles can cause up to a 4% increase in VMT in the short term and a 10% increase in the long term.
    - *Induced travel effects for constructing new roadways versus widening existing roadways were not definitive* – The research did not include any examples that isolated the effects of constructing new roadways versus widening existing roadways. However, somewhat higher elasticities where found when "new roadways and widenings" were considered together compared to "widenings only." This finding is based on a limited number of studies and indicates that more research is necessary to isolate these differences.
    - *Induced travel effects generally decrease with the size of the unit of study* – Larger effects are measured for single facilities while smaller effects are measured for regions and subareas. This is mainly due to diverted trips (drivers changing routes) causing more of the change on a single facility, whereas, at the regional level, diverted trips between routes within the region are not considered induced travel unless the trips become longer as a result.
    - *Traditional four-step travel demand models do not fully address induced travel or induced growth* – Land use allocation methods overlook accessibility effects, trip generation often fails to account for latent trips (potential trips constrained by congestion), many models overlook time-of-day shifts, and static traffic assignment algorithms may not account for queuing impacts on route shifts. Errors tend to be greatest when there is more or users are more responsive to travel costs. These weaknesses are due to the static nature of four-step models that carry base-year behavior parameters into future year scenarios when congestion may be much greater. For example, the percent of daily trips that occur during a peak hour is typically hard-coded in most traditional four-step models, and so does not change from the base year to future years. In reality, the percent of daily trips that occur during peak hours reduces as congestion increases. Failing to capture this effect ignores the potential trip suppression effects of congestion.

Figure 2 **VMT With Respect to Road Capacity** (Schiffer, Steinvorth and Milam 2005)



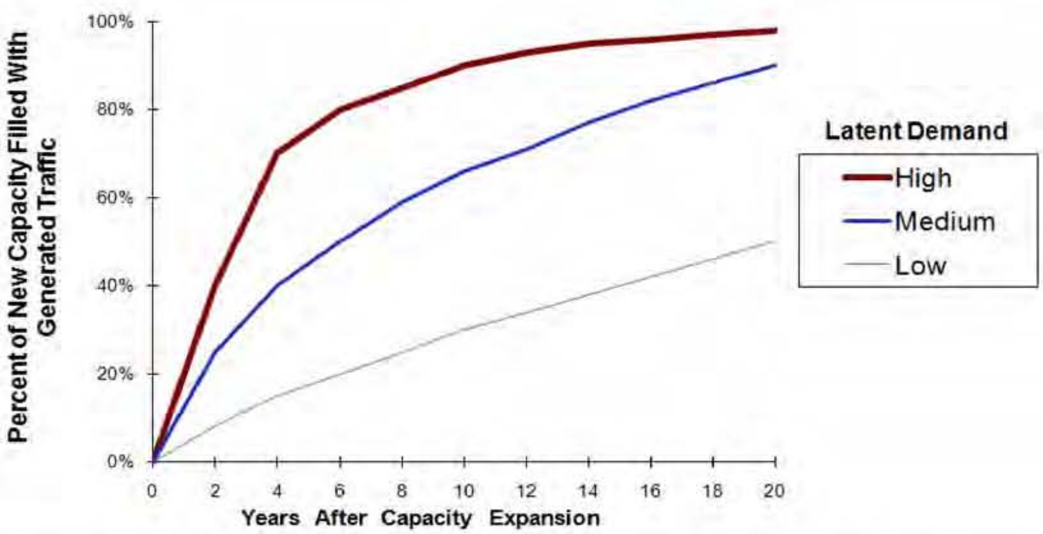
This figure summarizes long term vehicle travel elasticities with respect to roadway capacity.

The amount of traffic generated by a road project varies depending on conditions. It is not capacity expansion itself that generates travel, it is the reduction in congestion delays and therefore per-mile travel costs. Expanding uncongested roads will generate no traffic, although paving a dirt road or significantly raising roadway design speeds may induce more vehicle travel. In general, the more congested a road, the more traffic is generated by capacity expansion. Increased capacity on highly congested roads often generates considerable traffic (Marshall 2000). Older studies of the elasticity of VMT growth with respect to increased roadway lane-miles performed during the early years of highway building (during the 1950s through 1970s) have little relevance for evaluating current urban highway capacity expansion. In developed countries, where most highway expansion now occurs on congested links, such projects are likely to generate considerable amounts of traffic, providing only temporary congestion reduction benefits.

Gridlock?
Highway expansion advocates sometimes predict that roads will reach *gridlock* unless capacity increases. Such claims are usually exaggerated because they ignore the equilibrium tendency of traffic congestion. Gridlock is a specific condition that occurs when backups block intersections, stopping street network traffic flow as vehicles on each street wait for other vehicles to move. Gridlock can be avoided with proper intersection design that prevents such backups. Increasing regional highway capacity can *increase* rather than reduce this risk by adding more traffic to surface streets where gridlock occurs.

Generated traffic usually accumulates over several years (Goodwin 1998). Under typical urban conditions, more than half of added capacity is filled within five years of project completion by additional vehicle trips that would not otherwise occur, with continued but slower growth in later years. Figure 3 shows typical generated traffic growth indicated by various studies. Techniques for modeling these impacts into account are described in the next section (Dargay and Goodwin 1995).

Figure 3 **Elasticity of Traffic Volume With Respect to Road Capacity**



This illustrates traffic growth on a road after its capacity increases. About half of added capacity is typically filled with new traffic within a decade of construction. (Based on cited studies)

Modeling Generated Traffic

To predict generated traffic, transport models must incorporate "feedback," which reflects the impacts congestion has on travel behavior, and long-term transport and land use systems. This recognizes that congestion diverts traffic to other routes, times and modes, and reduces trip length and frequency, while reduced congestion has the opposite effects. Because of non-linear speed flow relationships, and typically small net differences between large costs and large benefits, a small amount of induced traffic can have a disproportionately large effect on the cost effectiveness of a roadway project.

Most current traffic models can predict route and mode shifts, and some can predict changes in scheduling and destination, but few adjust trip frequency, and most ignore the effects transportation decisions have on land use (Beimborn, Kennedy and Schaefer 1996; Ramsey 2005). For example, they do not recognize that highway capacity expansion encourages more automobile-dependent urban fringe development. As a result, current models recognize diverted traffic but do not account for most forms of long term induced vehicle travel, and thus underestimate the amount of traffic likely to be generated when congested roads are expanded. In one exercise, Ramsey (2005) found that the net benefits of a suburban highway capacity expansion project declined by 50% if the project caused 60,000 residents (about 2% of the regional population) to move from urban to suburban locations, thereby increasing traffic congestion on that roadway link. Analysis of urban highway expansion impacts on total emissions by Williams-Derry (2007) indicates that emissions from construction and additional vehicle traffic quickly exceed any emission reductions from reduced congestion delays.

Transportation modelers have developed techniques for incorporating full feedback (Harvey and Deakin 1993; SACTRA 1994; Loudon, Parameswaran and Gardner 1997; Schiffer, Steinvorth and Milam 2005). This recognizes that expanding the capacity of congested roads increases the number and length of trips in a corridor (DeCorla-Souza and Cohen 1999). Henk (1989) used analysis of vehicle traffic growth rates at 34 urban highways in Texas to develop a model which predicts the amount of latent demand, and therefore future traffic volumes from highway capacity expansion, taking into account the type of facility, the Volume/Capacity ratio, and local population densities. Even more accurate are integrated models that incorporate interrelationships between transport and land use patterns (Rodier, et al. 2001). Federal clean air rules require that these techniques be used in metropolitan transportation models to evaluate the effects transport system changes have on vehicle emissions, but many metropolitan planning organizations have yet to comply, and few models used in medium and small cities have full feedback.

Full feedback is necessary to accurately predict future traffic congestion and traffic speeds, and the incremental costs and benefits of alternative projects and policy options. Models without full feedback tend to overestimate future congestion problems and overestimate the benefits of roadway capacity expansion. In one example, modeling a congested road network without feedback underestimated traffic speeds by more than 20% and overestimated total vehicle travel by more than 10% compared with modeling with feedback (Comsis 1996). Models that fail to consider generated traffic were found to overvalue roadway capacity expansion benefits by 50% or more (Williams and

Yamashita 1992). Another study found that the ranking of preferred projects changed significantly when feedback is incorporated into project assessment (Johnston and Ceerla 1996). Ignoring generated traffic tends to skew planning decisions toward highway projects and away from No Build and mobility management alternatives such as road pricing, transit improvements and commute trip reduction programs (Boarnet 1995).

The FHWA *Spreadsheet Model for Induced Travel Estimation* (SMITE) was developed to predict the amount of traffic induced by road improvements and the effects on consumer welfare and vehicle emissions (DeCorla-Souza 2000). It is a relatively easy way to incorporate generated traffic impacts into road project assessments. Another approach involves integrated transport/ land use models (such as TRANUS and MEPLAN) that track transport benefits through their land value impacts (Abraham 1998).

Short Cut Methods of Incorporating Induced Demand
Based on comments in the *Transportation Model Improvement Program* listserve (TMIP-L@listserv.tamu.edu) by Phil Goodwin, 2001.

The easiest way to incorporate induced demand into conventional traffic models is to apply an overall demand elasticity to forecasted changes in travel speed, calculated either:

- Elasticities applied to generalized costs (travel time and financial costs) using a price elasticity (about -0.3 for equilibrium, less for short term), with monetized travel time costs. The time elasticity is generally about -0.5 to -0.8 or so, though this is highly dependent on context. Where to apply it depends on the model used. With a fixed trip matrix altered only by reassignment, apply elasticities to each separate cell, or the row and column totals, or the overall control total - depending on how short the short cut has to be. Or add a separate test at the end.

or

- Direct application of a 'capacity elasticity,' i.e. percent change in vehicle miles resulting from a 1% change in highway capacity, for which lane miles is sometimes used as a proxy, the elasticity in that case usually coming out at about -0.1. This will tend to underestimate the effect if the capacity increase is concentrating on bottlenecks.

Care is needed if the basic model has cost-sensitive distribution and mode split, as this will already make allowance for some induced traffic. Induced traffic consists of several types of travel changes that make vehicle miles "with" a scheme different from "without," including re-assignment to longer routes and some increased trip generation. Allowance for time-shifting, which is not induced traffic at all, is equally important because it has similar effects on calculation of benefits of reducing congestion, and is often a large response. Ideally you iterate on speed and allow for the effect from retiming of journeys, and separate the various behavioural responses which make up induced traffic. These short cuts are subject to bias, but less than the bias introduced by assuming zero induced traffic.

Land Use Impacts

An important issue related to generated and induced travel is the degree to which roadway improvements affect land use patterns, and in particular, whether highway capacity expansion stimulates lower-density, urban fringe development (i.e., urban sprawl), and the costs to society that result (Louis Berger & Assoc. 1998; USEPA 2001; ICF Consulting 2005). Land use changes are one category of induced travel. Such changes take a relatively long time to occur, and are influenced by additional factors, but they are durable effects with a variety of economic, social and environmental impacts.

Urban economists have long realized that transportation can have a major impact on land use development patterns, and in many situations improved accessibility can stimulate development location and type. Different types of transportation improvements tend to cause different types of land use development patters: highway improvements tend to encourage lower-density, automobile-oriented development at the urban fringe, while transit improvements tend to encourage higher-density, multi-modal, urban redevelopment, although the exact types of impacts vary depending on specific conditions and the type of transportation improvements implemented (Rodier, Abraham, Johnston and Hunt 2001; Boarnet and Chalermpong 2002; Litman 2002).

Some researchers claim that investing in road construction does not lead to the sprawl (Sen, et al. 1999; Hartgen 2003a and 2003b), although the evidence indicates otherwise. Even in relatively slow-growth regions with modest congestion problems, highway capacity expansion increases suburban development by 15-25%. These effects are likely to be much greater in large cities with significant congestion problems, where peak-period traffic congestion limits commute trip distances, and increased roadway capacity would significantly improve automobile access to urban fringe locations. This is particularly true if the alternative is to implement Smart Growth development policies and improved walking, cycling and transit transportation ("Smart Growth, VTPI 2006).

There has been considerable debate over the benefits and costs of sprawl and Smart Growth (Burchell, et al. 1998; Litman 2002). Table 2 summarizes some benefits that tend to result from reduced sprawl.

Table 2 **Smart Growth Benefits** ("Smart Growth, VTPI 2006)

Economic	Social	Environmental
Reduced development and public service costs. Consumer transportation cost savings. Economies of agglomeration. More efficient transportation.	Improved transportation choice, particularly for nondrivers. Improved housing choices. Community cohesion.	Greenspace and wildlife habitat preservation. Reduced air pollution. Reduce resource consumption. Reduced water pollution. Reduced "heat island" effect.

Costs of Induced Travel

Driving imposes a variety of costs, including many that are external, that is, not borne directly by users (Murphy and Delucchi 1998). Table 3 illustrates one estimate of the magnitude of these costs. Other studies show similar costs, with average values of 10-30¢ per vehicle-kilometer, and more under urban-peak conditions (Litman 2003).

Table 3 **Motor Vehicle Indirect and External Costs** (Delucchi 1996)

Cost Item	Examples	Vehicle-Year	Vehicle-Mile
Bundled private sector costs	Parking funded by businesses	$337-1,181	2.7-9.4 cents
Public infrastructure and services	Public roads, parking funded by local governments	$662-1,099	5.3-8.8 cents
Monetary externalities	External crash damages to vehicles, medical expenses, congestion.	$423-780	3.4-6.2 cents
Nonmonetary externalities	Environmental damages, crash pain.	$1,305-3,145	10.4-25.2 cents
Totals		*$2,727-6,205*	*22-50 cents*

This table summarizes an estimate of motor vehicle indirect and external costs. (US 1991 Dollars)

Any incremental external costs of generated traffic should be included in project evaluations, "incremental" meaning the difference between the external costs of the generated travel and the external costs of alternative activities (NHI 1995). For diverted traffic this is the difference in external costs between the two trips. For induced travel this is the difference in external costs between the trip and any non-travel activity it replaces, which tends to be large since driving has greater external costs than most other common activities. Most generated traffic occurs under urban-peak travel conditions, when motor vehicle external costs are greatest, so incremental external costs tend to be high.

Incremental external costs depend on road system conditions and the type of generated traffic. Generated traffic often increases downstream congestion (for example, increasing capacity on a highway can add congestion on surface streets, particularly near on- and off-ramps). In some conditions adding capacity actually increases congestion by concentrating traffic on a few links in the network and by reducing travel alternatives, such as public transit (Arnott and Small 1994). Air emission and accident rates per vehicle-mile may decline if traffic flows more freely, but these benefits decline over time and are usually offset as generated traffic leads to renewed congestion and increased vehicle travel (TRB 1995; Shefer and Rietvald 1997; Cassady, Dutzik and Figdor 2004).

Table 4 compares how different types of generated traffic affect costs. All types reduce user travel time and vehicle costs. Diverted trips have minimal incremental costs. Longer trips have moderate incremental costs. Shifts from public transit to driving may also have moderate incremental costs, since transit service has significant externalities but also experiences economies of scale and positive land use impacts that are lost if demand declines ("Social Benefits of Public Transit," VTPI 2001). Induced trips have the largest incremental costs, since they increase virtually all external costs. Longer and induced vehicle trips can lead to more automobile dependent transportation and land use over the long term. These costs are difficult to quantify but are probably significant (Newman and Kenworthy 1998; Burchell, et al 1998).

Table 4 Cost Impacts of Roadway Capacity Expansion

Costs Reduced	Costs Increased		
	Diverted Trips	*Longer Trips*	*Induced Trips*
Travel Time	Downstream congestion	Downstream congestion	Downstream congestion
Vehicle Operating Costs		Road facilities	Road facilities
Per-mile crash rates (if implemented in conjunction with roadway design improvements, but these are often offset if traffic speeds increase).		Traffic services	Parking facilities
		Per-capita crash rates	Traffic services
		Pollution emissions	Per-capita crash rates
		Noise	Pollution emissions
Per-mile pollution emissions (if congestion declines, but these may be offset if traffic speeds increase).		Resource externalities	Noise
		Land use impacts	Resource externalities
		Barrier effect	Land use impacts
			Barrier effect
			Transit efficiency
			Equity
			Vehicle ownership costs

Increased roadway capacity tends to reduce two costs, but increases others.

The incremental external costs of road capacity expansion tend to increase over time as the total amount of generated traffic grows and an increasing portion consists of induced motor vehicle travel and trips.

Table 5 proposes default estimates of the incremental external costs of different types of generated traffic. These values can be adjusted to reflect specific conditions and analysis needs.

Table 5 Estimated Incremental External Costs of Generated Traffic

Type	Description	Cost Per Mile
Time and route shift	Trips shifted from off-peak to peak, or from another route.	5 cents
Transit-to-Auto mode shift, and longer trips	Trips shifted from transit to driving alone, and increased automobile trip lengths.	15 cents
Induced vehicle trip	Additional motor vehicle trip, including travel shifted from walking, cycling and ridesharing.	30 cents.

This table indicates the estimated incremental costs of different types of generated traffic.

There is considerable discussion of the emission impacts of roadway expansion (TRB 1995). Although expanding highly congested roadways may reduce emission rates per vehicle-kilometer, expanding moderately congested roads may increase traffic speeds to levels (more than 80 kms/hr) that increase emission rates, and by inducing total vehicle travel tends to increase total emissions, particularly over the long run. According to a study by the Norwegian Centre for Transport Research (TØI 2009):

> "Road construction, largely speaking, increases greenhouse gas emissions, mainly because an improved quality of the road network will increase the speed level, not the least in the interval where the marginal effect of speed on emissions is large (above 80km/hr). Emissions also rise due to increased volumes of traffic (each person traveling further and more often) and because the modal split changes in favor of the private car, at the expense of public transport and bicycling."

Table 6 summarizes roadway improvement emission impacts, including effects on emission rates per vehicle mile, increases in total vehicle mileage, and emissions from road construction and maintenance activities.

Table 6 **Roadway Expansion Greenhouse Gas Emission Impacts** (TØI 2009)

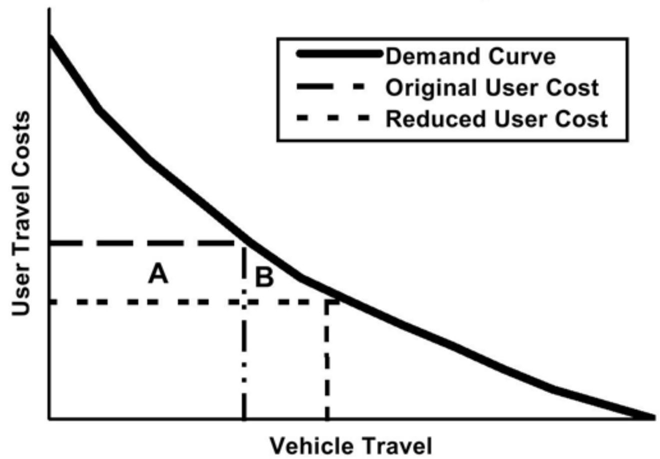
	General Estimates	Large Cities	Small Cities	Intercity Travel
Emission reductions per vehicle-kilometer due to improved and expanded roads.		Short term reductions. Stable or some increase over the long-term.	Depends on situation, ranging from no change to large increases.	Depends on situation. Emissions may decline or increase.
Increased vehicle mileage (induced vehicle travel), short term (under five years)	A 10% reduction in travel time increases traffic 3-5%	Significant emission growth	Moderate emission growth	Moderate emission growth
Increased vehicle mileage (induced travel), long term (more than five years)	A 10% reduction in travel time increases traffic 5-10%	Significant emission growth	Moderate emission growth	Moderate emission growth
Road construction and improvement activity	12 tonnes of CO_2 equivalent for 2-lane roads and 21 tonnes for 4-lane roads.	Road construction emissions are relatively modest compared with traffic emissions.		
Roadway operation and maintenance activity	33 tonnes of CO_2 equivalent for 2-lane roads and 52 tonnes for 4-lane roads.	Road operation and maintenance emissions are relatively modest compared with traffic emissions.		

This table summarizes roadway improvement emission impacts according to research by the Norwegian Centre for Transport Research.

Calculating Consumer Benefits

Generated traffic represents increased mobility, which provides consumer benefits. However, these benefits tend to be modest because generated traffic consists of marginal value trips, the trips that people are most willing to forego (Small 1998). To calculate these benefits economists use the *Rule of Half*, which states that the benefits of additional travel are worth half the per-trip saving to existing travelers, as illustrated in Figure 4 by the fact that B is a triangle rather than a rectangle (AASHTO 1977; Litman 2001a).

Figure 4 **Vehicle Travel Demand Curve Illustrating the Rule-of-Half**



Reduced user costs (downward shift on Y axis) increases vehicle travel (rightward shift on X axis). Rectangle A shows savings to existing trips. Triangle B shows generated travel benefits.

Because induced travel provides relatively small user benefits, and imposes external costs such as downstream congestion, parking costs, accident risk imposed on other road users, pollution emissions, sprawl and other environmental costs, the ratio of benefits to costs, and therefore total net benefits of travel, tend to decline as more travel is induced.

Failing to account for the full impacts of generated and induced travel tends to exaggerate the benefits of highway capacity expansion and undervalue alternatives such as transit improvements and pricing reforms (Romilly 2004). Some newer project evaluation models, such as the FHWA's SMITE and STEAM sketch plan programs, incorporate generated traffic effects including the Rule of Half and some externalities (FHWA 1997; FHWA 1998; DeCorla-Souza and Cohen 1998).

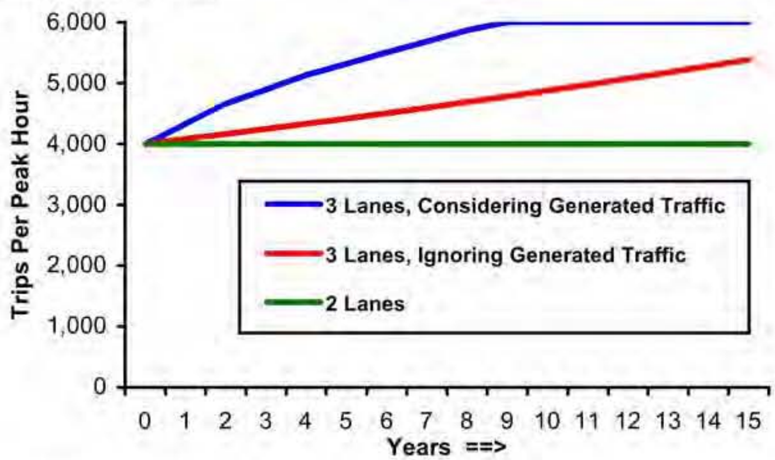
The benefits of increased mobility are often capitalized into land values. For example, a highway improvement can increase urban periphery real estate prices, or a highway offramp can increase nearby commercial land values (Moore and Thorsnes 1994). Because this increase in land values is an economic transfer (land sellers gain at the expense of land buyers), it is inappropriate to add increased real estate values and transport benefits, such as travel time savings (which represent true resource savings). This would double count benefits.

Example

A four-lane, 10-kilometer highway connects a city with nearby suburbs. The highway is congested 1,000 hours per year in each direction. Regional travel demand is predicated to grow at 2% per year. A proposal is made to expand the highway to six lanes, costing $25 million in capital expenses and adding $1 million in annual highway operating expenses.

Figure 5 illustrates predicted traffic volumes. Without the project peak-hour traffic is limited to 4,000 vehicles in each direction, the maximum capacity of the two-lane highway. If generated traffic is ignored the model predicts that traffic volumes will grow at a steady 2% per year if the project is implemented. If generated traffic is considered the model predicts faster growth, including the basic 2% growth plus additional growth due to generated traffic, until volumes levels off at 6,000 vehicles per hour, the maximum capacity of three lanes.

Figure 5 **Projected Traffic**

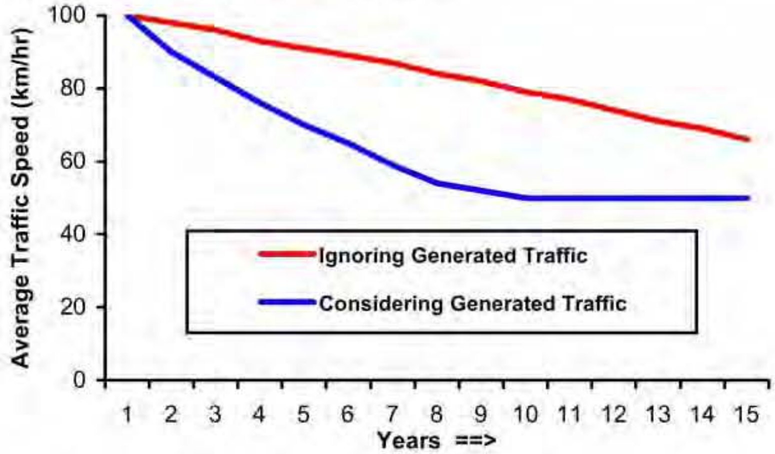


If generated traffic is ignored the model predicts that traffic volumes will grow at a steady 2% per year if the project is implemented. If generated traffic is considered the model predicts a higher initial growth rate, which eventually declines when the road once again reaches capacity and becomes congested. (Based on the "Moderate Latent Demand" curve from Figure 3)

The model divides generated traffic into diverted trips (changes in trip time, route and mode) and induced travel (increased trips and trip length), using the assumption that the first year's generated traffic represents diverted trips and later generated traffic represents induced travel. This simplification appears reasonable since diverted trips tend to occur in the short-term, while induced travel is associated with longer-term changes in consumer behavior and land use patterns.

Roadway volume to capacity ratios are used to calculate peak-period traffic speeds, which are then used to calculate travel time and vehicle operating cost savings. Congestion reduction benefits are predicted to be significantly greater if generated traffic is ignored, as illustrated in Figure 6.

Figure 6 **Projected Average Traffic Speeds**



Ignoring generated traffic exaggerates future traffic speeds and congestion reduction benefits.

Incremental external costs are assumed to average 10¢ per vehicle-km for diverted trips (shifts in time, route and mode) and 30¢ per vehicle-km for induced travel (longer and increased trips). User benefits of generated traffic are calculated using the Rule-of-Half.

Three cases where considered for sensitivity analysis. *Most Favorable* uses assumptions most favorable to the project, *Medium* uses values considered most likely, and *Least Favorable* uses values least favorable to the project. Table 7 summarizes the analysis.

Table 7 **Analysis of Three Cases**

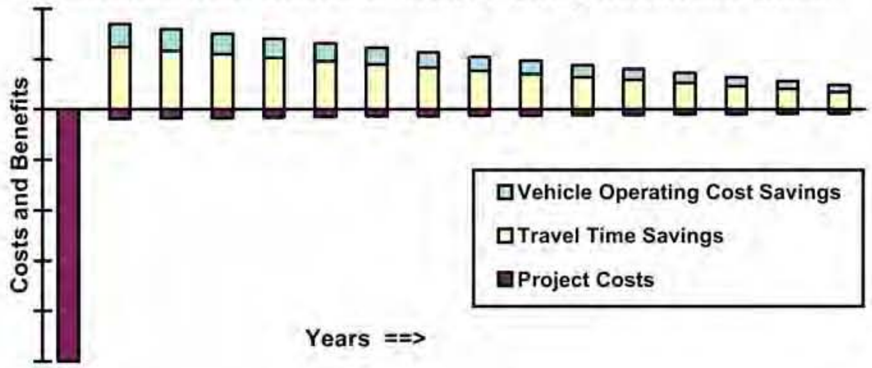
Data Input	Most Favorable	Medium	Least Favorable
Generated Traffic Growth Rate (from Figure 3)	L	M	H
Discount Rate	6%	6%	6%
Maximum Peak Vehicles Per Lane	2,200	2,000	1,800
Before Average Traffic Speed (km/hr)	40	50	60
After Average Traffic Speed (km/hr)	110	100	90
Value of Peak-Period Travel Time (per veh-hr)	$12.00	$8.00	$6.00
Vehicle Operating Costs (per km)	$0.15	$0.12	$0.10
Annual Lane Hours at Capacity Each Direction	1,200	1,000	800
Diverted Trip External Costs (per km)	$0.00	$0.10	$0.15
Induced Travel External Costs (per km)	$0.20	$0.30	$0.50
Net Present Value (millions)			
NPV Without Consideration of Generated Traffic	*$204.8*	*$45.2*	*-$9.8*
NPV With Consideration of Generated Traffic	*$124.5*	*-$32.1*	*-$95.7*
Difference	*-$80.3*	*-$77.3*	*-$85.8*
Benefit/Cost Ratio			
Without Generated Traffic	*6.90*	*2.30*	*0.72*
With Generated Traffic	*3.37*	*0.59*	*0.11*

This table summarizes the assumptions used in this analysis.

The most favorable assumptions result in a positive B/C even when generated traffic is considered. The medium assumptions result in a positive B/C if generated traffic is ignored but a negative NPV if generated traffic is considered. The least favorable assumptions result in a negative B/C even when generated traffic is ignored. In each case, considering generated traffic has significant impacts on the results.

Figure 7 illustrates project benefits and costs based on "Medium" assumptions, ignoring generated traffic. This results in a positive NPV of $45.2 million, implying that the project is economically worthwhile.

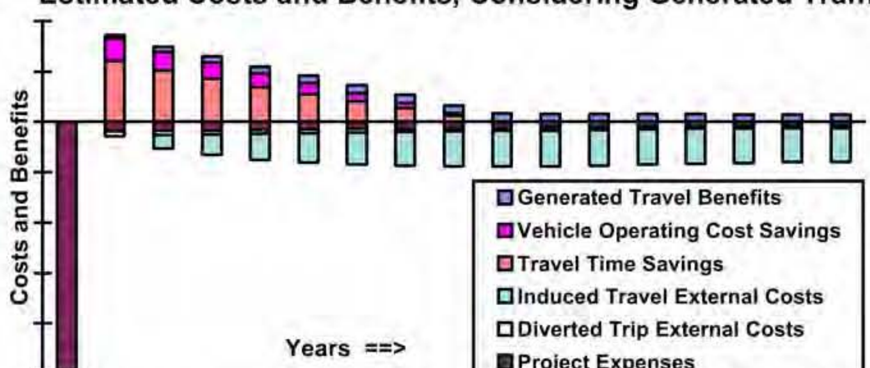
Figure 7 **Estimated Costs and Benefits, Ignoring Generated Traffic**



This figure illustrates annual benefits and costs when generated traffic is ignored, using "Medium" assumptions. Benefits are bars above the baseline, costs are bars below the baseline. Project expenses are the only cost category.

Figure 8 illustrates project evaluation when generated traffic is considered. Congestion reduction benefits decline, and additional external costs and consumer benefits are included. The NPV is –$32.1 million, indicating the project is not worthwhile.

Figure 8 **Estimated Costs and Benefits, Considering Generated Traffic**



This figure illustrates benefits and costs when generated traffic is considered, using medium assumptions. Benefits are bars above the baseline, costs are bars below the baseline. It includes consumer benefits and external costs associated with generated traffic. Travel time and vehicle operating cost savings end after about 10 years, when traffic volumes per lane return to pre-project levels, resulting in no congestion reduction benefits after that time.

This analysis indicates how generated traffic can have significant impacts on project assessment. Ignoring generated traffic exaggerates the benefits of highway capacity expansion by overestimating congestion reduction benefits and ignoring incremental external costs from generated traffic. This tends to undervalue alternatives such as road pricing, TDM programs, other modes, and "do nothing" options.

Counter Arguments

"Widening roads to ease congestion is like trying to cure obesity by loosening your belt" Roy Kienitz, executive director of the Surface Transportation Policy Project

"Increasing highway capacity is equivalent to giving bigger shoes to growing children" Robert Dunphy of the Urban Land Institute

Some highway expansion advocates argue that generated traffic has minor implications for transport planning decisions. They argue that increased highway capacity contributes little to overall growth in vehicle travel compared with other factors such as increased population, employment and income (Heanue 1998; Sen 1998; Burt and Hoover 2006), that although new highways generate traffic, they still provide net economic benefits (ULI 1989), and that increasing roadway capacity does reduce congestion (TRIP 1999; Bayliss 2008).

These arguments ignore critical issues, and are often based on outdated data and inaccurate analysis. Overall travel trends indicate little about the cost effectiveness of particular policies and projects. For example, studies which indicate that, in the past, increased lane-miles caused minimal growth in vehicle travel (Burt and Hoover 2006), provide little guidance for future planning, since, in the past, much of the added highway lane-miles occurred on uncongested rural highways while most future highway expansion occurs on congested urban highways. Strategies that encourage more efficient use of existing capacity, such as commute trip reduction programs and road pricing, may provide greater social benefits, particularly considering all costs (Goodwin 1997).

Highway expansion advocates generally ignore or severely understate generated traffic and induced travel impacts. For example, Cox and Pisarski (2004) use a model that accounts for diverted traffic (trips shifted in time or route) but ignores shifts in mode, destination and trip frequency. Hartgen and Fields (2006) assume that generated traffic would fill just 15% of added roadway capacity, based on generated traffic rates during the 1960s and 1970s, which is unrealistically low when extremely congested roads are expanded. They ignore the incremental costs that result from induced vehicle travel, such as increased downstream traffic congestion, road and parking costs, accidents and pollution emissions. They claim that roadway capacity expansion reduces fuel consumption, pollution emissions and accidents, because they measure impacts per vehicle-mile and ignore increased vehicle miles. As a result they significantly exaggerate roadway expansion benefits and understate total costs.

Debates over generated traffic and its implications often reflect ideological perspectives concerning whether automobile travel (and therefore road capacity expansion) is "good" or "bad". To an economist, such arguments are silly. Some automobile travel provides large net benefits (high user value, poor alternatives, low external costs), and some provides negative net benefits (low user value, good alternatives, and large external costs). The efficient solution to congestion is to use pricing or other incentives to test consumers' willingness to pay for road space and capacity expansion.

If consumers only demand roadway improvements when they are shielded from the true costs, such projects are likely to be economically inefficient. Only if users are willing to pay the full incremental costs their vehicle use imposes can society be sure that increased road capacity and the additional vehicle travel that results provides net benefits. Travel demand predictions based on underpriced roads overestimate the economically optimal level of roadway investments and capacity expansion. Increasing capacity in such cases is more equivalent to loosening a belt than giving a growing child larger shoes (see quotes above), since the additional vehicle travel is a luxury and economically inefficient.

Some highway advocates suggest there are equity reasons to subsidize roadway capacity expansion, to allow lower-income households access to more desirable locations, but most benefits from increased roadway capacity are captured by middle- and upper-income households (Deakin, et al. 1996). Improving travel choices for non-drivers tends to have greater equity benefits than subsidizing additional highway capacity since physically and economically disadvantaged people often rely on alternative modes.

Although highway projects are often justified for the sake of economic development, highway capacity expansion now provides little net economic benefit (Boarnet 1997). An expert review concluded, "The available evidence does not support arguments that new transport investment in general has a major impact on economic growth in a country with an already well-developed infrastructure" (SACTRA 1997).

Alternative Transport Improvement Strategies

Since roadway capacity expansion provides smaller net benefits than is often recognized, due to the effects of generated traffic, other solutions to transportation problems may provide relatively more benefits. A “No Build” option may become more attractive since peak-period traffic volumes will simply level off without additional capacity. This can explain, for example, why urban commute travel times are virtually unchanged despite increases in traffic congestion, and why urban regions that have made major investments in highway capacity expansion have not experienced significant reductions in traffic congestion (Gordon and Richardson 1994; STPP 1998).

Consideration of generated traffic gives more value to transportation systems management and transportation demand management strategies that result in more efficient use of existing roadway capacity. These strategies cannot individually solve all transportation problems, but a package of them can, often with less costs and greater overall benefit than highway capacity expansion. Below are examples (VTPI 2001):

- Congestion pricing can provide travelers with an incentive to reduce their peak period trips and use travel alternatives, such as ridesharing and non-motorized transport.

- Commute trip reduction programs can provide a framework for encouraging commuters to drive less and rely more on travel alternatives.

- Land use management can increase access by bringing closer common destinations.

- Pedestrian and cycle improvements can increase mobility and access, and support other modes such as public transit (since transit users also depend on walking and cycling).

- Public transit service that offers door-to-door travel times and user costs that are competitive with driving can attract travelers from a parallel highway, limiting the magnitude of traffic congestion on that corridor.

Legal Issues

Environmental groups successfully sued the Illinois transportation agencies for failing to consider land use impacts and generated traffic in the Environmental Impact Statement (EIS) for I-355, a proposed highway extension outside the city of Chicago (Sierra Club 1997). The federal court concluded that the EIS was based on the "implausible" assumption that population in the rural areas would grow by the same amount with and without the tollroad, even though project was promoted as a way to stimulate growth. The court concluded that this circular reasoning afflicted the document's core findings. The judge required the agencies to prepare studies identifying the amount of development the tollroad would cause, and compare this with alternatives. The Court's order states:

> Plaintiffs' argument is persuasive. Highways create demand for travel and expansion by their very existence…Environmental laws are not arbitrary hoops through which government agencies must jump. The environmental regulations at issue in this case are designed to ensure that the public and government agencies are well informed about the environmental consequences of proposed actions. The environmental impact statements in this case fail in several significant respects to serve this purpose. (ELCP)

In 2008 the California Attorney General recognized that regional transportation plans must consider induced travel impacts when evaluating the climate change impacts of individual projects to meet California Environmental Quality Act (CEQA) requirements (Brown 2008). CEQA requires that "[e]ach public agency shall mitigate or avoid the significant effects on the environment of projects that it carries out or approves whenever it is feasible to do so." The state Attorney General recognizes that transportation planning decisions, such as highway expansion projects, can have significant emission impacts due to induced vehicle travel.

Conclusions

Urban traffic congestion tends to maintain equilibrium. Congestion reaches a point at which it discourages additional peak-period trips. Increasing road capacity allows more vehicle travel to occur. In the short term this consists primarily of generated traffic: vehicle travel diverted from other times, modes, routes and destinations. Over the long run an increasing portion consists of induced vehicle travel, resulting in a total increase in regional VMT. This has several implications for transport planning:

- Ignoring generated traffic underestimates the magnitude of future traffic congestion problems, overestimates the congestion reduction benefits of increasing roadway capacity, and underestimates the benefits of alternative solutions to transportation problems.
- Induced travel increases many external costs. Over the long term it helps create more automobile dependent transportation systems and land use patterns.
- The mobility benefits of generated traffic are relatively small since they consist of marginal value trips. Much of the benefits are often capitalized into land values.

Ignoring generated traffic results in self-fulfilling *predict and provide* planning: Planners extrapolate traffic growth rates to predict that congestion will reach *gridlock* unless capacity expands. Adding capacity generates traffic, which leads to renewed congestion with higher traffic volumes, and more automobile oriented transport and land use patterns. This cycle continues until road capacity expansion costs become unacceptable.

The amount of traffic generated depends on specific conditions. Expanding highly congested roads with considerable latent demand tends to generate significant amounts of traffic, providing only temporary congestion reductions.

Generated traffic does not mean that roadway expansion provides no benefits and should never be implemented. However, ignoring generated traffic results in inaccurate forecasts of impacts and benefits. Road projects considered cost effective by conventional analysis may actually provide little long-term benefit to motorists and make society overall worse off due to generated traffic. Other strategies may be better overall. Another implication is that highway capacity expansion projects should incorporate strategies to avoid increasing external costs, such as more stringent vehicle emission regulations to avoid increasing pollution and land use regulations to limit sprawl.

Framing the Congestion Question

If you ask people, *"Do you think that traffic congestion is a serious problem?"* they frequently answer yes. If you ask, *"Would you rather solve congestion problems by improving roads or by using alternatives such as congestion tolls and other TDM strategies?"* a smaller majority would probably choose the road improvement option. This is how transport choices are generally framed.

But if you present the choices more realistically by asking, *"Would you rather spend a lot of money to increase road capacity to achieve moderate and temporary congestion reductions and bear higher future costs from increased motor vehicle traffic, or implement other types of transportation improvements?"* the preference for road building might disappear.

References and Information Resources

John Abraham (1998), *Review of the MEPLAN Modelling Framework from a Perspective of Urban Economics*, Civil Engineering Research Report CE98-2, U. of Calgary, (www.acs.ucalgary.ca/~jabraham/MEPLAN_and_Urban_Economics.PDF).

Richard Arnott and Kenneth Small (1994), "The Economics of Traffic Congestion," *American Scientist*, Vol. 82, Sept./ Oct. 1994, pp. 446-455.

Lawrence C. Barr (2000), "Testing for the Significance of Induced Highway Travel Demand in Metropolitan Areas," *Transportation Research Record 1706*, Transportation Research Board (www.trb.org); at http://trb.metapress.com/content/lq766w66540p7432/fulltext.pdf.

David Bayliss (2008), *Misconceptions and Exaggerations about Roads and Road Building in Great Britain*, Royal Automobile Club Foundation (www.racfoundation.org/index.php?option=com_content&task=view&id=597&Itemid=35)

Marlon Boarnet (1997), "New Highways & Economic Productivity: Interpreting Recent Evidence," *Journal of Planning Literature*, Vol. 11, No. 4, May 1997, pp. 476-486.

Marlon Boarnet (1997), *Direct and Indirect Economic Effects of Transportation Infrastructure*, UCTC (www.uctc.net).

Marlon Boarnet and Saksith Tan Chalermpong (2002), *New Highways, Induced Travel and Urban Growth Patterns: A "Before and After" Test*, Paper 559, University of California Transportation Center (www.uctc.net).

Edward Beimborn, Rob Kennedy and William Schaefer (1996), *Inside the Blackbox: Making Transportation Models Work for Livable Communities*, Center for Urban Transportation Studies University of Wisconsin-Milwaukee (www.uwm.edu/Dept/CUTS); at http://ctr.utk.edu/TNMUG/misc/blackbox.pdf.

Antonio M. Bento, Maureen L. Cropper, Ahmed Mushfiq Mobarak and Katja Vinha (2003), *The Impact of Urban Spatial Structure on Travel Demand in the United States*, World Bank Group Working Paper 2007, World Bank (http://econ.worldbank.org/files/24989_wps3007.pdf).

Robert Burchell, et al. (1998), *Costs of Sprawl – Revisited*, TCRP Report 39, Transportation Research Board (www.trb.org).

Michael Burt and Greg Hoover (2006), *Build It and Will They Drive? Modelling Light-Duty Vehicle Travel Demand*, Conference Board of Canada (www.conferenceboard.ca); at http://sso.conferenceboard.ca/e-Library/LayoutAbstract.asp?DID=1847.

Edward G. Brown (2008), *Comments on the Notice of Preparation for Draft Environmental Impact Report For the Transportation 2035 Plan*, California Attorney General (http://ag.ca.gov); at http://ag.ca.gov/globalwarming/pdf/comments_MTC_RT_Plan.pdf.

Sally Cairns, C. Hass-Klau and Phil Goodwin (1998), *Traffic Impacts of Highway Capacity Reductions: Assessment of the Evidence*, London Transport Planning (London; www.ucl.ac.uk/transport-studies/tsu/tpab9828.htm). Also see Sally Cairns, Stephen Atkins and

Phil Goodwin (2002), "Disappearing Traffic? The Story So Far," Proceedings of the Institution of Civil Engineers; *Municipal Engineer*, Vo. 151, Issue 1 (www.municipalengineer.com) March 2002, pp. 13-22; at www.ucl.ac.uk/transport-studies/tsu/disapp.pdf.

Alison Cassady, Tony Dutzik and Emily Figdor (2004), *More Highways, More Pollution: Road-Building and Air Pollution in American's Cities*, U.S. PIRG Education Fund (www.uspirg.org).

Robert Cervero (2002), "Induced Travel Demand: Research Design, Empirical Evidence, and Normative Policies," *Journal of Planning Literature*, Vol. 17, No. 1, pp. 4-19

Robert Cervero (2003a), "Are Induced Travel Studies Inducing Bad Investments?," *ACCESS*, Number 22, University of California Transportation Center (www.uctc.net), Spring 2003, 22-27.

Robert Cervero (2003b), "Road Expansion, Urban Growth, and Induced Travel: A Path Analysis," *Journal of the American Planning Association*, Vol. 69, No. 2 (www.planning.org), Spring 2003, pp. 145-163.

Robert Cervero and Mark Hansen (2000), *Road Supply-Demand Relationships: Sorting Out Casual Linkages*, Institute of Transportation Studies, University of California (www.uctc.net).

Harry Cohen (1995), "Review of Empirical Studies of Induced Traffic," *Expanding Metropolitan Highways: Implications for Air Quality and Energy Use*, Transportation Research Board, Special Report 345, National Academy Press (www.trb.org), Appendix B, pp. 295-309.

Wendell Cox and Alan Pisarski (2004), *Blueprint 2030: Affordable Mobility And Access For All*, Georgians for Better Mobility (http://ciprg.com/ul/gbt/atl-report-20040621.pdf).

J. M. Dargay and P. B. Goodwin (1995), "Evaluation of Consumer Surplus with Dynamic Demand Changes." *Journal of Transport Economics and Policy*, Vol. XXIX, No. 2, pp. 179-93.

Elizabeth Deakin, et al. (1996), *Transportation Pricing Strategies for California: An Assessment of Congestion, Emissions, Energy and Equity Impacts*, California Air Resources Board (www.arb.ca.gov).

Patrick DeCorla-Souza (2000), "Estimating Highway Mobility Benefits," *ITE Journal* (www.ite.org), February 2000, pp. 38-43. Also, Patrick DeCorla-Souza, "Evaluating the Trade-Offs Between Mobility and Air Quality," *ITE Journal*, February 2000, pp. 65-70.

Patrick DeCorla-Souza and Harry Cohen (1998), *Accounting for Induced Travel in Evaluation of Urban Highway Expansion*, FHWA (www.fhwa.dot.gov/steam/doc.htm).

Patrick DeCorla Souza and Harry Cohen (1999), "Estimating Induced Travel For Evaluation of Metropolitan Highway Expansion," *Transportation*, Vol. 26, pp. 249-261.

Mark Delucchi (1996), "Total Cost of Motor-Vehicle Use," *Access* (http://violet.berkeley.edu/~uctc), No. 8, Spring 1996, pp. 7-13.

DfT (2007), *Transport Analysis Guidance*, UK Department For Transport (www.webtag.org.uk).

Anthony Downs (1992), *Stuck in Traffic*, Brookings Institution (www.brookings.edu).

Gilles Duranton and Matthew A. Turner (2008), *The Fundamental Law of Highway Congestion: Evidence from the US*, University of Toronto (http://individual.utoronto.ca/gilles/Papers/Law.pdf).

FHWA (1997), *Spreadsheet Model for Induced Travel Estimation* (SMITE), Federal Highway Administration (www.fhwa.dot.gov/steam/smite.htm).

FHWA (1998), *Surface Transportation Efficiency Analysis Model* (STEAM), Federal Highway Administration (www.fhwa.dot.gov/steam).

FHWA (1999), *Social Costs of Alternative Land Development Scenarios*, Federal Highway Administration (www.fhwa.dot.gov/scalds/scalds.html).

FHWA (2002), *Highway Economic Requirements System: Technical Report*, FHWA, USDOT (www.fhwa.dot.gov/infrastructure/asstmgmt/hersindex.htm); at http://isddc.dot.gov/OLPFiles/FHWA/010945.pdf.

FHWA (2004), *Induced Travel: Frequently Asked Questions*, Federal Highway Administration (www.fhwa.dot.gov/planning/itfaq.htm).

Phil Goodwin (1996), "Empirical Evidence on Induced Traffic," *Transportation*, Vo. 23, No. 1, pp. 35-54.

Phil Goodwin (1997), *Solving Congestion*, Inaugural lecture for the Professorship of Transport Policy, University College London (www.ucl.ac.uk/transport-studies/tsu/pbginau.htm).

Phil B. Goodwin (1998), "The End of Equilibrium," in *Theoretical Foundations of Travel Choice Modelling*, edited by T. Garling et al., Elsevier, ISBN 0080430627.

Phil Goodwin and Robert B. Noland (2003), "Building New Roads Really Does Create Extra Traffic: A Response to Prakash et al.," *Applied Economics* (www.tandf.co.uk/journals).

Peter Gordon and Harry W. Richardson (1994), "Congestion Trends in Metropolitan Areas," *Curbing Gridlock*, Special Report 242, Transportation Research Board (www.nas.edu/trb).

Roger Gorham (2009), *Demystifying Induced Travel Demand*, Sustainable Transportation Technical Document, Sustainable Urban Transportation Project (www.sutp.org) and GTZ (www.gtz.de); at www.sutp.org/index2.php?option=com_content&do_pdf=1&id=1461.

Mark Hammer (1998), "Roadblocks Ahead," *New Scientist*, 24 January 1998; at (www.newscientist.com/cgi-bin/pageserver.cgi?/ns/980124/ntraffic.h).

Mark Hansen, et al. (1993), *Air Quality Impacts of Urban Highway Capacity Expansion: Traffic Generation and Land Use Changes*, Institute of Transport Studies, University of California (www.uctc.net), UCB-ITS-RR-93-5.

Mark Hansen, "Do New Highways Generate Traffic?" *Access* No. 7 (www.uctc.net), Fall 1995, pp.16-22.

Mark Hansen and Yuanlin Huang (1997), "Road Supply and Traffic in California Urban Areas," *Transportation Research A*, Vol. 31, No. 3, pp. 205-218.

David T. Hartgen (2003a), *The Impact of Highways and Other Major Road Improvements on Urban Growth in Ohio*, The Buckeye Institute (www.buckeyeinstitute.org).

David T. Hartgen (2003b), *Highways and Sprawl in North America*, John Locke Foundation (www.johnlocke.org).

David T. Hartgen and M. Gregory Fields (2006), *Building Roads to Reduce Traffic Congestion in America's Cities: How Much and at What Cost?*, Reason Foundation (www.reason.org).

Greig Harvey and Elizabeth Deakin (1993), *A Manual of Regional Transportation Modeling Practice for Air Quality*, National Association of Regional Councils (www.narc.org).

Kevin Heanue (1998), *Highway Capacity Expansion and Induced Travel; Evidence and Implications*, Circular 481, Transportation Research Board (www.trb.org); at http://pubsindex.trb.org/document/view/default.asp?lbid=477750.

Russell H. Henk (1989), "Quantification of Latent Travel Demand on New Urban Facilities in the State of Texas," *ITE Journal*, December 1989, pp. 24-28.

Highways Agency (2003), "Guidance on Induced Traffic: Methods for Modelling Situations Where Road Improvements May Generate Additional Traffic," *Design Manual for Roads and Bridges*, Volume 12, Section 2, Part 2, ISBN 0-11-551908-4, Highways Agency (www.official-documents.co.uk/document/deps/ha/dmrb/index.htm).

Peter Hills (1996), "What is Induced Traffic?" *Transportation*, Vol. 23, No. 1, pp. 5-16.

Ronald W. Holder and Vergil G. Stover (1992), *Evaluation of Induced Traffic On New Highway Facilities*, Research Report 167-5, Texas Transportation Institute, for the THD and the USDOT.

ICF Consulting (2005), *Handbook on Integrating Land Use Considerations Into Transportation Projects to Address Induced Growth*, prepared for AASHTO Standing Committee on the Environment; at www.trb.org/NotesDocs/25-25(3)_FR.pdf.

Peter Jacobsen (1997), "Liquid vs. Gas Models for Traffic," *Los Angeles Times*, Letters to Editor, 14 May 1997.

Robert Johnston and Raju Ceerla (1996), "The Effects of New High-Occupancy Vehicle Lanes on Travel and Emissions," *Transportation Research*, Vol. 30A, No. 1, pp. 35-50.

Robert A. Johnston, Caroline J. Rodier, John E. Abraham, John Douglas Hunt and Griffith J. Tonkin (2001), *Applying an Integrated Model to the Evaluation of Travel Demand Management Policies in the Sacramento Region*, Mineta Transportation Institute (http://transweb.sjsu.edu/publications/01-03.pdf).

Keith T. Lawton (2001), *The Urban Structure and Personal Travel: an Analysis of Portland, or Data and Some National and International Data*, E-Vision 2000 Conference (www.rand.org/scitech/stpi/Evision/Supplement/lawton.pdf).

Douglass Lee, Lisa Klein and Gregorio Camus (1998), *Induced Traffic and Induced Demand in Benefit-Cost Analysis*, USDOT Volpe National Transport. Systems Center (www.volpe.dot.gov).

Douglass Lee, Lisa Klein and Gregorio Camus (1999), "Induced Traffic and Induced Demand," *Transportation Research Record 1659*, TRB (www.trb.org), pp. 68-75.

David Levinson and Ajay Kumar (1995), "Activity, Travel, and the Allocation of Time," *APA Journal*, Vol. 61, No. 4, Autumn 1995, pp. 458-470.

David Levinson and Ajay Kumar (1997), *Density and the Journey to Work, Growth and Changes*, Vol. 28, No. 2 1997, pp. 147-72; at www.ce.umn.edu/~levinson/papers-pdf/doc-density.pdf.

Todd Litman (2001a), *What's It Worth? Life Cycle and Benefit/Cost Analysis for Evaluating Economic Value*, Presented at Internet Symposium on Benefit-Cost Analysis, Transportation Association of Canada (www.tac-atc.ca); at www.vtpi.org/worth.pdf.

Todd Litman (2001b), "Generated Traffic: Implications for Transport Planning," *ITE Journal*, Vol. 71, No. 4, Institute of Transportation Engineers (www.ite.org), April 2001, pp. 38-47.

Todd Litman (2002), *Transportation Land Use Impacts*, VTPI (www.vtpi.org); at www.vtpi.org/landuse.pdf.

Todd Litman (2003), *Transportation Cost Analysis: Techniques, Estimates and Implications*, VTPI (www.vtpi.org/tca).

Louis Berger & Assoc. (1998), *Guidance for Estimating the Indirect Effects of Proposed Transportation Projects*, NCHRP Report 403, Transportation Research Board (www.trb.org).

William R. Loudon, Janaki Parameswaran and Brian Gardner (1997), "Incorporating Feedback in Travel Forecasting: Methods, Pitfalls and Common Concerns," *Transportation Research Record 1607*, TRB (www.trb.org), pp. 185-195; at http://trb.metapress.com/content/120399.

Peter Mackie (1996), "Induced Traffic and Economic Appraisal," *Transportation*, Vol. 23.

Norman Marshall (2000), *Evidence of Induced Demand in the Texas Transportation Institute's Urban Roadway Congestion Study Data Set*, TRB Annual Meeting (www.trb.org).

Gert Marte (2003), "Slow Vehicle Traffic Is A More Attractive Alternative To Fast Vehicle Traffic Than Public Transport" *World Transport Policy & Practice*, Volume 9, Number 2, (www.eco-logica.co.uk/WTPPhome.html).

Martin J. H. Mogridge (1990), *Travel in Towns: Jam Yesterday, Jam Today, Jam Tomorrow?*, MacMillan (www.macmillan.com).

Martin Mogridge (1997), "The Self-Defeating Nature of Urban Road Capacity Policy; A Review of Theories, Disputes and Available Evidence," *Transport Policy*, Vo. 4, No. 1, pp. 5-23.

Patricia Mokhtarian, et al. (2002), "Revisiting the Notion of Induced Traffic Through A Matched-Pairs Study," *Transportation*, Vol. 29, pp. 193-202.

Terry Moore and Paul Thorsnes (1994), *The Transportation/Land Use Connection*, American Planning Association (www.planning.org), #448/449.