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Subject: **Development of BMP assumptions for stream restoration projects in  
Portland streams and rivers**  
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The City of Portland is establishing a set of assumptions describing the impacts of Best Management Practices (BMPs) on urban streams and watersheds. These assumptions describe the effectiveness of an action to change the environment. For example, the BMP assumptions might describe the effectiveness of a stormwater swale to reduce pollutant inputs to a watershed. BMPs describe watershed actions, such as options for stormwater management as well as in-stream and riparian actions intended to restore normative conditions in Portland streams. This memo will describe the assumptions and procedures used to develop assumptions for stream restoration BMPs.

The BMP assumptions will form the input to a set of modeling tools that will be used to analyze and compare the effectiveness of watershed alternatives to help the city meet environmental obligations under the Clean Water Act, Endangered Species Act and other legislation and city policies. For the stream restoration BMPs described here, the assumptions will be used to analyze the effectiveness of actions to change the potential of Portland streams to support native salmonid fishes using Ecosystem Diagnosis and Treatment (EDT) model. Watershed actions to deal with and treat stormwater and other pollutants will be analyzed in other models that may ultimately be linked to EDT to assess overall changes in salmonid habitat potential.

Development of assumptions for BMPs is not straightforward. This is because of limited and highly variable scientific conclusions and because the effect of most actions has a strong site-specific component. Thus, even where scientific studies exist, application to Portland watershed and specific sites still requires a strong measure of professional judgment and interpretation. Often, scientific literature is sufficient to define a general type of response, but judgment is required to apply this knowledge to a specific application. Because of this, the city has assembled a team of experts from city departments and consultants to develop effectiveness assumptions based on the scientific literature and their professional experience.

Because of the knowledge limitations and site-specific nature of BMPs, the intention was not to develop a definitive set of conclusions but rather to develop a consistent set of assumptions that can be applied across Portland watersheds that reflects the existing literature and the judgment of city professional staff. For each BMP the intent was to provide a point assumption as well as high and low range assumptions reflecting presumed and documented variation or uncertainty. The exercise has also focused on documenting assumptions so that they can be professionally reviewed. The assumptions and their associated models will provide the city will have an analytical

means to compare watershed and stream restoration actions within and between watersheds.

## **Procedure for developing stream restoration BMPs**

The problems of knowledge limitations and site-specificity described above in general particularly apply to the development of stream restoration BMPs. Quantitative relationships between actions, such as placement of large woody debris (LWD) in a stream, and geomorphic, hydrologic and biological response have not been established in the scientific literature. The effectiveness of actions is further complicated by synergistic effects between multiple attributes as well as variation in stream character due to size, geology and climate. This is not to say that we have no basis for describing the effectiveness of actions. In fact, there is a rich scientific literature relating stream geomorphology, hydrology and biology as well as numerous studies that evaluated the effectiveness of restoration actions. This knowledge can be used to establish working hypotheses relating actions to changes in specific environmental attributes. These working hypotheses represent informed judgments based on existing knowledge that may be refined in the future due to local observation or advances in scientific knowledge.

The task of establishing the working hypotheses for stream restoration BMPs in Portland streams was assigned to Chris Prescott (City of Portland, Bureau of Environmental Services) and Chip McConnaha (Jones & Stokes). Our task was to suggest assumptions regarding the *effectiveness* of actions to affect stream attributes. Another dimension of stream restoration is the *intensity* of application of a particular strategy at a location within a stream or watershed. Intensity is related to overall restoration plans and is not addressed in this memo. Our development of effectiveness used the following steps and assumptions:

1. Effectiveness was assigned based on stream size. We establish four categories of streams within Portland to which we assigned effectiveness assumptions. Stream categories were small streams (e.g. Kelley Creek, Arnold Creek), medium streams (e.g. Johnson Creek, lower Tryon Creek), large rivers (the Willamette) and sloughs (Columbia slough). Our rationale for creating stream categories was that the effectiveness of actions would vary significantly between streams. For example, the effectiveness of riparian restoration along the Willamette would be expected to have a relatively minor effect compared to riparian restoration in smaller streams like Kelley Creek or Johnson Creek. Riparian forests have been shown to exercise key control on conditions in small streams (Gregory et al. 1991, Naiman et al. 1998) because they can form a complete canopy closure and moderate temperature through shading and contribute large wood to stream structure. Conditions in large rivers such as the Willamette are largely determined by upstream conditions (Vannote et al. 1980) and the riparian zone has a much more limited impact on temperature and other attributes (Gregory et al. 1991). Likewise, in our judgment, the Columbia Slough including Smith and Bybee lakes represents a distinct aquatic environment in which wood and other attributes have distinct impacts.
2. We developed categories of stream restoration actions that potentially could be applied to each of the four stream types. These action categories were:

- a. Adding habitat structure. This strategy refers to placement of LWD in the stream as well as other structural elements associated with the channel form. It includes actions to place logs, root wads or wood structures in streams to increase habitat structure. Lack of structure, usually due to the loss of large wood, is a common and major habitat limitation in Northwest streams (Bilby and Bisson 1998).
  - b. Restore channel functions. Channel functions refer to the normative hydrogeomorphic processes leading to habitat creation and maintenance. This includes lateral channel movement that erodes banks and contributes gravel, hydrologic processes that move and shape gravel and the connection between the stream and its floodplain (Montgomery and Buffington 1998). Action within this strategy include removal of dikes or armoring that prevents channel movement, reshaping engineered banks to restore floodplain connections and the addition of gravel to promote development of riffles, bars and complex channels.
  - c. Restore riparian vegetation and forests. As discussed above, riparian forests are key determinants of stream conditions, especially in smaller streams (Gregory et al. 1991). Urban streams are characterized by narrow or missing riparian forests with consequent limitations on stream performance (Roy et al. 2006). Riparian conditions affect structure, through the addition of LWD and channel form; temperature, through shading; and can improve water quality by slowing overland flow. Actions within this strategy include planting and maintenance of native forests along streams, elimination of non-native species, especially shrubs such as blackberry, and land uses that encourage and protect streamside vegetation.
  - d. Remove migration barriers. Human-caused migration barriers are typically culverts and dams. Culverts are a particular problem within urban areas due to frequent road crossings (May et al. 1997). Culverts can completely block migration. In addition, they can be theoretically passable yet still not “inviting” in the sense of encouraging migration including movement into newly restored habitats. Actions within this strategy consist of improvements to existing culverts and bridges, particularly in high priority areas into which passage of anadromous fish is currently impeded.
  - e. Flow management. Flow management can include the effects of regulatory dams (e.g. the Willamette) as well as flow effects caused by urban watershed conditions (Booth 1991). Urban streams are often “flashy” with increased frequency of flow peaks and rapid response to storms (Booth and Reinelt 1993). Actions within this strategy include moderation of flow regulation as well as watershed actions to decrease overland flow of stormwater and increase groundwater recharge.
3. A set of stream attributes were identified that would be acted on by the strategies. These attributes were:

- a. Food
- b. Channel form
- c. Flow
- d. Habitat types
- e. Temperature
- f. Pollutants
- g. Obstructions to migration.

These attributes are those commonly associated with salmon performance and recorded in most stream survey techniques including the ODFW Aquatic Inventory Project (Moore et al. 1997) employed by the city. These attributes also relate to the habitat attributes included within EDT (Lestelle 2004).

- 4. The effectiveness of the strategies (point 2) to change attributes (point 3) in the different categories of stream (point 1) was rated based on our experience and review of the current scientific literature. Effectiveness was rated from 0 (no effect) to 5 (able to restore the attribute to its normative condition). Each integer increase in effectiveness is roughly a 20 percent restoration of the attribute toward the normative condition.
  - a. Add structure (Table 1). We concluded that adding structure (LWD) was most effective in medium streams such as Johnson Creek and small stream such as Kelley Creek. Adding wood is less effective in large rivers such as the Willamette. Adding structure primarily adds to habitat types by creating pools, riffles and winter refugia. Wood also affects channel form and can contribute food by providing substrate for aquatic invertebrates.

**Table 1. Effectiveness of adding structure**

<b>Add Structure</b>	<b>Food</b>	<b>Channel Form</b>	<b>Flow</b>	<b>Habitat types</b>	<b>Temperature</b>	<b>Pollutants</b>	<b>Obstructions</b>
Small	2	2	0	3	0	0	0
Medium	3	3	0	4	0	0	0
Large	1	1	0	2	0	0	0
Sloughs	2	0	0	2	0	0	0

- b. Restoring channel functions. We judged that efforts to restore channel functions would be most effective in medium streams (Johnson Creek) and large rivers (Willamette) (Table 2). These types of systems generally have

well-developed floodplains whereas small streams (e.g. upper Tryon Creek) are often confined within steep walled valleys with little opportunity for lateral movement. Actions to restore channel function primarily affected the Channel Form attribute but also affected Temperature (by recharging hyporheic zones through flooding), flow (hyporheic impacts on base flows) and habitat types (by allowing geomorphic habitat forming processes).

**Table 2. Effectiveness of restoring channel functions**

Restore channel functions	Food	Channel Form	Flow	Habitat types	Temperature	Pollutants	Obstructions
Small	1	2	1	1	2	0	0
Medium	1	4	2	2	3	0	0
Large	1	3	2	3	3	0	0
Sloughs	1	1	0	1	0	0	0

- c. Restoring riparian forests. We concluded that the influence of the riparian zone, and hence the effectiveness of riparian restoration, is roughly inversely proportional to the size of the stream (Table 3). Small streams (e.g. Kelley Creek) can be shaded by complete canopy closure, whereas the riparian forest has little shading effect in large rivers (e.g. the Willamette). Impacts of riparian restoration are highest for Temperature and, in smaller stream, Food by supplying terrestrial insects to streams. Riparian zones can also improve water quality by intercepting overland storm flow (Roy et al. 2006).

**Table 3. Effectiveness of Riparian restoration**

<b>Restore riparian</b>	<b>Food</b>	<b>Channel Form</b>	<b>Flow</b>	<b>Habitat types</b>	<b>Temperature</b>	<b>Pollutants</b>	<b>Obstructions</b>
Small	3	1.5	0	2	5	2	0
Medium	2	2	0	3	4	2	0
Large	1	1	0	0.5	1	1	0
Sloughs	2	1	0	1	4	2	0

- d. Effectiveness of removal of migration barriers. Removal or improvements to culverts and other man-made obstructions is highly, and equally, effective in all stream categories (Table 4). However, obstruction improvements can be prioritized based on potential benefits of opening upstream habitat.

**Table 4. Effectiveness of barrier removal**

<b>Barrier removal</b>	<b>Food</b>	<b>Channel Form</b>	<b>Flow</b>	<b>Habitat types</b>	<b>Temperature</b>	<b>Pollutants</b>	<b>Obstructions</b>
Small							5
Medium							5
Large							5
Sloughs							5

- e. Effectiveness of flow management. We concluded that actions to improve flow management would be most effective in the slough and in medium streams and large rivers (Table 5). Flow conditions in the slough are highly non-normative and are tightly regulated by upstream flow control structures. These lead to temperature and water quality impairment. Upriver tributary dams designed to minimize flooding in Portland regulate

flow in the Willamette. As a result, summer flows are appreciably higher and winter flows lower than the normative condition. In streams such as Johnson Creek, flow impacts are related to the level of watershed impervious surfaces and stormwater management. These can increase flashiness and decrease summer base flows. Flow is the driver for most stream processes and for this reason, flow management actions can affect most attributes, especially Flow, Temperature and Pollutants.

**Table 5. Effectiveness of Flow Management**

Flow management	Food	Channel Form	Flow	Habitat types	Temperature	Pollutants	Obstructions
Small	0	2	2	2	1	2	0
Medium	0	2	4	3	2	2	0
Large	0	2.5	4	3	3	2	0
Sloughs	0	2	5	0	2	2	0

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