CHAPTER 5.
GEOMORPHOLOGY

This chapter provides an overview of the geomorphology of Vashon-Maury Island based on a review of soil maps, USGS topography maps, aerial photography, forest cover, and estimated future changes in the effective impervious area (EIA) based on current zoning. The Judd Creek and Shinglemill Creek basins were analyzed in more detail than the other basins on the island, but only limited field observations were obtained.

5.1 EIA AND FOREST COVER ANALYSIS

Reduced forest cover and increased effective impervious area affect watershed flow regimes. Damage to stream channels tends to occur when forest cover is reduced below 65 percent (Booth et al.) and when EIA exceeds 10 percent (Center for Watershed Protection, 2002). The EIA and forest cover for 75 drainage basins on Vashon-Maury Island were analyzed for current and future conditions.

Future forest cover was estimated assuming that future development on Vashon-Maury Island would follow a pattern similar to current development. A logarithmic regression analysis of current land use pattern of the 75 streams on Vashon-Maury Island was used to interpolate a trend, as shown in Figure 5-1. The major trend slope was used to predict future forest cover for each of the 75 streams. The results are presented in Table 5-1. The Washington Trout stream numbers with subbasin numbers were used for Judd Creek and Shinglemill Creek. For instance 12.4 means Shinglemill Creek Subbasin 4. Highlighted cells indicate likely channel geomorphology impact. Basins that are likely to be impacted are mapped in Figure 5-2.

Under current conditions, no basins have more than 10 percent EIA and 13 basins have less than 65 percent forest cover. At future buildout, four basins—Shinglemill Creek Subbasin 4, Judd Creek Subbasin 2, Gorsuch Creek, and Ellisport Creek—will have more than 10 percent EIA and less than 65 percent forest cover. Forty-six other basins will have less than 65 percent forest cover. Based on this analysis, given projected development patterns, streams are more likely to be impacted by decreased forest cover than by increased EIA. Therefore, limiting forest reduction should be a high priority to protect streams from potential impacts. On streams already indicating impact, reforestation or acquisition of cleared land is recommended.

5.2 HYDROLOGIC ANALYSIS – JUDD CREEK AND SHINGLEMILL CREEK

The results of the hydrologic modeling performed on Judd Creek and Shinglemill Creek were analyzed in more detail to identify potentially unstable areas and assess development trends. Two land use scenarios were modeled: predevelopment, which assumes that the subbasin is essentially entirely forested (Qpre); and existing land use (Qpost).

Research on stream stability and land development has identified a transition zone from “stable” to “unstable” channels. This has been observed when the two-year current (Q2post) discharge approaches the 10-year predevelopment discharge (Q10pre).

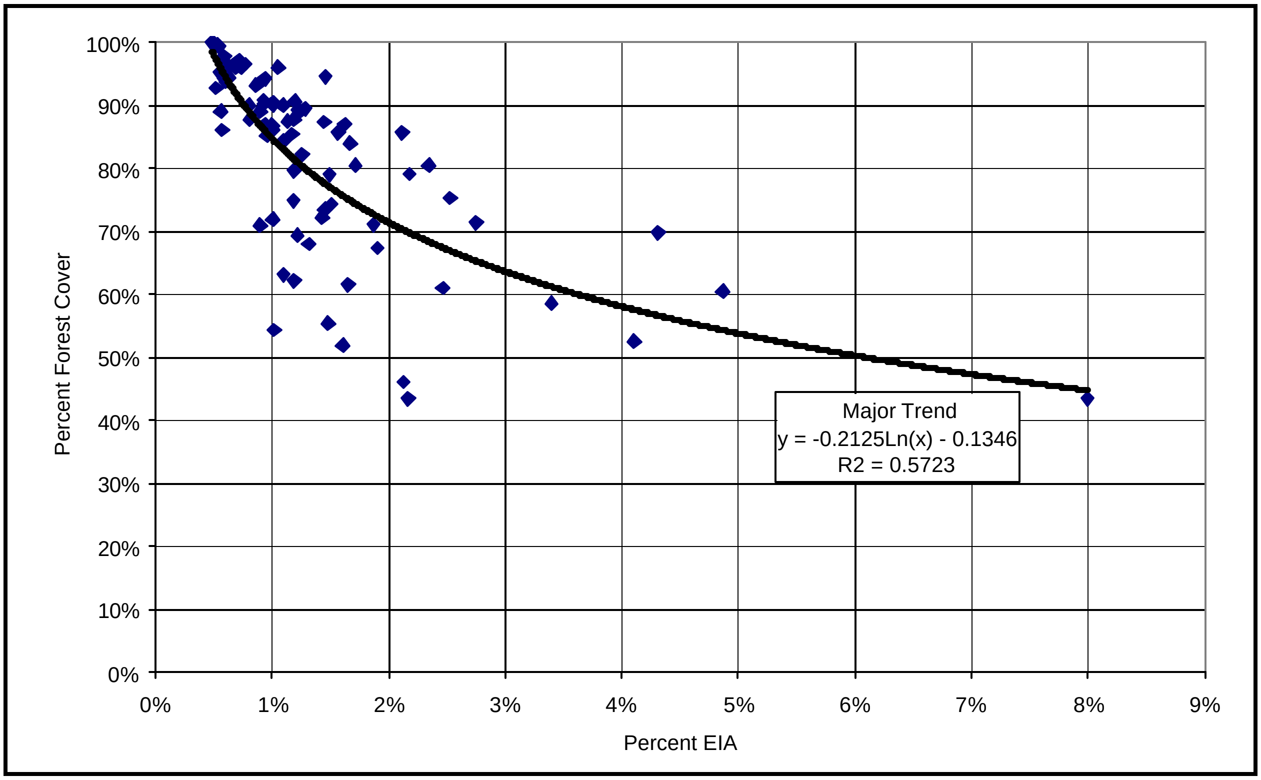


Figure 5-1. Percent Forest Cover and EIA Under Existing Conditions for the 75 Drainage Basins

TABLE 5-1.
EXISTING AND FUTURE FOREST COVER AND EFFECTIVE IMPERVIOUS AREA

Basin No.	Total Basin Area (acres)	Forest Cover			Effective Impervious Area			
		Existing Area (acres)	Existing Percentage	Future Percentage	Existing Area (acres)	Future Areas (acres)	Existing Percentage	Future Percentage
1	72.21	59.35	82.2%	68.6%	0.91	1.72	1.3%	2.4%
2	54.71	48.70	89.0%	68.0%	0.49	1.31	0.9%	2.4%
3	43.12	42.92	99.5%	70.6%	0.23	0.90	0.5%	2.1%
4	15.34	13.15	85.7%	80.1%	0.24	0.31	1.6%	2.0%
5	14.96	12.56	84.0%	81.0%	0.25	0.29	1.7%	1.9%
6	34.08	33.95	99.6%	62.9%	0.18	1.01	0.5%	3.0%
7	14.26	14.26	100.0%	60.5%	0.07	0.45	0.5%	3.2%
8	58.78	53.03	90.2%	61.8%	0.55	2.09	0.9%	3.6%
9	39.06	37.98	97.2%	62.8%	0.28	1.41	0.7%	3.6%
10	141.06	113.61	80.5%	66.1%	2.42	4.78	1.7%	3.4%
11	58.64	56.94	97.1%	70.8%	0.42	1.45	0.7%	2.5%
12	1845.85	1318.71	71.4%	51.6%	50.74	129.11	2.7%	7.0%
12.1	315.53	282.48	89.5%	63.7%	4.04	13.63	1.3%	4.3%
12.2	310.39	220.41	71.0%	32.5%	2.80	17.14	0.9%	5.5%

TABLE 5-1.
EXISTING AND FUTURE FOREST COVER AND EFFECTIVE IMPERVIOUS AREA

Basin No.	Total Basin Area (acres)	Forest Cover			Effective Impervious Area			
		Existing Area (acres)	Existing Percentage	Future Percentage	Existing Area (acres)	Future Areas (acres)	Existing Percentage	Future Percentage
12.3	418.56	357.72	85.5%	56.7%	4.90	19.01	1.2%	4.5%
12.4	801.37	485.10	60.5%	45.4%	39.00	79.33	4.9%	9.9%
13	65.30	55.11	84.4%	61.7%	0.72	2.09	1.1%	3.2%
14	77.69	40.36	52.0%	34.0%	1.25	2.92	1.6%	3.8%
15	128.07	78.91	61.6%	45.6%	2.12	4.49	1.7%	3.5%
16	206.53	179.75	87.0%	70.3%	3.36	7.38	1.6%	3.6%
17	108.48	77.06	71.0%	61.0%	2.03	3.25	1.9%	3.0%
18	72.53	65.62	90.5%	64.9%	0.73	2.43	1.0%	3.4%
19	58.97	43.86	74.4%	61.1%	0.89	1.66	1.5%	2.8%
20	154.24	147.97	95.9%	65.2%	1.13	4.80	0.7%	3.1%
21	355.88	320.33	90.0%	68.5%	2.86	7.89	0.8%	2.2%
22	38.52	21.36	55.4%	46.4%	0.57	0.87	1.5%	2.3%
23	644.73	474.29	73.6%	62.3%	9.37	15.95	1.5%	2.5%
24	112.73	99.03	87.8%	65.6%	1.34	3.81	1.2%	3.4%
25	80.57	68.67	85.2%	57.9%	0.77	2.79	1.0%	3.5%
26	172.08	151.20	87.9%	56.5%	1.39	6.09	0.8%	3.5%
27	34.71	33.32	96.0%	61.1%	0.24	1.24	0.7%	3.6%
28	65.08	61.02	93.8%	55.0%	0.39	2.42	0.6%	3.7%
30	225.24	212.21	94.2%	57.6%	1.33	7.44	0.6%	3.3%
31	127.56	123.76	97.0%	70.0%	0.73	2.60	0.6%	2.0%
32	134.24	127.00	94.6%	86.2%	1.96	2.90	1.5%	2.2%
33	38.53	34.96	90.7%	71.2%	0.46	1.15	1.2%	3.0%
34	33.18	29.01	87.4%	69.9%	0.48	1.09	1.4%	3.3%
35	38.58	38.31	99.3%	59.6%	0.21	1.36	0.5%	3.5%
36	94.04	88.84	94.5%	58.9%	0.60	3.19	0.6%	3.4%
37	777.60	699.92	90.0%	76.3%	8.50	16.19	1.1%	2.1%
38	385.94	337.45	87.4%	77.3%	4.37	7.04	1.1%	1.8%
39	156.57	139.37	89.0%	82.1%	1.95	2.70	1.2%	1.7%
40	241.41	215.79	89.4%	73.5%	2.94	6.21	1.2%	2.6%
41	1117.05	752.40	67.4%	60.9%	21.30	28.83	1.9%	2.6%
42	3292.10	2478.95	75.3%	51.9%	83.17	250.54	2.5%	7.6%
42.1	1080.25	854.62	79.1%	62.4%	23.54	51.75	2.2%	4.8%
42.2	998.14	584.33	58.5%	28.8%	33.91	137.41	3.4%	13.8%
42.3	1213.71	1040.00	85.7%	67.2%	25.72	61.38	2.1%	5.1%
43	284.79	123.89	43.5%	21.5%	6.18	17.41	2.2%	6.1%

TABLE 5-1.
EXISTING AND FUTURE FOREST COVER AND EFFECTIVE IMPERVIOUS AREA

Basin No.	Total Basin Area (acres)	Forest Cover			Effective Impervious Area			
		Existing Area (acres)	Existing Percentage	Future Percentage	Existing Area (acres)	Future Areas (acres)	Existing Percentage	Future Percentage
44	312.37	169.73	54.3%	30.6%	3.18	9.73	1.0%	3.1%
45	493.64	342.59	69.4%	51.8%	6.02	13.77	1.2%	2.8%
46	160.79	144.94	90.1%	71.9%	1.62	3.82	1.0%	2.4%
47	181.81	165.24	90.9%	45.6%	1.69	14.21	0.9%	7.8%
48	97.08	94.87	97.7%	44.2%	0.57	7.07	0.6%	7.3%
49	40.58	37.83	93.2%	73.8%	0.35	0.87	0.9%	2.1%
50	27.67	26.08	94.3%	73.3%	0.26	0.70	0.9%	2.5%
51	28.41	25.31	89.1%	59.1%	0.16	0.65	0.6%	2.3%
52	22.10	21.35	96.6%	73.2%	0.17	0.51	0.8%	2.3%
53	36.46	34.72	95.2%	66.3%	0.20	0.78	0.5%	2.1%
54	39.98	34.43	86.1%	60.8%	0.23	0.76	0.6%	1.9%
55	80.50	57.86	71.9%	58.0%	0.81	1.56	1.0%	1.9%
56	103.88	77.78	74.9%	58.0%	1.23	2.72	1.2%	2.6%
57	79.48	36.67	46.1%	47.4%	1.69	1.60	2.1%	2.0%
58	56.76	45.72	80.5%	73.2%	1.33	1.88	2.3%	3.3%
59	173.52	109.50	63.1%	50.7%	1.91	3.43	1.1%	2.0%
60	106.95	65.27	61.0%	56.0%	2.64	3.34	2.5%	3.1%
61	121.53	82.65	68.0%	51.5%	1.60	3.48	1.3%	2.9%
62	518.66	362.17	69.8%	82.6%	22.37	12.28	4.3%	2.4%
63	628.86	330.40	52.5%	25.5%	25.83	92.10	4.1%	14.6%
64	193.72	139.89	72.2%	55.2%	2.77	6.16	1.4%	3.2%
65	312.28	135.61	43.4%	27.5%	24.96	52.83	8.0%	16.9%
66	377.80	234.76	62.1%	37.0%	4.50	14.72	1.2%	3.9%
67	92.86	80.70	86.9%	64.6%	0.87	2.49	0.9%	2.7%
68	90.04	78.21	86.9%	61.9%	0.90	2.92	1.0%	3.2%
69	14.38	14.38	100.0%	70.0%	0.07	0.29	0.5%	2.0%
70	79.15	68.26	86.2%	66.5%	0.80	2.03	1.0%	2.6%
71	51.00	49.15	96.4%	72.8%	0.32	0.97	0.6%	1.9%
72	105.31	101.11	96.0%	73.8%	1.11	3.15	1.1%	3.0%
73	21.12	19.61	92.8%	55.4%	0.11	0.64	0.5%	3.0%
74	67.09	53.44	79.7%	57.8%	0.80	2.24	1.2%	3.3%
75	159.18	125.84	79.1%	62.8%	2.38	5.11	1.5%	3.2%

General Notes:

1 Forest Cover represents the sum acreage of coniferous, deciduous, and mixed forest classes per basin.

2. One Washington Trout stream number is not included as a basin for the following reasons:

TABLE 5-1.
EXISTING AND FUTURE FOREST COVER AND EFFECTIVE IMPERVIOUS AREA

Basin No.	Total Basin Area (acres)	Forest Cover			Effective Impervious Area			
		Existing Area (acres)	Existing Percentage	Future Percentage	Existing Area (acres)	Future Areas (acres)	Existing Percentage	Future Percentage

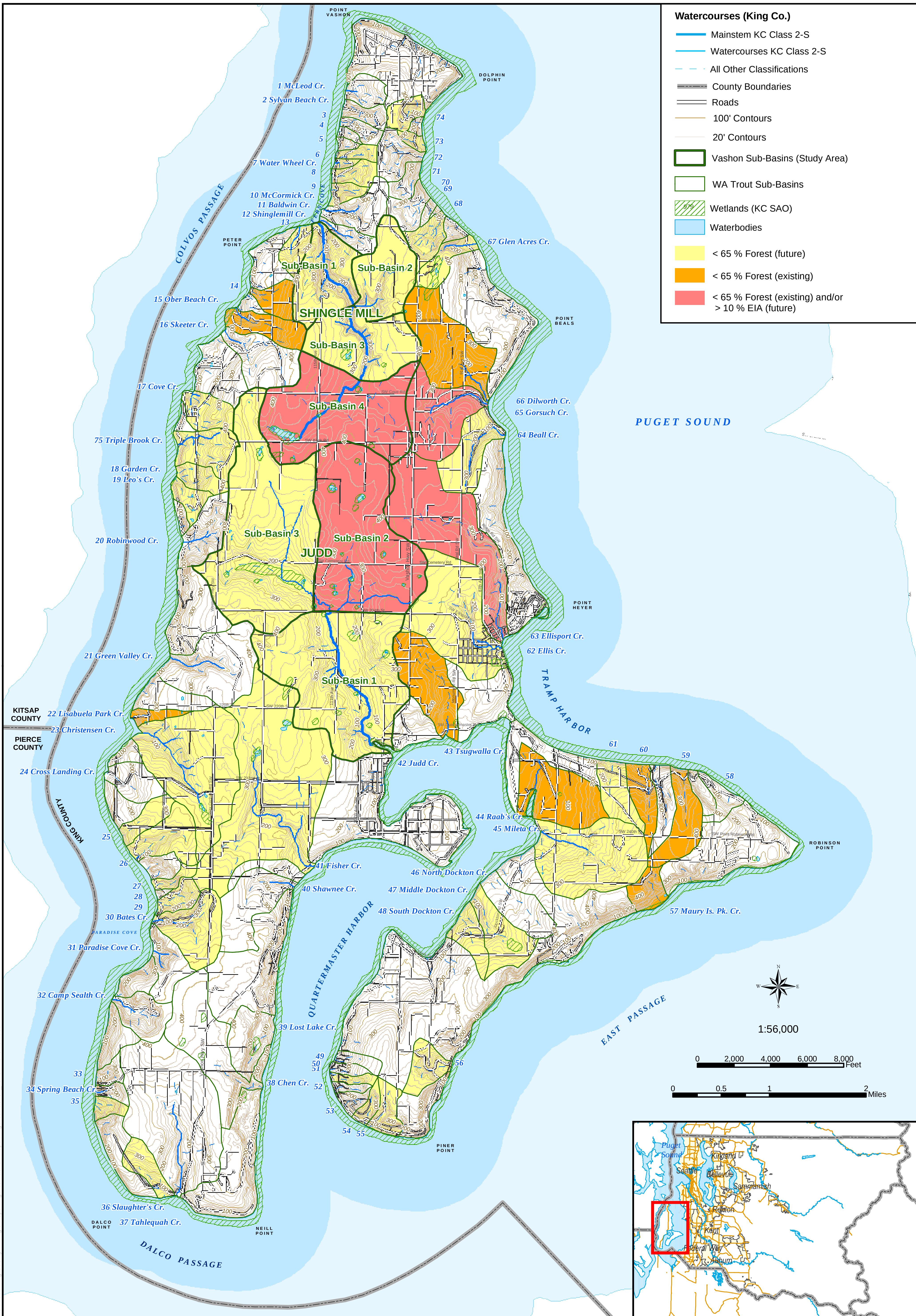
29 - Streams 28 and 29 both fall into the basin delineated as #28

3. Anomalies: A reduction in future EIA was observed in two basins:
   - 57 Existing land cover includes urban areas (8-75% EIA) while Zoning is completely RA-10 (2% EIA)
   - 62 Existing land cover includes urban areas (8-75% EIA); zoning in these areas is RA-5 (4% EIA) and RA-10 (2% EIA)
4. Future Forest Cover estimated based on regression analysis
5. Highlighted cells indicate basins at risk (<65% Forest Cover and/or > 10% EIA)
6. Go to Figure 1-1 for Basin No. names

GIS Land Cover Assumptions for Future Development:

1. Base future conditions on zoning, where impervious area is based on dwelling units per acre. For the remaining portions of the land, assume the following parameters:
   a) Commercial and Residential areas will not retain trees - all pervious area converts from forest to grass
   b) Rural Residential areas will retain 10% forest
   c) Agricultural Resource lands will convert to pasture
   d) Forest Resource lands will remain forest
2. For commercial, residential, and agricultural areas only, subtract out water bodies and sensitive areas with the following assumptions:
   a) Assume 75 foot buffer on all mapped wetlands according to the SAO coverage (our budget will not allow applying various buffers based on individual wetland class - Class 1= 100; Class 2 = 50; Class 3 = 25)
   b) Assume 100' buffer on all KC Class I or II (Type 1,2, or 3 according to WA TROUT) streams. (same budget constraints apply for defining distinct buffers per stream)
   c) A 35' buffer instead of 50' was assumed for steep slope areas (40% slope or greater) to account for some approved exceptions within the buffer areas.
3. Sensitive areas and buffer areas were excluded from zoning areas before applying EIA.
4. EIA values based on revised values provided by Jeff Burkey in Tech Memo dated 2/14/03 to L. Gibbons and additional communication with Jeff Burkey on 4/10/03.

Table 5-2 compares these flows as modeled for Judd and Shinglemill Creeks. None of the modeled Q2post flows approach the Q10pre flows.



King County
Department of Natural Resources and Parks
Water and Land Resources Division

Map prepared for King County by Adolfson Associates, Inc. The map data shown are the property of the sources listed below. Inaccuracies may exist, and Adolfson Associates, Inc. implies no warranties or guarantees regarding any aspect of data depiction.

Source: King County GIS, 2002; WDNR: WA Trout, 2002; WA Trout stream types 2 and 3 (WAS 222-16-031) shown as King County Class 2 with salmonids (KCC 21A.06.1240).

VASHON ISLAND - BASINS AT RISK TO STREAM EROSION AND INSTABILITY

KING COUNTY RAPID RURAL RECONNAISSANCE

Date Last Revised: 01/05/04
File Name: vashon_erosion

Figure 5-2

TABLE 5-2.
COMPARISON OF Q10PRE AND Q2POST FLOWS FOR JUDD AND SHINGLEMILL CREEKS

Reach	Q10pre (cfs)	Q2post (cfs)
Judd Reach 400	75.1	41.1
Judd Reach 300	190.6	94.7
Judd Reach 200	242.3	121.2
Judd Reach 100	230.2	116.6
Shinglemill Reach 400	108.6	49.0
Shinglemill Reach 300	136.1	61.0
Shinglemill Reach 100	183.6	84.2

An analysis of channel stability in rural watersheds with impervious cover less than 10 percent can be made based on HSPF modeling (Booth et al) to predict channels as stable, unstable, or of uncertain stability. It was used for comparison of historical, current and future buildout conditions of the Judd and Shinglemill Creek subbasins. For historical conditions it was assumed that all areas were forested and that 90 percent of the forest cover was removed during logging. The results are shown in Figures 5-3 through 5-9 and summarized in Table 5-3.

Under current conditions, channel stability is uncertain in two subbasins because the forest cover is less than 65 percent. Under future buildout conditions, the model predicts unstable channels in three subbasins and uncertain stability in the remaining four subbasins based on the assumptions presented in Section 5.1. The results of this analysis suggest that the channel stability of Judd Subbasin 2 and Shinglemill Subbasin 4 should be monitored for erosion. Future significant impacts on the subbasins of Judd and Shinglemill Creeks are likely. Reductions in future EIA and increased forest cover are recommended to mitigate impacts and preserve stream habitats.

TABLE 5-3.
CHANNEL STABILITY FOR JUDD AND SHINGLEMILL CREEK SUBBASINS

Subbasin	Predevelopment	Logging	Current	Future
Judd 1	Stable	Unstable	Stable	Uncertain
Judd 2	Stable	Unstable	Uncertain	Unstable
Judd 3	Stable	Unstable	Stable	Uncertain
Shinglemill 1	Stable	Unstable	Stable	Uncertain
Shinglemill 2	Stable	Unstable	Stable	Unstable
Shinglemill 3	Stable	Unstable	Stable	Uncertain
Shinglemill 4	Stable	Unstable	Uncertain	Unstable

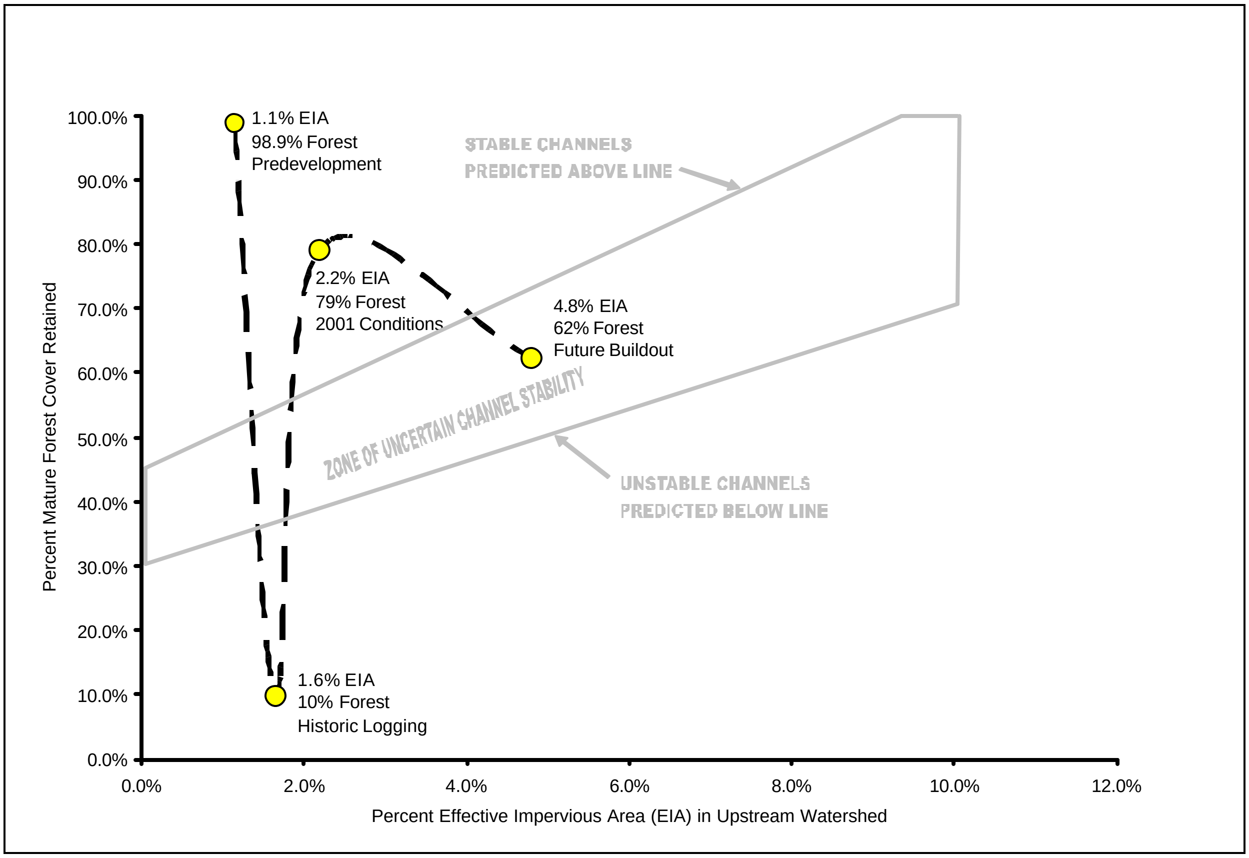


Figure 5-3. Historical, Current, and Future Channel Stability in Judd Creek Subbasin 1

5.3 SOILS EROSION POTENTIAL

Streams flowing through outwash soils are typically more susceptible to erosion than those flowing through till. Likewise, streams in steeper slopes are more susceptible to erosion than those on shallow slopes. Table 5-4 lists the soils on Vashon-Maury Island, the associated HSPF soil type and their respective erosion potential (King County Soils Survey 2000). Streams that are likely impacted should be monitored in reaches that contain soils of high erosion potential.

5.4 LANDSLIDES

Many of the valleys and shoreline bluffs of Puget Sound, including Vashon-Maury Island, are bordered by steeply sloping unconsolidated glacial deposits highly susceptible to landslides. These unstable slopes area are a major hazard to people, structures, and habitat.

Certain types of glacial sediments are easily eroded and the action of streams and waves has produced slopes cutting through layered glacial deposits. The stability of these slopes is highly dependent on the water content of the underlying sediments. Undisturbed dry sand can maintain a slope of 50 percent to 70 percent; water-saturated sand can maintain a slope of only about 35 percent. Loose water-saturated silts can maintain slopes of only about 15 percent.

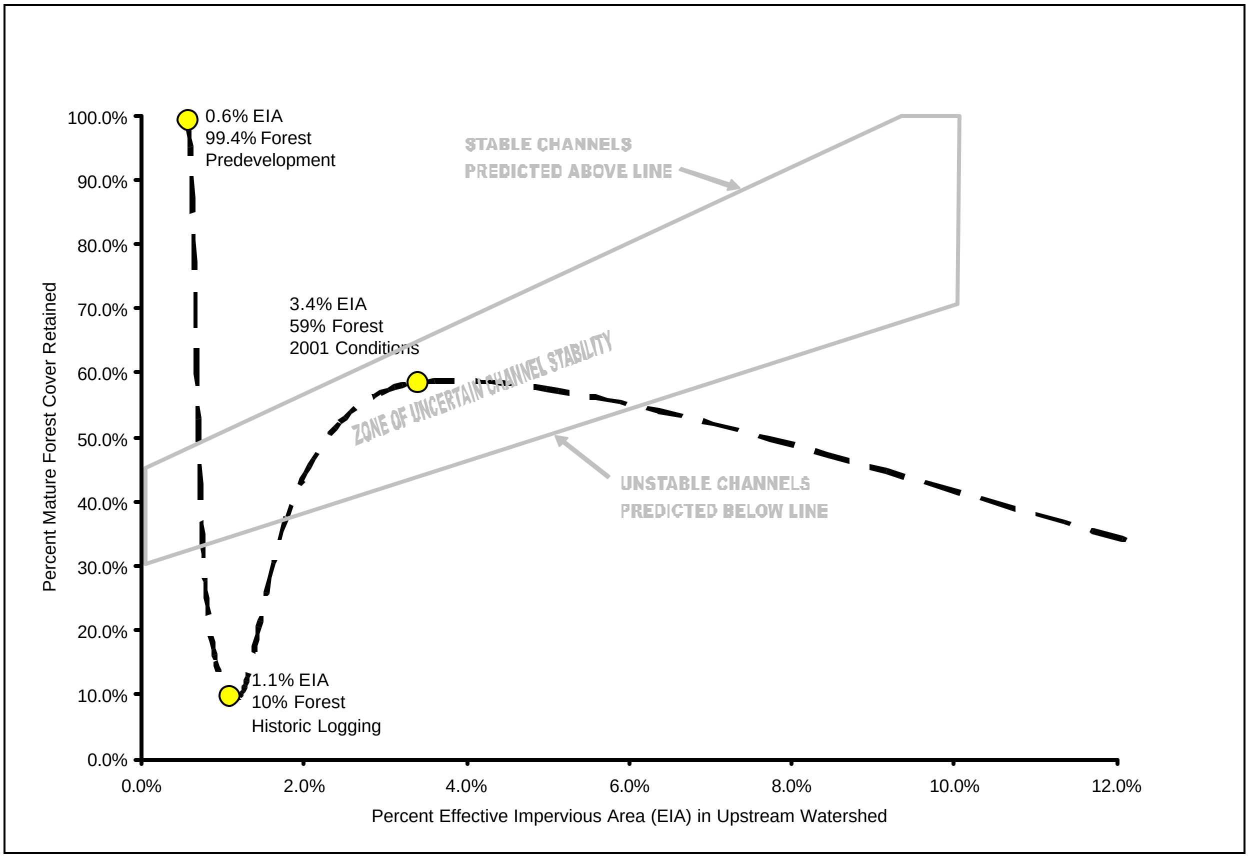


Figure 5-4. Historical, Current, and Future Channel Stability in Judd Creek Subbasin 2

Water readily percolates through sand and gravels but it ponds above less permeable silt, clay and till layers, saturating the overlying deposits. Where a less permeable layer intersects a hill slope, water often seeps from the layers above. This combination of sedimentary deposits, topography, and local groundwater flow results in a high potential for landslides. An event that increases groundwater flow, such as a rain storm or discharge of surface water above a slope, can cause a failure of a slope that would be stable under dryer conditions. Likewise, erosion along a stream channel or wave erosion along a beach can steepen a slope or expose deposit that may become water-saturated. This also increases the potential for landslides on a previously stable slope. Earthquakes and the collection and discharge of surface water runoff at the top of a slope can also trigger landslides. The Shinglemill “Grand Canyon” slide in subbasin 3 is a good example of this.

The King County Sensitive Area Ordinance (SAO) Landslide Hazard Areas map in Appendix H depicts areas where topographic and geologic conditions indicate a high potential for hill slope failure. The criteria for potential failures are as follows:

- Slopes greater than 15 percent and;
    - Impermeable soils frequently interbedded with granular soils; and
    - Springs or groundwater seepage
- Any area that has shown movement during the Holocene epoch (from 10,000 years to present) or that is underlain by mass wastage debris of this epoch

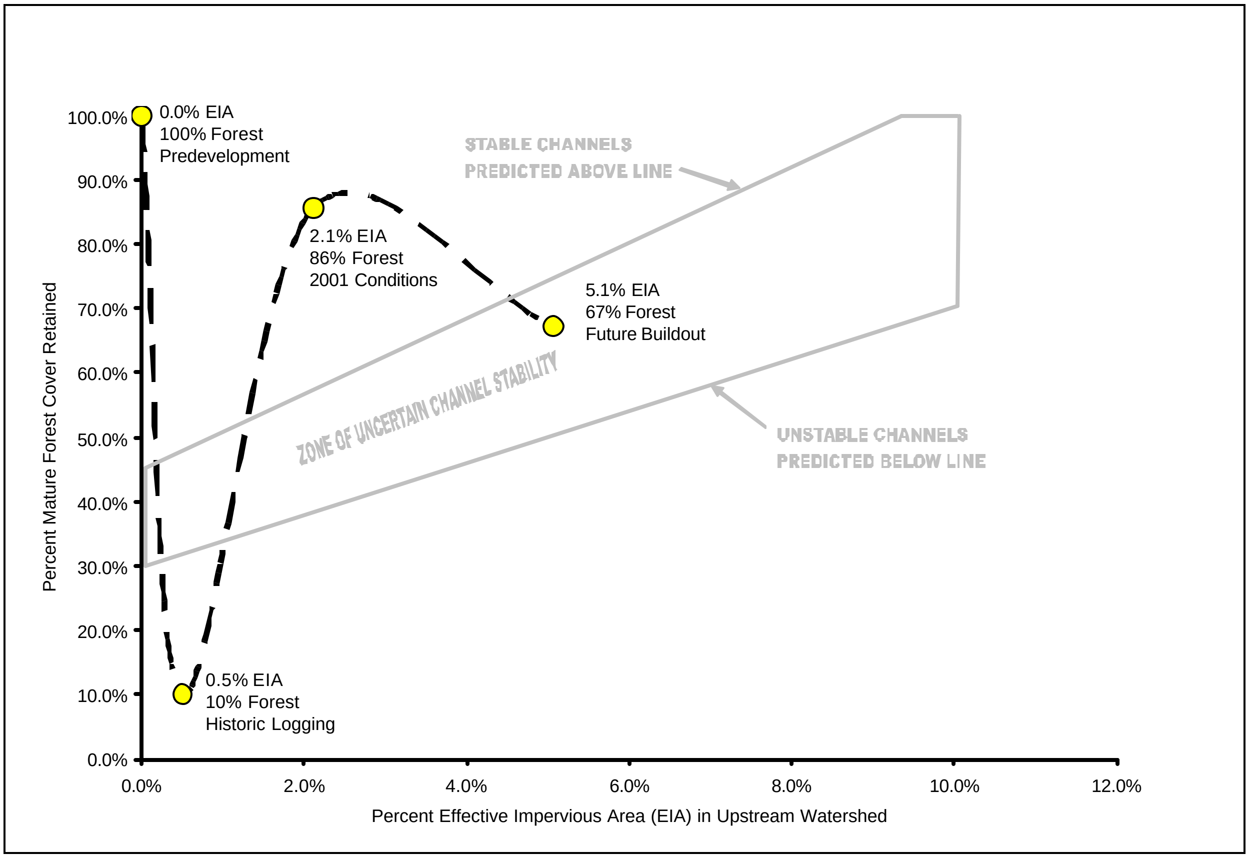


Figure 5-5. Historical, Current, and Future Channel Stability in Judd Creek Subbasin 3

- Any area potentially unstable as a result of rapid stream incision, stream bank erosion or undercutting by wave action

The SAO landslide hazard map is based on average, regional conditions and does not portray smaller local variations. Appendix H contains more detailed maps of landslide areas from the Department of Ecology found at the following website:

http://www.ecy.wa.gov/programs/sea/femaweb/king.htm

Other than identifying some of the more critical slide problems, as reported by the King County Maintenance Division and as described in the SAO, no additional landslide investigation was done.

5.5 CONCLUSIONS AND RECOMMENDATIONS

Current impacts on stream geomorphology due to increased flow regimes are likely on several Vashon-Maury Island streams. Future impacts are likely to increase with development, affecting most of the streams on the island. The analysis indicates that maintaining forest cover is very important, especially in rural residential densities. Although zoning effectively limits the range of EIA to between 2 and 6 percent of the gross development area, without clearing limitations, forest cover can range from 5 to 85 percent, creating unstable channels. Reforestation and acquisition of cleared land are recommended in Shinglemill Creek Subbasin 4, Judd Creek Subbasin 2, Gorsuch Creek, and Ellisport Creek to restore or maintain stream flow regimes and protect habitat. For more details on these streams and other streams on VMI see Chapter 7.1.

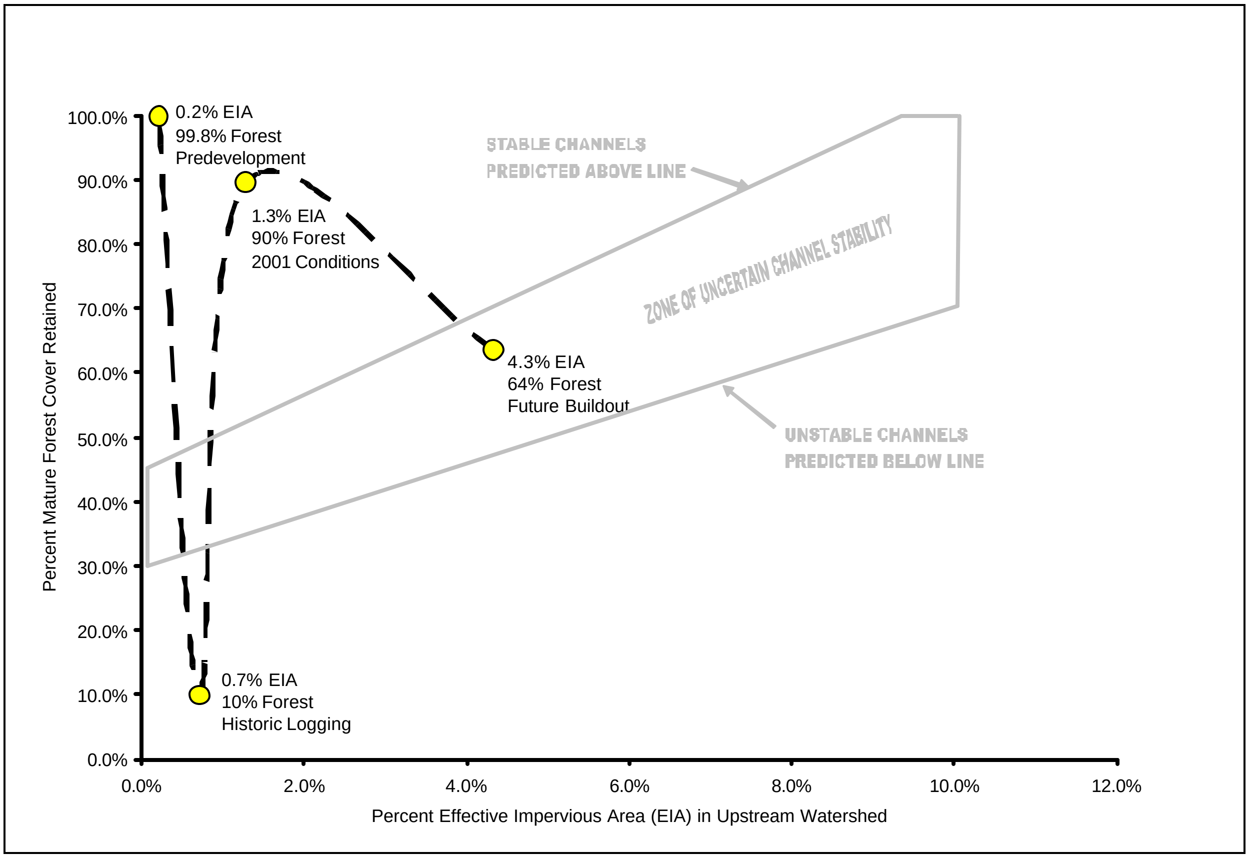


Figure 5-6. Historical, Current, and Future Channel Stability in Shinglemill Creek Subbasin 1

Many of the valleys and shoreline bluffs of Vashon-Maury Island are bordered by steeply sloping unconsolidated glacial deposits highly susceptible to landslides. These unstable slopes are a major hazard to people, structures, and habitat. A pilot landslide study is recommended to analyze the effects of uphill drainage at six known problem areas, recommend solutions, and prioritize projects for construction. Some revegetation work has been done to the Shinglemill "Grand Canyon" slide. The site is being monitored by County staff and additional work may be needed in the future.

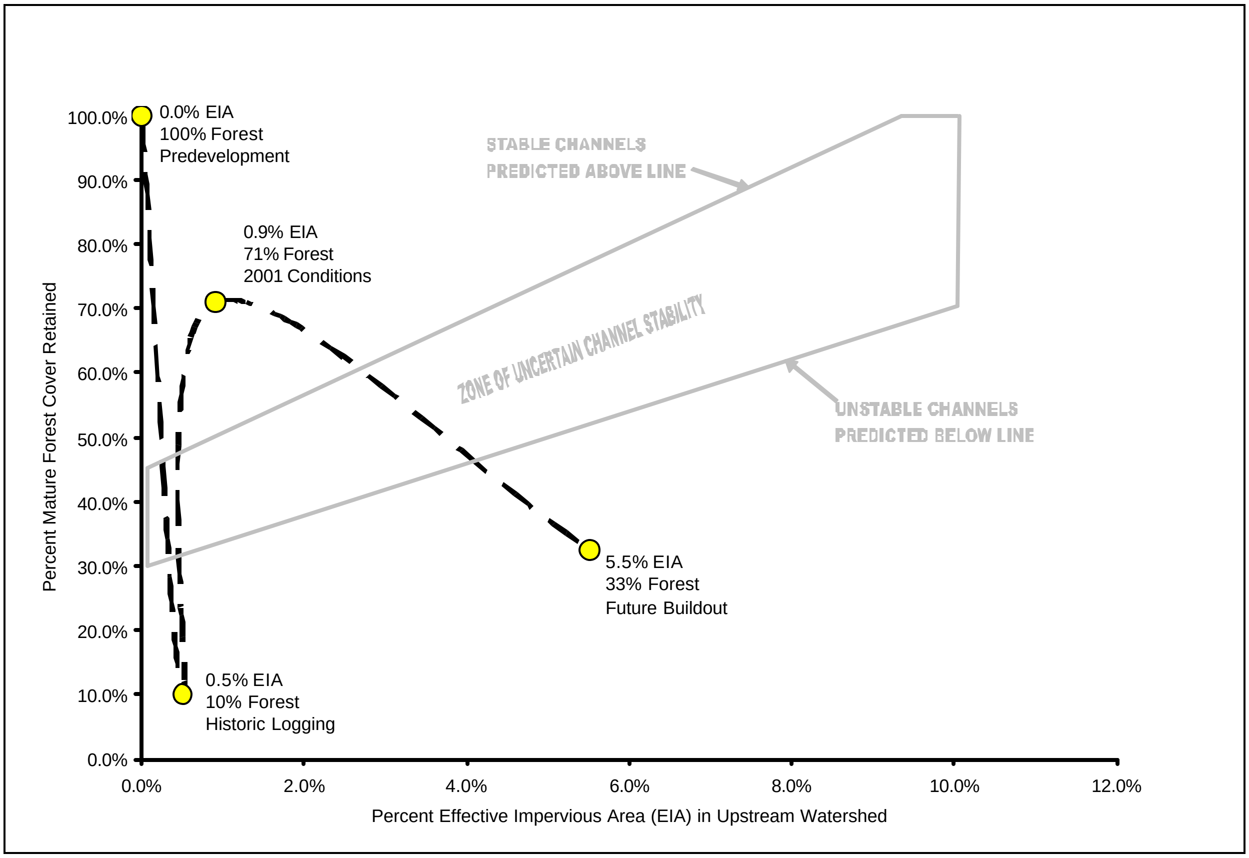


Figure 5-7. Historical, Current, and Future Channel Stability in Shinglemill Creek Subbasin 2

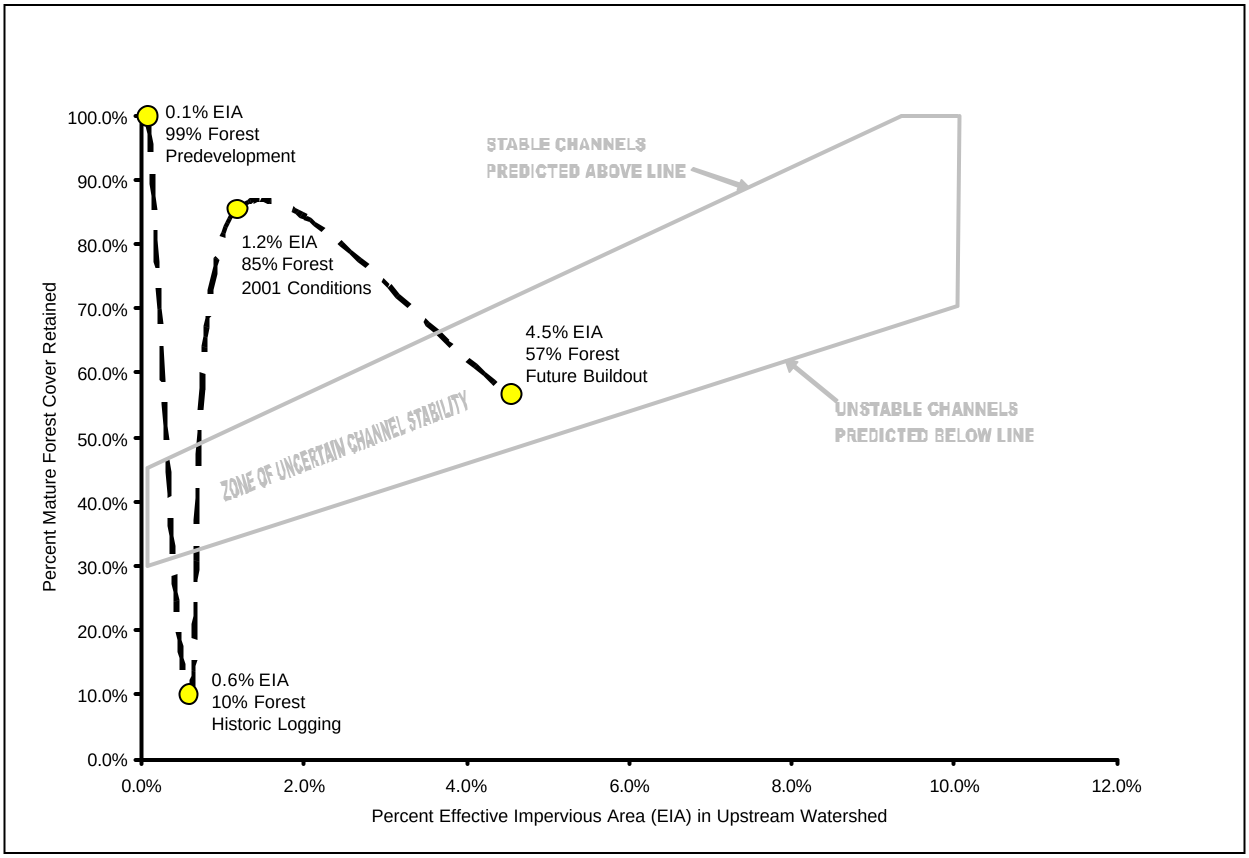


Figure 5-8. Historical, Current, and Future Channel Stability in Shinglemill Creek Subbasin 3

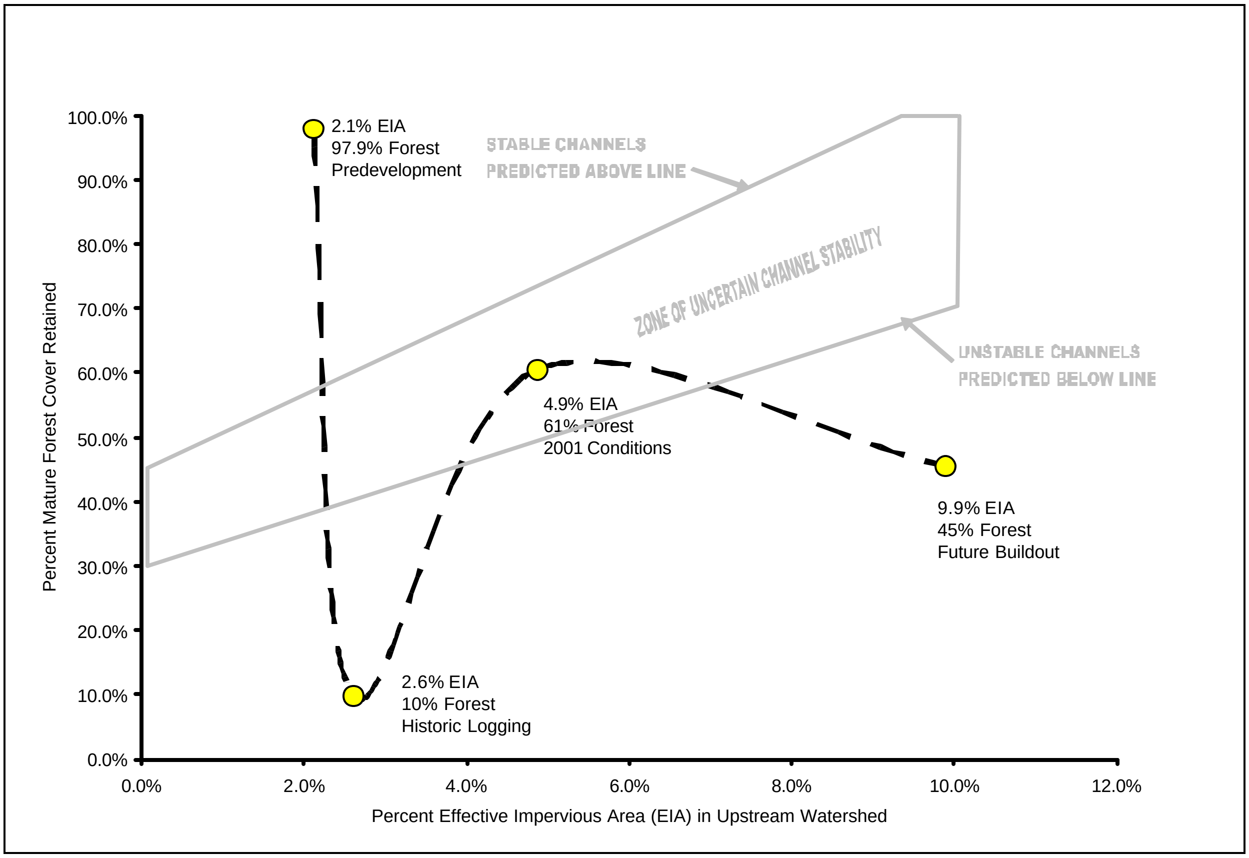


Figure 5-9. Historical, Current, and Future Channel Stability in Shinglemill Creek Subbasin 4

TABLE 5-4.
SOIL TYPE EROSION POTENTIAL

Soil Name	HSPF Soil Type	Erosion Potential
Alderwood gravelly sandy loam, 0 to 6 percent slopes	Till	slight
Alderwood gravelly sandy loam, 6 to 15 percent slopes	Till	moderate
Alderwood gravelly sandy loam, 15 to 30 percent slopes	Till	severe
Arents, Alderwood material, 6 to 15 percent slope		moderate to severe
Bellingham silt loam	Till	slight
Coastal beaches	Saturated	
Everett gravelly sandy loam, 0 to 5 percent slopes	Outwash	slight
Everett gravelly sandy loam, 5 to 15 percent slopes	Outwash	slight to moderate
Everett gravelly sandy loam, 15 to 30 percent slopes	Outwash	moderate to severe
Everett-Alderwood gravelly sandy loams, 6 to 15 percent slopes	Outwash	slight to moderate
Indianola loamy fine sand, 0 to 4 percent slopes	Outwash	slight
Indianola loamy fine sand, 4 to 15 percent slopes	Outwash	slight to moderate
Indianola loamy fine sand, 15 to 30 percent slopes	Outwash	moderate to severe
Kitsap silt loam, 2 to 8 percent slopes	Till	slight to moderate
Kitsap silt loam, 8 to 15 percent slopes	Till	moderate to severe
Kitsap silt loam, 15 to 30 percent slopes	Till	severe
Mixed alluvial land		
Norma sandy loam	Till	slight
Orcas peat	Saturated	none
Ragnar-Indianola association, sloping	Outwash	
Ragnar-Indianola association, moderately steep	Outwash	
Riverwash	Saturated	
Seattle muck	Saturated	none
Shalcar muck		
Urban land		slight to moderate