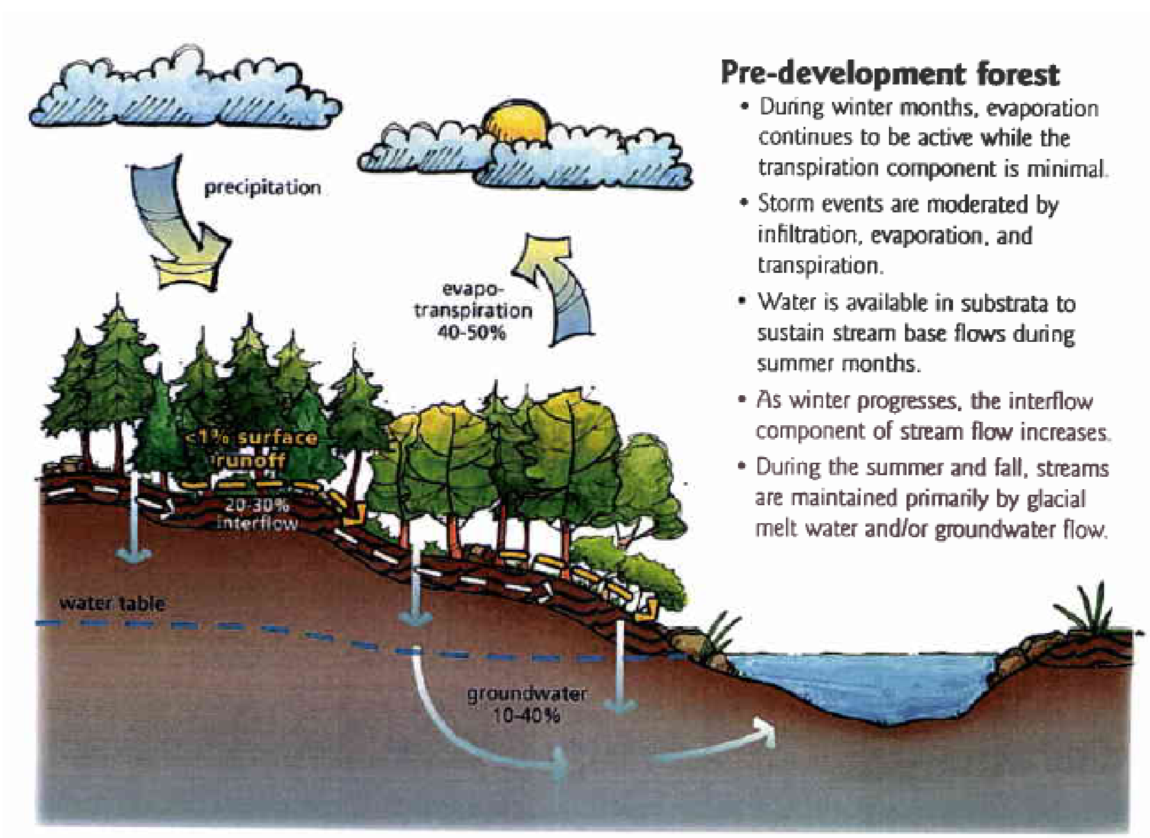
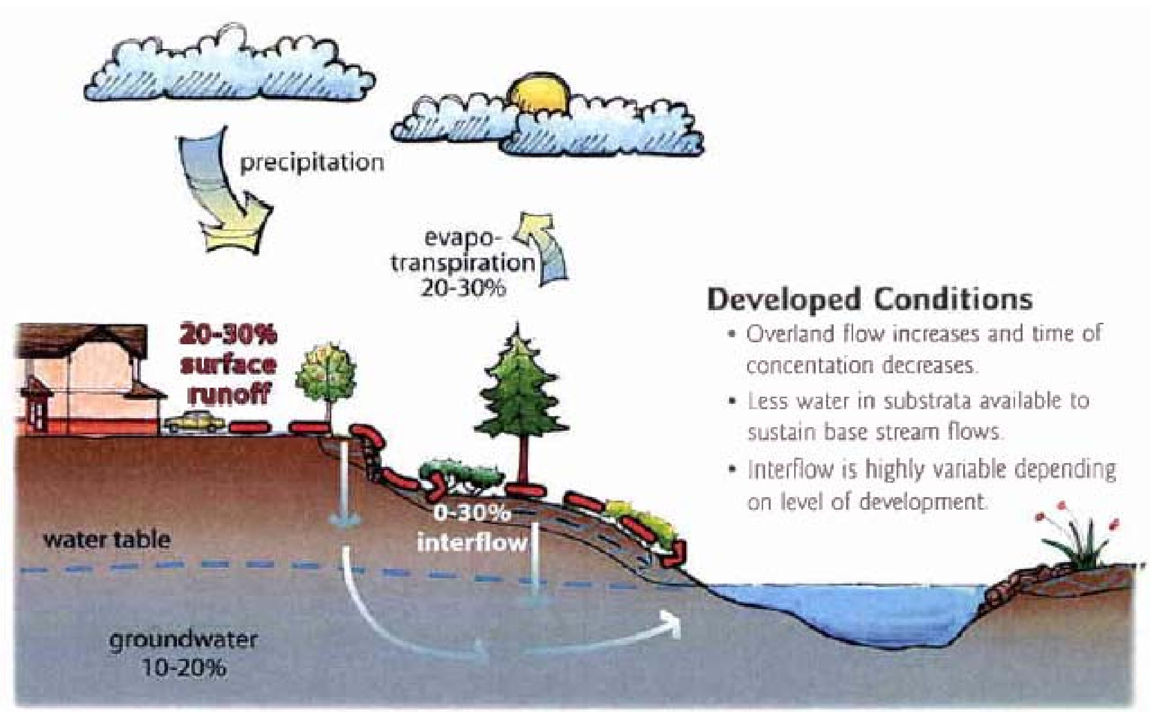
WATERSHED PROCESSES: AN OVERVIEW

In our busy day-to-day lives most of us don't give much thought to the ground beneath our feet, nor to minor changes in the landscapes that surround us. The ground appears reliably solid enough -- and it's mostly the "old-timers" who note the loss of trees, or the fact that some parts of town that never used to flood, now sometimes do. If we see some rocks and mud slumping onto a roadway, water seeping through a rock wall, a gully eroded by rainfall runoff, or a ponded area in our neighbor's yard – we tend to see them as isolated incidents and we're just glad it wasn't at our house.

In reality, these seemingly minor, isolated incidents are all reminding us that the landscapes of which we humans are an integral part, are not so stable after all. Just think of the *cumulative* changes you've seen over the past, 10, 20, or 30 years. Natural landscapes are continually changing in response to a wide variety of interactive landscape or "watershed processes." It is these naturally operating "watershed processes" that mold our Northwest landscapes and create the terrestrial and aquatic habitats that support our rich diversity of native vegetation, fish, and wildlife (Kruckeberg 2003). When population growth, logging, agriculture, and urban development are added into the mix, the pace of landscape change speeds up. The watershed processes that were functioning "beneficially" in natural landscapes keep working as urbanization increases – *but their impacts can change dramatically.*



A frequently cited example of such changes, is the increase in surface water flow (overland flow) that accompanies replacement of forest cover with more urban landscapes. Under Pacific Northwest forested conditions, surface runoff typically represents less than one percent of total precipitation -- while shallow groundwater flow (interflow) and deeper groundwater flow represent 20-30% and 10-40%, respectively, of total precipitation (Figure 1; AHBI, in Hinman 2005). As buildings, roads, and other impervious surfaces replace trees, surface runoff can increase to 20-30% of precipitation, dramatically increasing both stream erosion and the potential for flooding. Shallow and deeper groundwater flow typically both decline to 0-30% and 10-20% of precipitation, respectively (Figure 2; AHBI, in Hinman 2005). Shallow groundwater flow tends to be highly variable depending on the level of impervious surface and overall, less groundwater is available to maintain stream flows in the drier months (base flow). Increased surface water runoff and stream erosion also result in more "flashy" stream flows, as well as both more extreme and increasingly degraded water quality conditions.



From AHBI, in Hinman 2005.

If urban communities are to address stormwater, surface and subsurface water quality, and habitat preservation concerns more effectively, then it is critical to understand how watershed processes worked under more natural conditions -- and how urbanization has changed their functioning. Understanding the effects of these changes can provide a practical framework for addressing recovery and enhancement.

The seven figures set out below are provided as a *general aid* to understanding how various landscape-scale watershed processes work. Each diagram is more easily read from left to right. The box furthest to the left represents some “starting condition,” which results in the consequences reflected by the arrows and boxes, further to the right. Watershed processes often have “cascading effects” on several other functions operating within a watershed; “feedback loops’ are also common. For clarity, each diagram focuses on a single facet of watershed functions, but in the real world they are all operating together --on a variety of different (area) scales, rates, and time frames. It’s very easy to see how changing just a few variables among these interrelationships could result in substantial changes elsewhere in the system, or even throughout the system. Without knowledge of the types of interactions diagramed here, it’s also easy to see how changes that “pop up down the line” could first appear as unexpected, or unrelated, to the initial condition.

The seven diagrams that follow, depict several aspects of ***landscape-scale watershed processes*** -- note that while several diagrams are labeled for “river processes”, these processes are equally applicable for smaller stream systems as well –

1. Some fundamental fluvial (river) processes.

2. Flow-controlled river processes.

3. Influences of Large Woody Debris (LWD) on riverine habitats.

4. River processes related to flooding and groundwater exchange and mixing.

5. Chemical and biological processes related to upwelling and downwelling of hyporheic flows. (The hyporheic zone is a region beneath and lateral to a stream bed, where there is mixing of shallow and surface flow.)

6. Cumulative effects of urbanization on small streams in the Puget Sound Lowland.

7. Cumulative effects of urbanization on flood frequency and salmon habitat suitability.

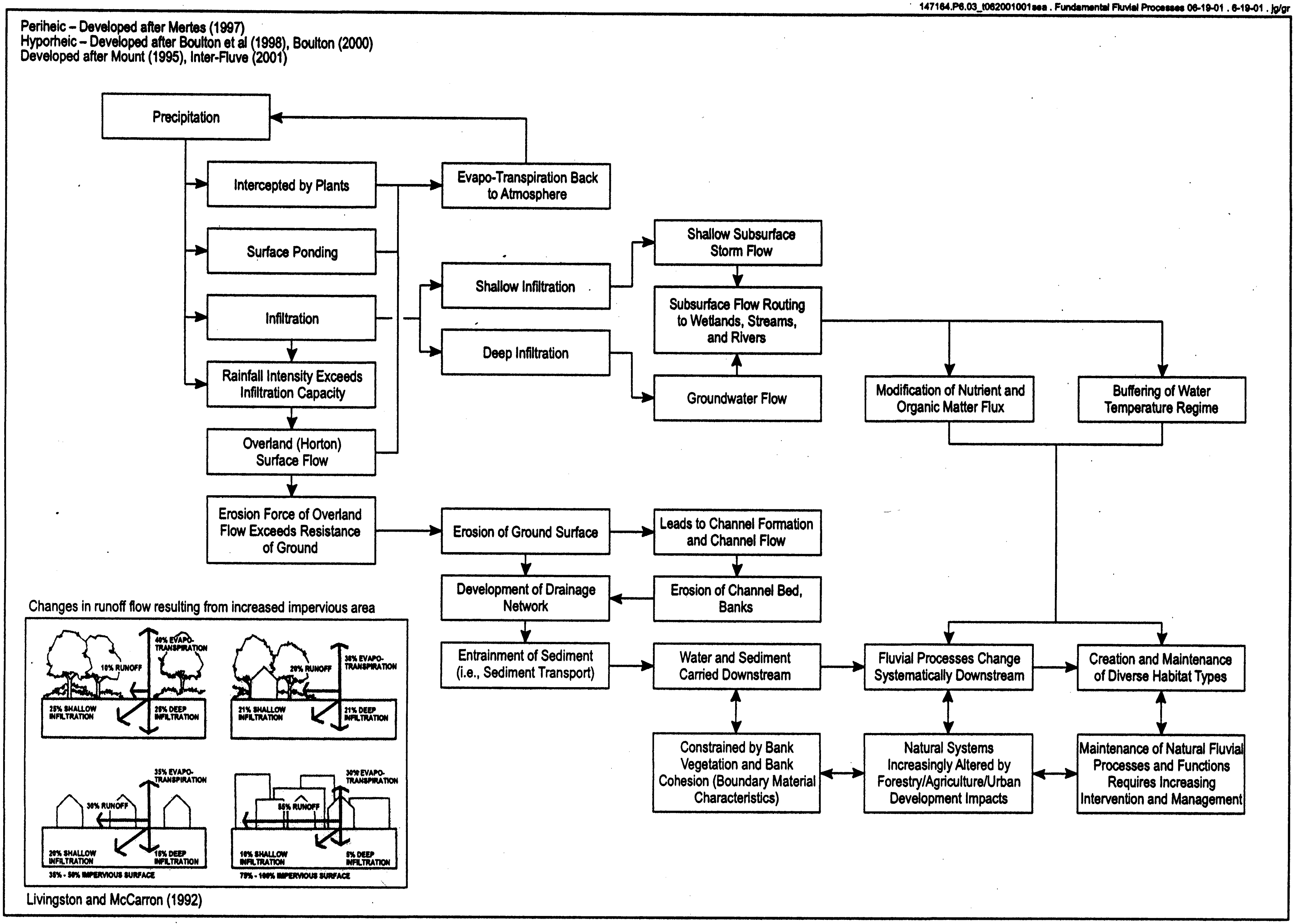


Figure 1
Some Fundamental Fluvial Processes

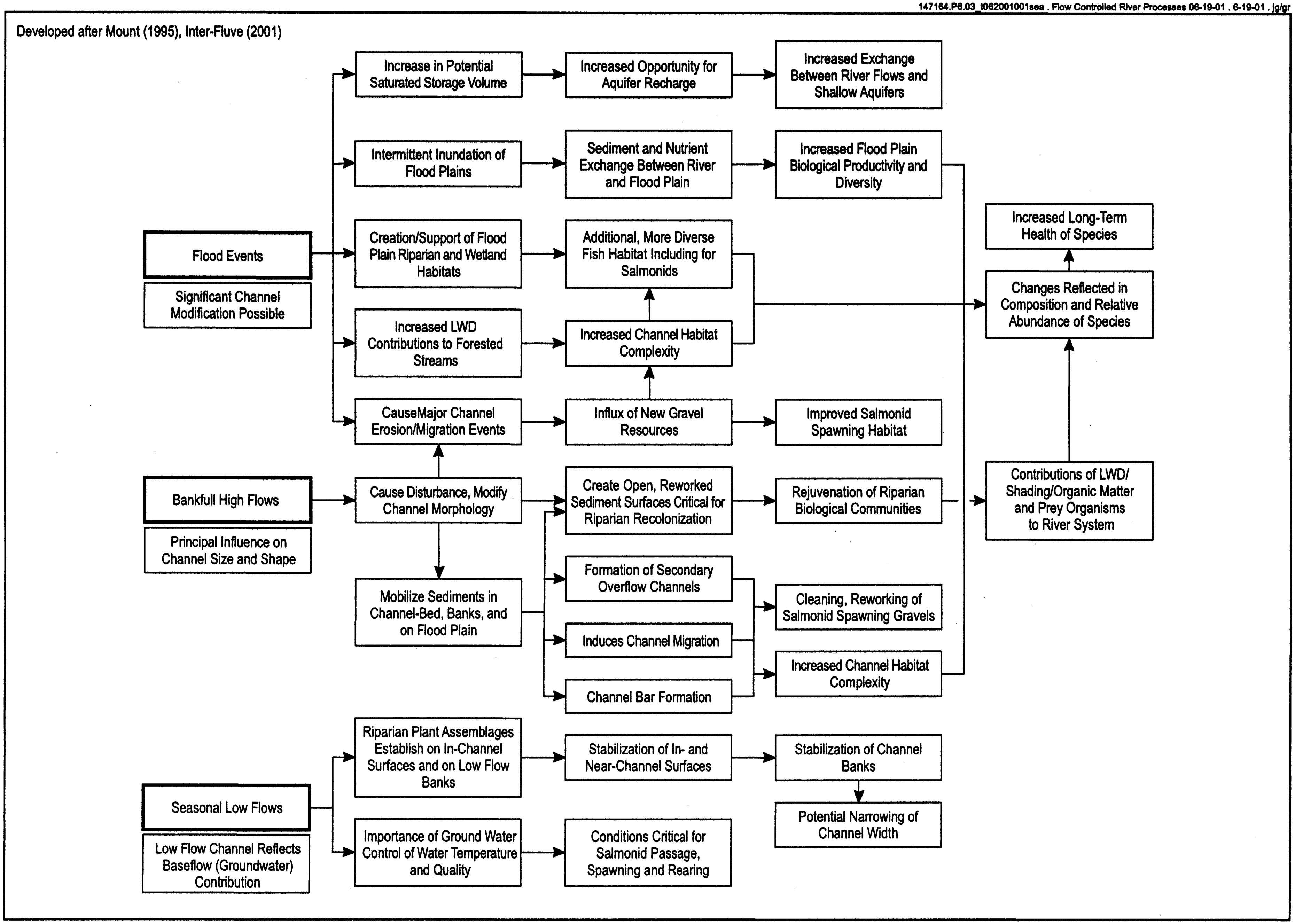


Figure 2
Flow-Controlled River Processes

147164.P6.03_t062001001sea . Influence of Large Woody Debris 06-19-01 . 6-19-01 . jp/gr

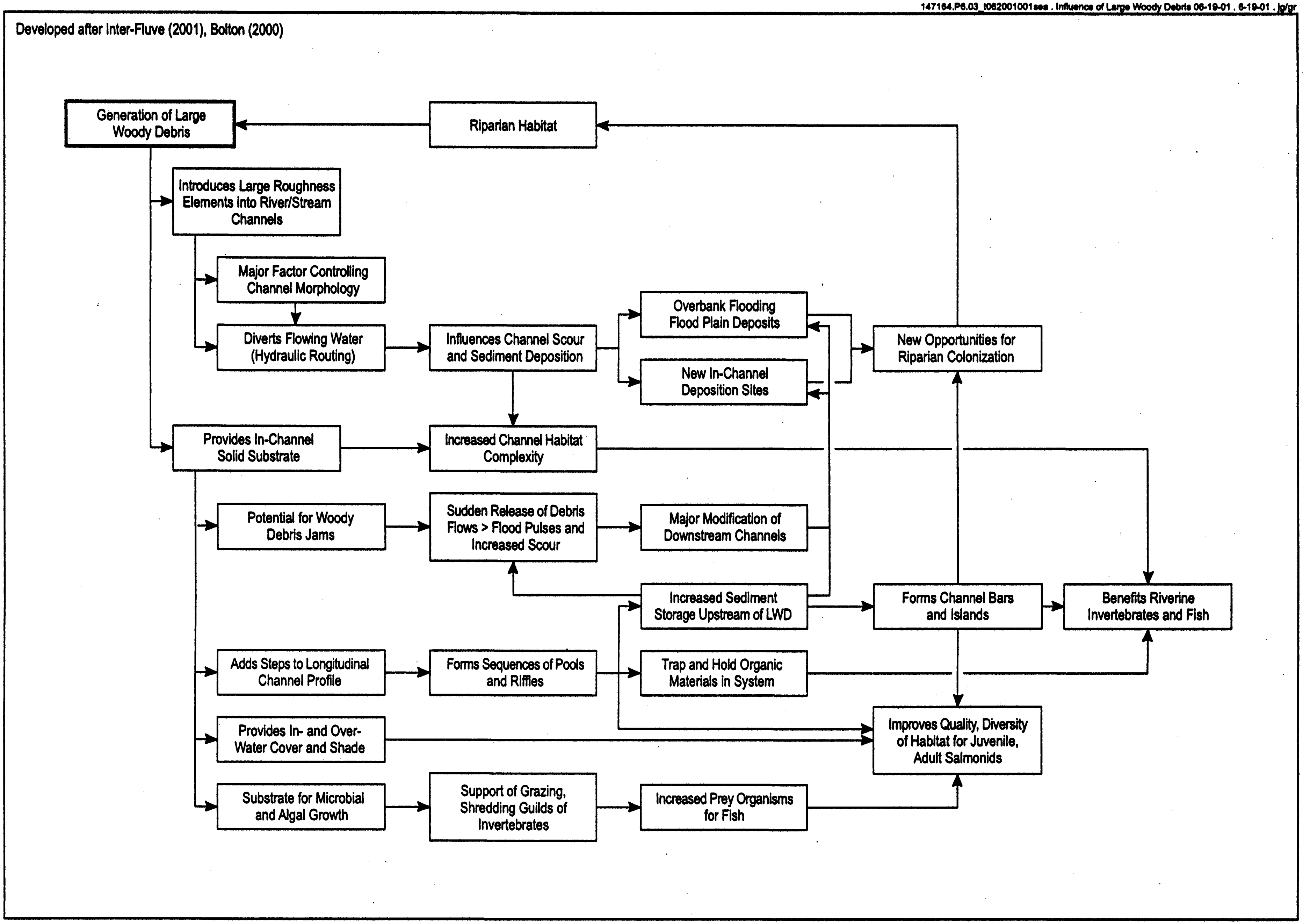


Figure 3
Influences of Large Woody Debris (LWD) on Riversine Habitats

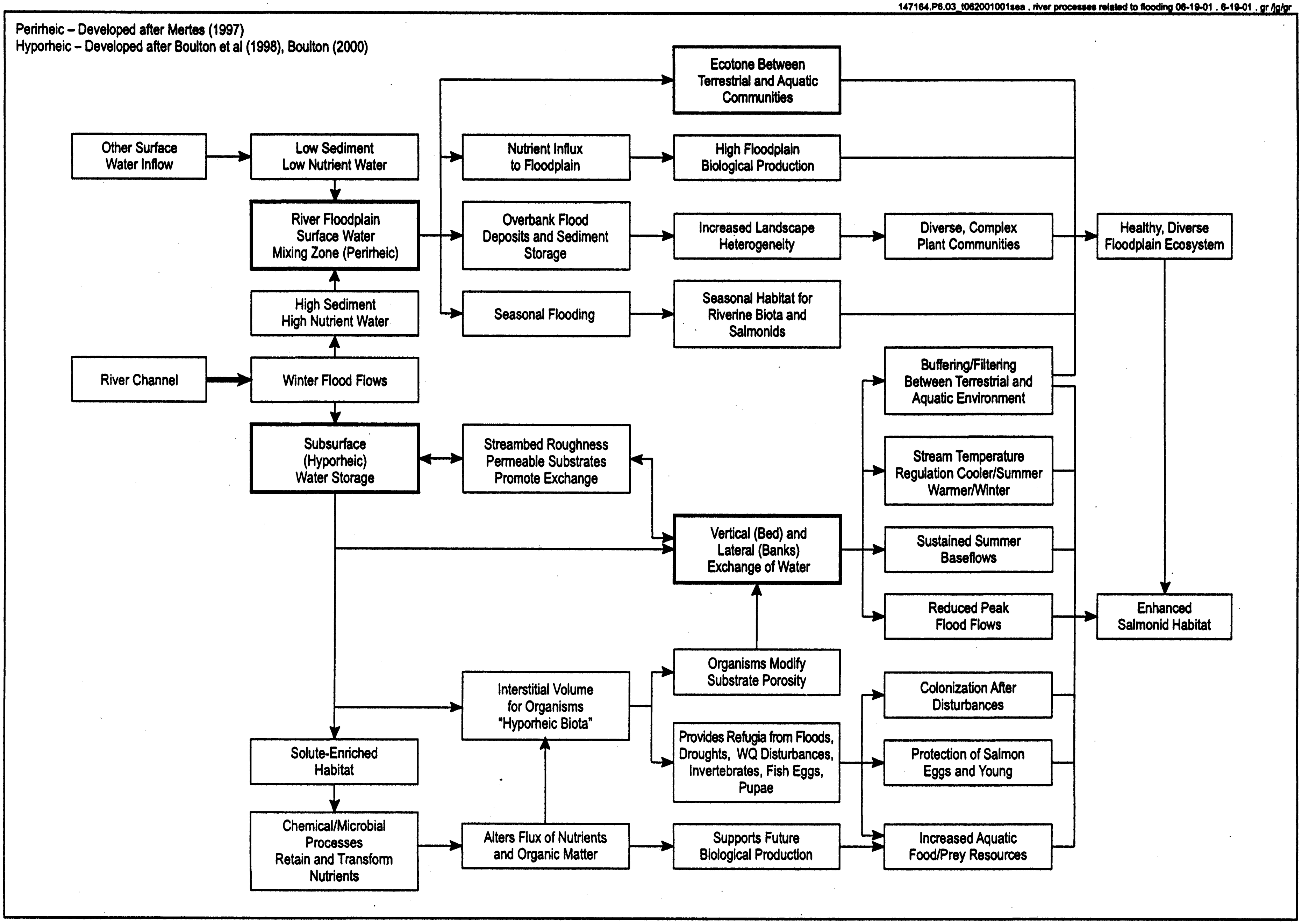


Figure 4
River Processes Related to Flooding and Groundwater Exchange and Mixing

Developed after Boulton et al (1998)

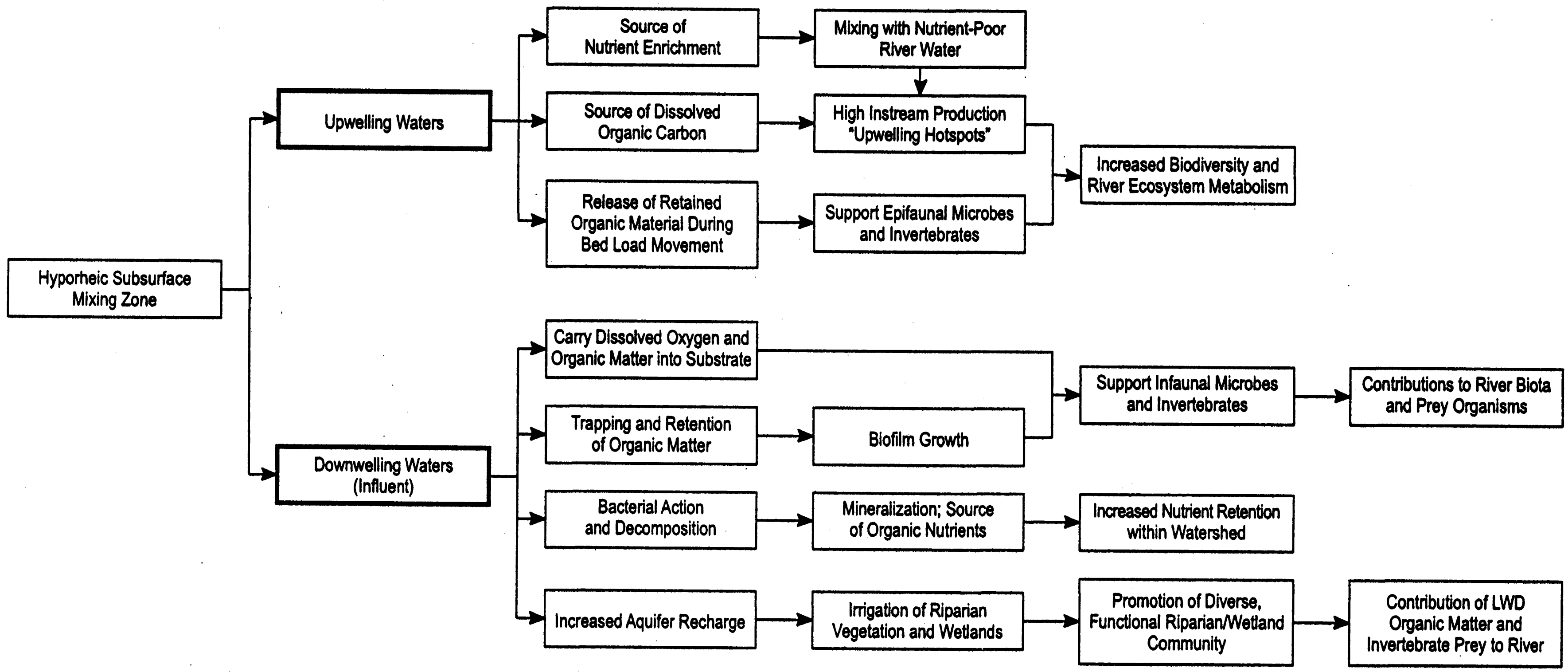


Figure 5
Chemical and Biological Processes Related to Upwelling and Downwelling of Hyporheic Flows

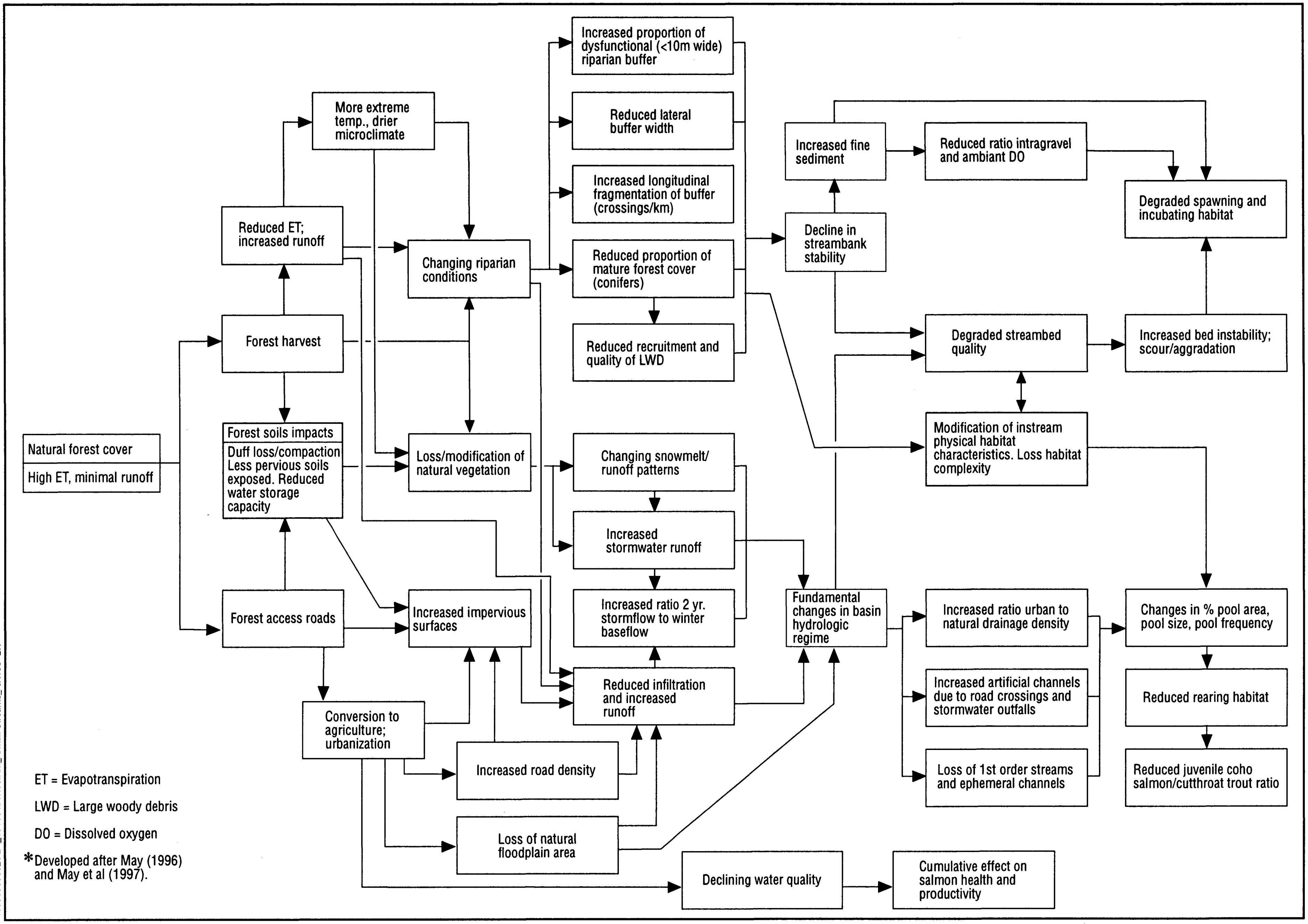
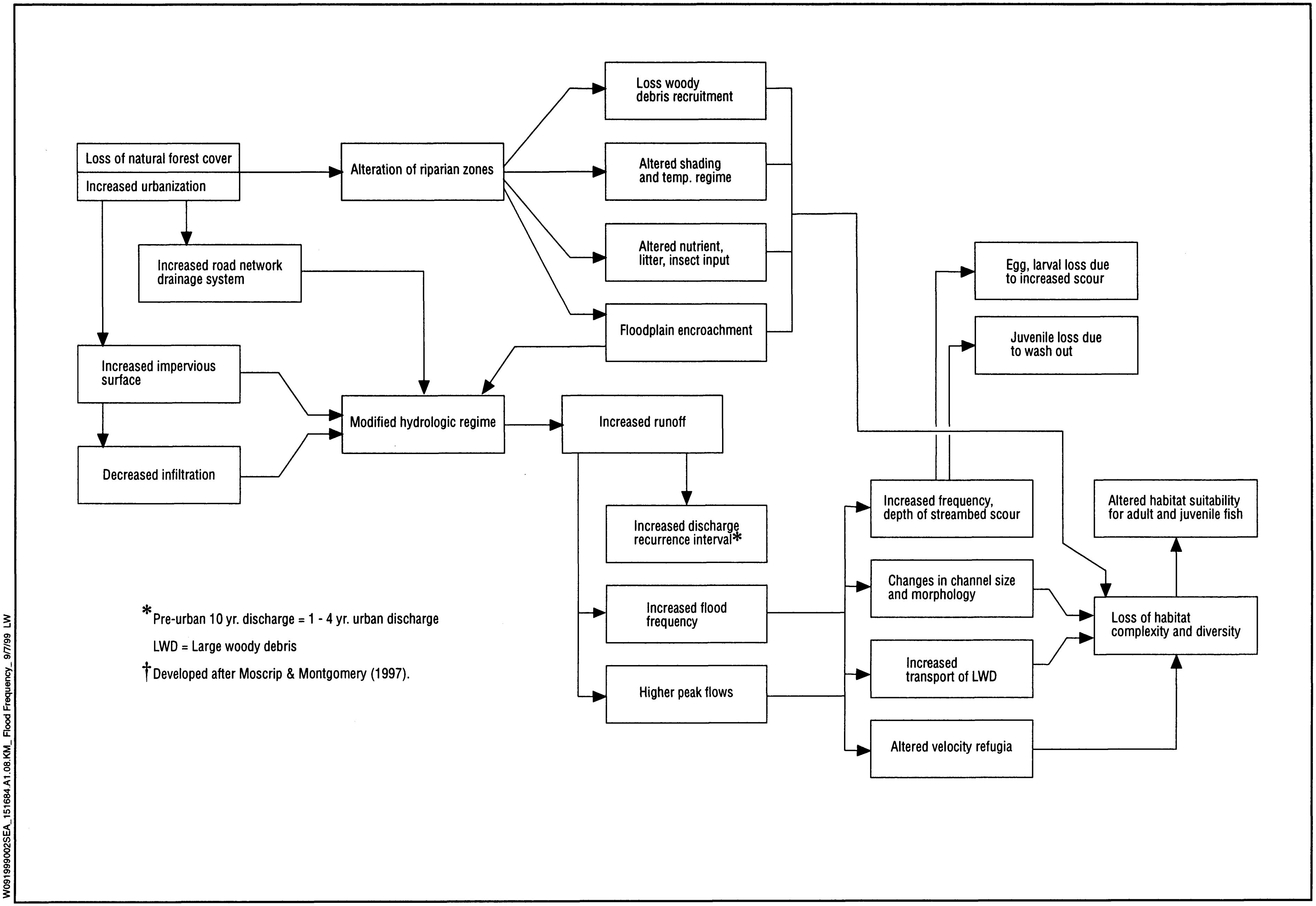


Figure 6
Cumulative Effects of Urbanization on Small Streams in Puget Sound Lowland*



W0919902SEA_151684.A1.08.KM_ Flood Frequency_ 9/7/99 LW

Figure 7
Cumulative Effects of Urbanization on Flood Frequency and Salmon Habitat Suitability†