Appendix M

Wind & Shadow memos

ESA Environmental Science Associates

TECHNICAL MEMORANDUM

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DATE: **February 6, 2002**

SUBJECT: **Evaluation of Shadow and Wind Effects**
Downtown Height and Bulk Alternatives
Seattle, Washington
ESA 201358

This memorandum provides an overview of the general shadow and wind effects that would occur in downtown Seattle due to four proposed City of Seattle development alternatives. In summary, the overall differences between the Alternatives are relatively minor. The overall shadow and wind consequences of any development alternative will depend strongly upon the specific designs for each of the individual structures erected in accordance with the general height and bulk regulations.

Discussion of General Shadow and Wind Effects

Shadows: Very generally, increased building height will extend the length of the shadow cast by the building and increased bulk (or cross-section width) will widen the shadow cast by the building. While the increased reach of the shadow may mean that the effects are noticed farther from the building, the shadow effects far from the building are more transitory, because the shadow moves with the angle of the sun, and that angular motion is translated into faster travel over the ground. Buildings with increasing amounts of bulk will generally result in wider shadows and an increased amount of shadowed area. The amount and impact of shadows cast by a group of buildings depends upon the spacing, orientation and relative locations of those buildings (e.g., some building arrangements may result in overlapping shadows, or cast shadows in patterns that are not detrimental to public areas where solar access is desirable).

Aside from altering the height or the bulk (or cross-section width) of the building, little can be done to change the shadow effects that will result from a single building. Altering the spacing, orientation and relative locations of new buildings within a group of buildings can sometimes result in benefits, such as lesser area in shadow, or retention of good solar access in favored areas. Conceptually, taller and narrower towers with wide spacing may result in shadow impacts and light conditions that are more transitory and less objectionable than conditions resulting from lower and more bulky buildings set close together.

Wind: Tall buildings and structures can strongly affect the wind environment for pedestrians. In cities, groups of structures tend to slow the winds near ground level, due to the friction and drag of the structures themselves. Buildings that are much taller than the surrounding buildings intercept and redirect winds that might otherwise flow overhead, and bring them down the vertical faces of the building to ground level, where they can create ground-level wind and turbulence. These redirected winds can be relatively strong and also relatively turbulent. Furthermore, they can be incompatible with the intended uses of nearby ground-level spaces and even can be hazardous.

Generally, the higher that a building rises above its surroundings, the stronger the wind that it encounters. These intercepted winds can be especially strong when the upwind buildings are very much shorter than the subject, and can be diminished when the upwind buildings' heights are similar to the height of the subject building. If, in addition, the building provides a wide face to the wind, more air will flow down that face of the building toward ground level. Thus, both height and bulk can affect the winds directed toward the ground. However, these flows can be controlled by building design features that redirect them away from pedestrian areas. Typically, it is sufficient to provide substantial horizontal structures near the base of a building to intercept winds flowing down the face of the building and to redirect those winds horizontally, well above ground level. Usually, this is design strategy is effective for both taller towers and lower, bulkier buildings.

Public Comfort and Public Safety

Different conditions of sun exposure, temperature, clothing, and wind speed are known to influence the comfort and safety of people engaged in various outdoor activities. Over the years, many studies have been performed to establish criteria that relate wind speed to the ability of a person to carry out certain activities, such as sitting in the park and reading a newspaper, walking comfortably or walking safely along a sidewalk. The relationship of pedestrian comfort and safety to local wind speeds is discussed in the 1985 Downtown Seattle Draft EIS.

Sun exposure and shading also affects pedestrian comfort in the Downtown. Pedestrians expect to encounter both shade and sunshine along the sidewalks of Downtown on a clear day, and may or may not adjust their routes to favor one or the other, according to the temperature. Shade usually does not result in safety hazards, except for potential icy conditions during winter.

Public safety and comfort concerns are potential reasons to establish quantitative criteria for determining hazardous wind conditions and unacceptable shadowing of essential open spaces and walkways. The City's SEPA regulations do address shadowing of specified public open spaces in Downtown, including Freeway Park, Westlake Park, Steinbrueck Park, Convention Center Park, and Kobe Terrace/I.D. Community Garden. Only two of these open spaces, Freeway Park and Convention Center Park, are within the study area, and they are located on the far eastern edge of the office core. Furthermore, significant increases in the shadow on any of these open spaces are not expected from development in the study area because, in the portion of the study area where shadows cast by tall development could reach them, there are only very limited development opportunities.

A number of design requirements and guidelines also attempt to avoid or mitigate wind effects. This provides the City the opportunity to regulate and influence future development to avoid potential shadow and wind impacts. However, the City does not have quantitative wind or shadow criteria in its regulations,

which makes it difficult to apply rational methodologies to determine the performance of a project relative to shadow and wind abatement.

Access to Natural Light in Adjacent Development

Shadows cast by new development not only have impacts on the public street and open space environment, but also affect conditions in adjacent development. Studies have shown that workspaces with access to natural light can contribute to increased productivity of office employees, increased retail sales in retail stores, and reduced use of overhead lighting, which conserves energy. Bulky buildings casting shadows on adjacent sites will likely reduce the amount of natural light that developments on these sites receive, thereby reducing the benefits associated with access to natural light. However, due to the reflection of sunlight from other buildings, a substantial amount of natural light will remain even in a cluster of high-rise buildings in the Downtown office core.

ANALYSIS OF ALTERNATIVES

In the downtown among many tall buildings, people do not usually expect that sunshine will be available on all sidewalks; however, they do expect that most public open spaces will provide open areas where direct sun can be experienced, even downtown. The City has ordinances and design controls that seek to mitigate shadow impacts and improve sunlight availability. For example, the City's SEPA ordinance allows for the assessment of shadow impacts on any of five downtown parks: Freeway Park, Westlake Park and Plaza, Market (Steinbrueck) Park, Convention Center Park, and Kobe Terrace Park/I.D. Community Garden. Based on such impacts, the decision maker may deny a project or require mitigation measures (SMC 25.05.675-Q). The following table is a qualitative comparison of the potential wind and shadow effects that may result from future development under the four Alternatives. Overall, the differences among the potential impacts of the alternatives are relatively subtle.

Comparative Shadow and Wind Effects of the Alternatives

	Description of Alternative	Potential Shadow Effects	Potential Wind Effects
Alt. 1: High End Height and Density Increase	--135 ft. maximum height increase in DOC 1 office core. --100 ft. increase and 40% density increase in Denny Triangle. --30% height increase in other peripheral DMC zoned areas. --Density increases in all areas.	--New tall buildings in the DOC 1 office core will add to the already considerable shading of city streets. --Taller buildings in all of Denny Triangle will add to the shading of those city streets. --Taller buildings in 1st/Western Ave. vicinity and edge of Belltown will add to the shading of those city streets. --Significant added shading of Downtown SEPA-identified parks is not likely. --Additional building heights near Denny Park at Denny Way have the potential to add to the shading of the park.	--New tall buildings in the office core and some peripheral areas would create potential for additional wind effects near street level. New buildings interspersed with existing buildings in the core may have less exposure to strong winds. --Taller buildings in the Denny Triangle, 1st/Western Ave. vicinity and edge of Belltown may help slow certain winds reaching the office core. However, those new tall buildings at the periphery of the clusters also would be exposed to winds. --Substantive site design and architectural features can reduce potential adverse wind effects at street level.
Alt. 2: Concentrated Office Core	--Height increases only in office core and central Denny Triangle office core zone. --Density increases similar or slightly less than Alt. 1.	--Potential shadow effects in the DOC 1 office core and the central Denny Triangle would be nearly the same as for Alternatives 1 and 3. --No zone changes in peripheral areas of Denny Triangle means no changes in shading of city streets. --No zone changes in 1st Ave./ Western Ave. vicinity or edge of Belltown would avoid additional shading effects. --Similar to Alternatives 1 and 3, significant added shading of Downtown SEPA-identified parks is not likely. --No zone changes near Denny Way would avoid additional shading effects on Denny Park.	--Potential wind effects in the office core would be nearly the same as for Alternatives 1 and 3. --Due to somewhat less height and bulk of future buildings in the Denny Triangle and peripheral areas, potential wind effects would be somewhat less than for Alternative 1. --As with all other alternatives, substantive site design and architectural features can reduce potential adverse wind effects at street level.

Alt. 3: Resid. Emphasis	--Height increases in office core, portion of Denny Triangle DOC 2 zone. --Portions of Denny Triangle and peripheral areas zoned for intensive use to provide incentives to include housing in mixed use development.	--Potential shadow effects in DOC 1 office core would be roughly the same as for Alternatives 1 and 2. --Less intensive zoning in some peripheral areas of Denny Triangle and edge of Belltown would result in less bulky buildings, reducing potential for shading of city streets. Shading would be less than for Alternatives 1 and 2 and more than for Alternative 4. --Similar to Alternatives 1 and 2, significant added shading of Downtown SEPA-identified parks is not likely. --No zone changes near Denny Way would limit additional shading of Denny Park.	--Potential wind effects in the DOC 1 office core would be nearly the same as for Alternatives 1 and 2. --Due to somewhat less height and bulk of the future buildings in the Denny Triangle and peripheral areas, potential wind effects would be somewhat less than for Alternatives 1 or 2, but more than for Alternative 4. --As with all other alternatives, substantial site design and architectural features can reduce potential adverse wind effects at street level.
Alt. 4: No Action	--No change from existing height and density regulations.	--Future developments in the DOC1 office core under existing height/density limits could add to the already considerable shading of city streets. This increment could be slightly less than for the other alternatives. --Future developments under existing height/density limits could add to shading of city streets in Denny Triangle and other peripheral areas of Downtown. Existing bulk and site coverage regulations reduce upper level bulk, and shading. --Although future development closer to protected parks could possibly trigger the need to use SEPA protections, significant added shading of Downtown SEPA-identified parks might not occur.	--Due to less potential for height and bulk in future development, potential wind effects in the office core could be the same or slightly less than for the other alternatives. --Due to somewhat less height and bulk of future buildings in the Denny Triangle and peripheral areas, potential wind effects there would be less than for the other alternatives. --Existing bulk and site coverage regulations provide some benefits in avoiding wind effects. --As with all other alternatives, substantial site design and architectural features can reduce potential adverse wind effects at street level.

Potential Mitigation Strategies

Given the current regulations, including the City's SEPA Ordinance, none of the alternatives can be said to generate significant adverse shadowing or wind impacts, per se. Adverse wind impacts resulting from new high-rise developments can usually be controlled by project-specific measures, especially site design and architectural elements, which prevent adverse winds from reaching pedestrian areas. Therefore, no SEPA mitigation measures are required to be implemented.

However, the City may wish to explore a few strategies over the long term to improve overall consideration of shadowing and wind effects of future development.

- The City could review existing regulations and guidelines pertaining to control of wind effects. Additional quantitative criteria on acceptable wind speeds and/or design criteria for avoiding adverse wind conditions at the street level of structures could be developed and provided to potential developers. If identified, inconsistencies in Code requirements and guidelines could be remedied. This could aid City reviewers in evaluating the performance of proposals by providing consistent review criteria with regard to acceptable wind conditions and the effectiveness of wind abatement measures.
- The City could consider additional design guidelines or regulatory requirements to assure that important public open spaces continue to have sufficient solar access. To do this effectively, it is likely that some quantifiable measure of adverse effect would have to be developed, so as to reflect the correct level of community concern for the issue. Among the actions that could be taken are: 1) to develop general criteria for the daytime hours or daily duration of solar access (over certain days or seasons) for parks or open spaces, 2) to develop specific criteria for each identified critical park or open space, and/or 3) to develop measurable standards for the amount of new shadow that a project could add to certain parks. This also could mean considering additional locations for SEPA protection against possible shadow impacts, and/or other measures.

Memorandum

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From: Joseph Gellings and Todd Chase

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Date: December 14, 2001 – Revision of December 6, 2001 memorandum

Subject: *Existing Regulations Affecting Wind and Shadow Impacts*

This memorandum provides an overview of existing City of Seattle development regulations that address wind and shadow impacts in downtown Seattle. In summary, there are very few controls that are aimed exclusively at these impacts; however, there are many design criteria that can mitigate potential wind and shadow impacts. In searching for these controls, Otak reviewed the Seattle Land Use Code (Title 23 of Seattle Municipal Code), the Guidelines for Downtown Development (design review), the Seattle SEPA program (Title 25 of Seattle Municipal Code) and the City of Seattle Street Vacation Policies. The section number for each regulation is cited below. "Revised code" refers to code provisions not yet published but adopted through Ordinance #120443 in July 2001.

Regulations Addressing Wind Impacts

1. The fine grain of zones with different heights across downtown minimizes the length of continuous multi-block tall facades, which increase wind velocities.
2. Placement of street trees is required for all new development in the DOC-1, DOC-2, DRC, and DMC zones (SMC 23.49.56-F, 23.49.76-F, 23.49.106-F, 23.49.134-F).
3. The downtown zones of DOC-1, DOC-2 and DMC have upper level coverage limits. These are narrow zones lying close to the property line over which only a percentage of each floor plate may occupy. A narrow zone starts at a height of 125 feet and increases in size (more restrictive area) at a height of 240 feet. The percent of the zone that may be occupied by floor plate depends on the size of the site. This regulation mitigates wind impacts by controlling the size of sheer facades and it tends to result in interruptions that slow downwash wind patterns (SMC 23.49.058-A, 23.49.78-A, and 23.49.136-A).
4. The downtown zones of DOC-1, DOC-2 and DMC have upper-level maximum façade lengths. Above a height of 125 feet, this control specifies a maximum length of any single façade permitted within 15 feet of the street property line – measured parallel to the property line. This mitigates wind impacts similar to the upper level coverage limits described above (SMC 23.49.058-B, 23.49.78-B, and 23.49.136-B). The general intent of controls #3 and #4 is to encourage designs that push portions of towers away from the street, without mandating continuous upper level setbacks across the entire frontage.

5. The FAR bonus program rewards provision of parcel parks and plazas, which break-up wind patterns in a high-rise environment (revised code 23.49.013).
6. Overhead weather protection[1] is required with street level retail to qualify for the street level retail FAR exemption (revised code 23.49.011-B-1-b-3). Overhead weather protection is required outright wherever street-level retail is required by street designation (revised code 23.49.025-B-5). The streets for which street level retail/ weather protection is required are within a one-block buffer of the DRC and extending approximately seven blocks outward along the armatures of 1st and 3rd Avenues and Westlake Avenue. There are also some shorter armatures consisting of Pike and Pine to I-5; Stewart Street to Boren Ave, and 7th and 8th avenues from Westlake to Convention Center (Pike and Union Streets)
7. Design for wind protection is a design criterion for open space that is to serve as a TDR sending site (revised code 23.49.027-E-2).
8. Overhead weather protection can qualify as a bonus on DMC streets with a Pedestrian Class I designation (SMC 23.49.126).
9. The Downtown Design Guidelines publication contains the guidelines used to evaluate new projects in the Design Review process. There are four relevant guidelines that encourage the wind mitigation: façade articulation; provision of overhead weather protection; open space; and landscaping (Guidelines C2, C5, D1, and D2).

Regulations Addressing Shadow Impacts

1. The north-south orientation of the zones that allow tall buildings as well as the downtown block spacing generally have the effect of minimizing downtown shadows at midday. There is also a difference in platting between the commercial core and the Denny Triangle — the smaller square blocks of the commercial core create more interruptions in the potential massing of development because there is a street occurring every 240 feet as opposed to every 360 feet on the longer blocks in the Denny Triangle. Consequently, there is a more open feeling due to the higher ratio of street right-of-way area to development parcel area. Furthermore, the Avenues in Denny Triangle are narrower (66 feet as opposed to 80 to 90 feet) — so the longest dimension of the block is along the narrower right-of-way, which may further reduce the amount of light that penetrates into the area.
2. The upper level coverage limits described in item 3 above also relate to shadows. Because the sun usually strikes a building at some angle, (rather than perpendicular to a façade) scaling-back the corners of a building is particularly critical to maximizing sunlight. The narrow zone over which each floor plate is restricted (see description in item 3 above) has a shape that flares-out at block corners. Since the zone is larger in this area, a builder's floor area allowance is consumed more quickly when the floor plate is focused in this area.
3. In each of the zoning code regulations concerning overhead weather protection above, encouragement or extra bonus is given for the use of transparent materials.
4. Design for maximum sun exposure is a design criterion for open space that is to serve as a TDR sending site (revised code 23.49.027-E-2).
5. Four of the guidelines in the Downtown Design Guidelines document address shadow issues. Under Guideline A1 "Respond To the Physical Environment" sunlight access is listed as a consideration. Under Guideline B4 "Design a Well-Proportioned and Unified

[1] Overhead weather protection is considered to mitigate wind impacts since high-rise buildings often create a downwash wind pattern.

Building" shadow patterns are listed as a consideration. Under Guideline C5 "Encourage Overhead Weather Protection" material transparency is strongly suggested. Under Guideline D1 "Provide Inviting and Usable Open Space" maximizing sun exposure is listed as a consideration.

6. The City's SEPA program allows for the assessment of shadow impacts on any of five downtown parks: Freeway Park, Westlake Park and Plaza, Market (Steinbrueck) Park, Convention Center Park, and Kobe Terrace Park. Based on such impacts, the decision maker may deny a project or require one of the following mitigation measures: limiting the height of the development, limiting the bulk of the development, redesigning the profile of the development, limiting or rearranging walls, fences, or plant material, limiting or rearranging accessory structures, and relocating the project on the site (SMC 25.05.675-Q).
7. While future street vacations in Downtown are not likely, the City's street vacation policy document contains a guideline stating that proposed alley vacations should be analyzed to determine if there are sunlight impacts on surrounding parks and open spaces. Where such impacts are found, another guideline provides for alley vacation approval conditioned on mitigation requirements (City of Seattle Street Vacation Policy, Guidelines 3.1 and 3.6).
8. A recently adopted amendment to DOC 1 and DOC 2 height provisions allows for a 10% or 20% height increase above the current mapped height limits if projects meet certain conditions. There is no density increase — so the added height allows for the same floor area density to be stretched out in a taller, presumably less bulky appearing structure. For the 10% increase, the building must reduce the bulk of upper floors to achieve a narrower structure over all, which may have some benefit for solar access. For the 20% increase, in addition to the reduction in bulk, a specified percentage of the development site must either be in open space or occupied by low base structures, or some combination, to create more open conditions at the pedestrian level.