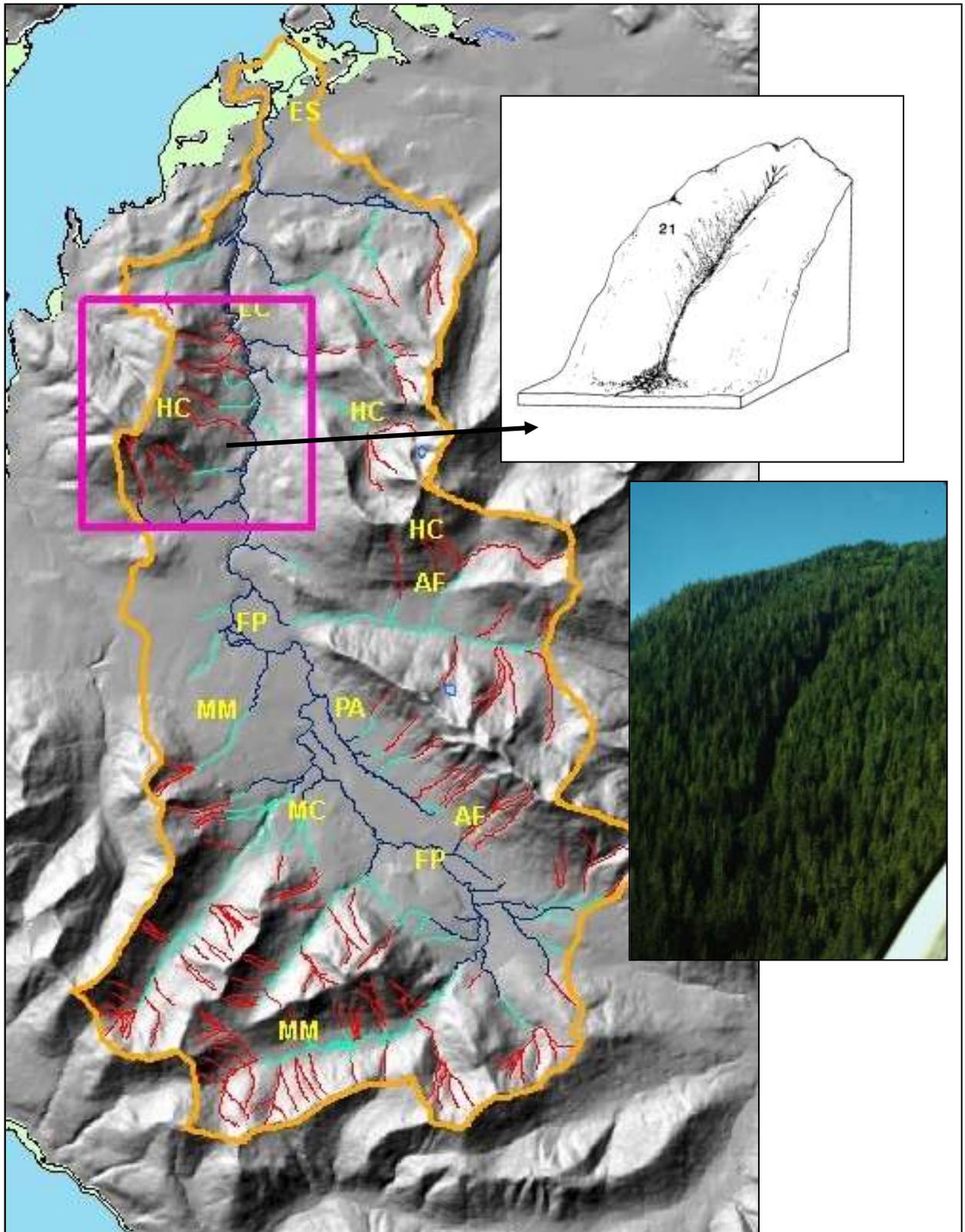


## High Gradient Contained Process Group



**The High Gradient Contained Process Group** includes steep headwater channels shallowly to deeply incised in mountainslope landforms. Stream flow is dependent upon mountain slope runoff and may be intermittent. These channels both produce sediment and transport it. High stream energy enables these streams to transport large sediment loads during spring and fall flows. Over the long term HC channels act as conduits to move large wood and gravel to downstream fish bearing streams. The associated riparian area generally extends to the upper stream bank slope break. The Glacial High Gradient Contained channel can also be included in this process group.

The HC process group of channels often begin in Mountain Summit Landforms (10s), and are found on the Mountainslope Landforms (30s), and Hills landforms (40s). HCs will also extend through the footslope landform (51 and 52) and Sloping lowlands (61 landform).

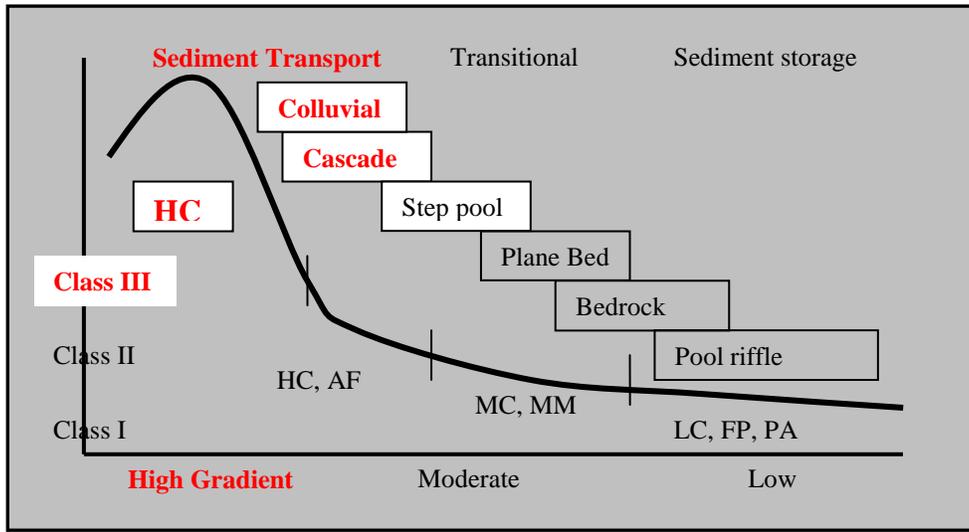
Channel Types:	Label:	Former CT label
Micro High Gradient Contained	HCO	HC0
High Gradient Contained Low Incision	HCL	HC1, HC2
High Gradient Contained Moderate Incision	HCM	HC5
High Gradient Contained Deep Incision	HCD	HC4, HC6, HC9
High Gradient Contained Upper Valley	HCV	HC3, HC8

The incision depth breaks determine the differences in the channel types within the HC process group.

Incision Designation	Depth Range
Low	Less than or equal to 2 meters
Moderate	2 to less than or equal 6 meters
Deep	Greater than 6 meters

#### Habitat Response Variables

Variable	Percentile	HC	Variable	Percentile	HC
WD	25	8.3	RPD/CBW	25	0.06
	50	11.1		50	0.08
	75	13.0		75	0.09
TLWD/M	25	0.23	D50	25	36
	50	0.34		50	93
	75	0.48		75	135
TKWD/M	25	0.07	PLNGTH/M	25	0.17
	50	0.08		50	0.28
	75	0.27		75	0.44
POOLS/KM	25	50	REL_SUBMRG	25	3.3
	50	60		50	4.8
	75	100		75	11.4
POOL SPACE	25	2.4	POOL_SIZE	25	0.43
	50	3.4		50	0.59
	75	5.7		75	1.02



Longitudinal profile of Stream Class, Process Group, sediment function, gradient and corresponding Montgomery-Buffington channel forms. HC characteristics in red.

## Micro High Gradient Contained Channel – HCO

**Geomorphic Setting.** The HCO is situated on mountainslopes, hillslopes and footslopes. Often this is the first section of channelized stream on a mountainslope and can be fed by springs or upslope swales and rills. On un-vegetated slopes HCLs may be detectable on resource aerial photography, however on timbered slopes it is undetectable and can only be verified by field reconnaissance.



### Channel Characteristics:

Stream Gradient: > 6%,  
Incision Depth:  $\leq$  3 m (10ft)  
Channel Width: 0.3 to 1.5 m  
Sideslope Length:  $\leq$  4.5m (15 ft)  
Bed Substrate: Silt to coarse gravel  
Stream Bank Composition:  
Bedrock, organic material  
Associated Landform: 30s, 40s, 51, 52, and 61

### Riparian Vegetation:

Overstory: Western .Hemlock, Yellow Cedar, Mountain.Hemlock, and Mixed Conifer  
Understory: shrub species such as Blueberry and Sitka Alder.

## **Management Considerations**

HCOs are small channels that do not transport significant sediment loads. They do not provide any fish habitat and usually designated as Stream Class IV. However, if situated on a footslope landform and linked to a valley bottom channel that is Class I or II the HCO may provide some resident fish habitat and therefore be given a Stream Class II designation.

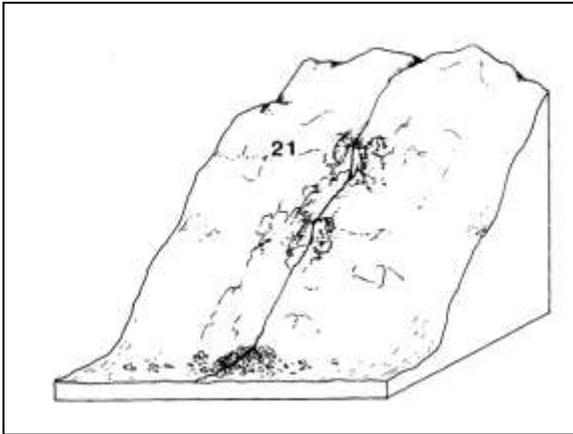
**Channel Type Phases:**

**HCOw- Wetland phase.** This phase of the HCO is situated on sloping wetlands vegetated by scrub forest of shore Pine or mixed conifers with sphagnum and low sedge ground cover. A step-pool morphology is typical of this channel type phase.



HCOw - channel width is 1-2 m, and gradient is 10%.

## High Gradient Contained Low Incision Channel – HCL

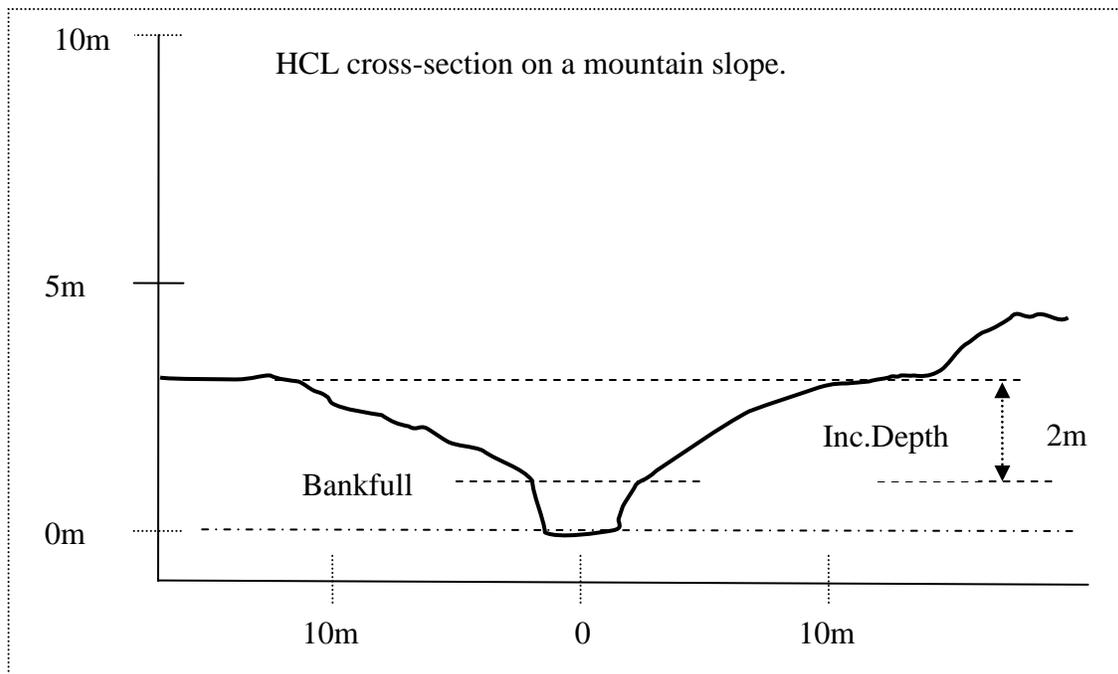


**Geomorphic Setting:** The HCL lies in upper headwater regions of glacially scoured valleys. Normally associated with alpine, snow avalanche, and sub-alpine mountain landforms, less frequently on hill and sloping lowlands. Often these channels are the outlets to alpine lakes, cirque basins and hanging valleys.

They can extend from the cirque basin through high relief alpine or sub-alpine sideslopes directly to the main valley floor. The HCL has shallow incision. The gradient is steep but variable due to falls and cascades. These are singular linear channels with bedrock control.

**Riparian Vegetation:** The riparian plant communities are variable with Western Hemlock series, Sitka Spruce and mixed conifer series being the most dominant. Non-forested species are also quite common, representing 16% of the riparian vegetation cover.

Plant Association Series	% cover
Western Hemlock	26%
Sitka Spruce	21%
Mixed Conifer	18%
Non-forest	16%
Western Hemlock-Alaska Cedar	7%
Mountain Hemlock	6%
Western Hemlock-Red Cedar	6%





**Channel Characteristics:**

- Stream Class:..... III
- Stream gradient:..... greater than 6%
- Incision Depth:..... less than or equal to 2 m
- Bankfull Width:..... Variable
- Dominant Substrate:..... Coarse gravel to small boulder, and bedrock
- Streambank composition:..... Bedrock, alluvium or colluvium
- Sideslope Length:..... < 10m, mean = 7.5m (25ft)
- Sideslope angle:..... Mean = 42%
- Channel Pattern:..... Singular, linear
- Drainage basin area:..... < 2.6km<sup>2</sup> (< 1mi<sup>2</sup>)

**Channel Type Phases:**

**HCLw - Wetland Phase**, an HCL situated in a sloping wetland land type. The HCLw was formerly labeled HC1.



## Management Considerations

Hydrologic Function: HCL channels function as sediment transport systems. Surface erosion and hillslope mass wasting are the principal source of stream sediment load. Stream flow responds quickly to intense rainfall and rain on snow events.

Aquatic Habitat Capability	
Large Wood	2700ft <sup>3</sup> /1000 linear ft
Available Spawning Area	Negligible
Available Rearing Area	Negligible

Indicator Species Ratings		
MIS	ASA	ARA
Coho	Negligible	Negligible
Pink	Negligible	Negligible
Chum	Negligible	Negligible
Sockeye	Negligible	Negligible
Dolly Varden	Negligible	Negligible
Steelhead	Negligible	Negligible

Fish access to these channels is prevented by high velocity stream flows and barriers. No significant fish habitat occurs within these channels. However, if resident fish populations (e.g. grayling or rainbow trout) are present in the associated alpine lakes, the confluence of the stream and lake may be used for spawning. Typically HCL channels affect downstream anadromous fish habitat through

transport of sediment, large wood, nutrients and aquatic species.

## Riparian Management Considerations

The significant amount of bedrock influence makes HCL channels fairly stable. However, the unstable shallow soils on steep channel sideslopes present a high risk for mass erosion when disturbed by road construction or timber harvesting (BMPs 13.5, 14.2, 14.3).

These are classified a Stream Class III. Timber harvesting unit design should incorporate water quality protection needs for these streams (BMPs 13.2, 13.3).

Concern of Management for:	
Large Wood	Low
Sediment Retention	Low
Stream Bank Sensitivity	Low
Sideslope Sensitivity	Moderate
Flood Plain Protection	N/A
Culvert Fish Passage	N/A

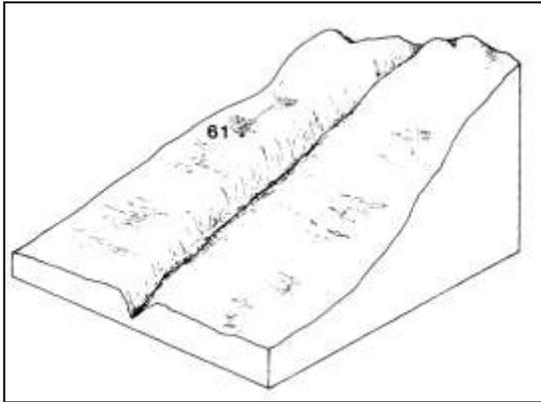
## Riparian Management Opportunities

Sport Fish Potential.....Low  
 Enhancement Opportunities..... N/A

### Stream Class

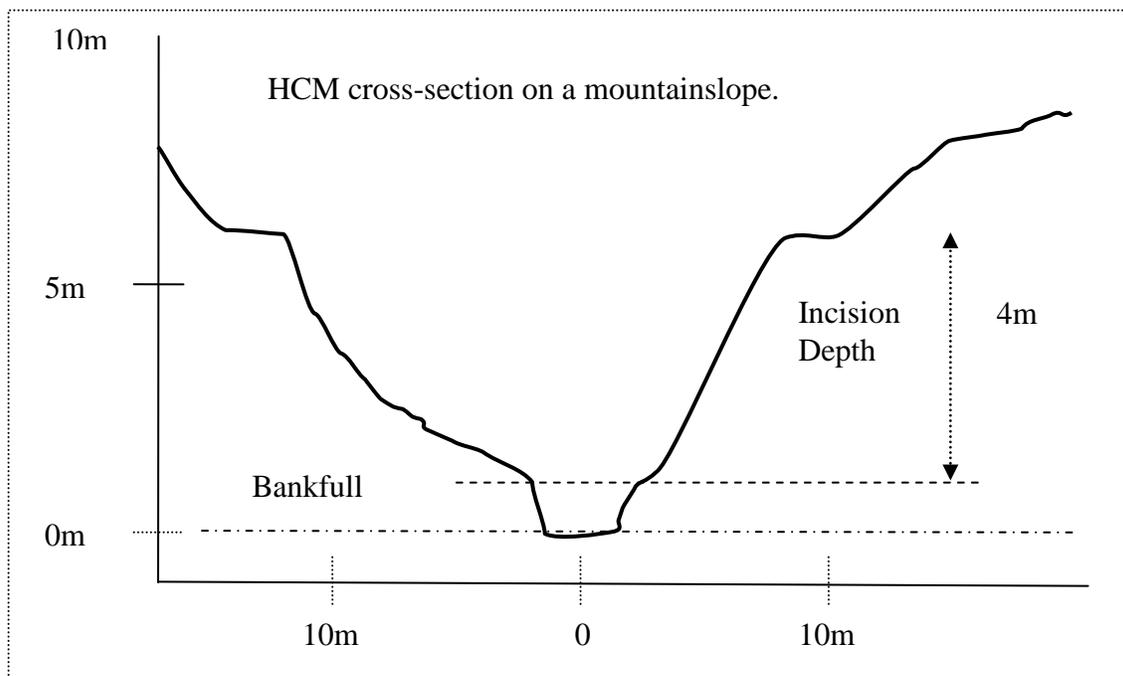
Most HCLs will be designated as Stream Class III. However transition sections may contain short reaches of Class II habitat.

## High Gradient Contained Moderate Incision Channel – HCM



**Geomorphic Setting:** The HCM lies in upper headwater regions of glacially scoured valleys. Normally associated with alpine, snow avalanche, and sub-alpine mountain landforms, less frequently on hill and sloping lowlands. Often these channels are located mid-slope or on the footslope of mountainslope landforms.

The HCM has moderate incision (2 to 6 meters). They are singular linear channels, channel bed and banks consist of alluvium with intermittent bedrock sections. HCM channels may lie between HCD (deep incision) channels and valley bottom MM or FP channels.





**Channel Characteristics:**

Stream Class:.....III, II  
 Stream gradient:..... greater than 6%  
 Incision Depth:..... 2 to 6 m,  
 Bankfull Width:.....Variable  
 Dominant Substrate:..... Coarse gravel to small boulder and bedrock  
 Streambank composition:..... Alluvium, colluvium or Bedrock  
 Sideslope Length:..... < 15m, mean = 10m (33ft)  
 Sideslope angle:..... < 30%, mean = 19%  
 Channel Pattern:.....Singular, linear  
 Drainage basin area:.....< 2.6km<sup>2</sup> (< 1mi<sup>2</sup>)

**Riparian Vegetation:** The riparian plant communities are variable with Western Hemlock/blueberry the most common. Nonforested communities and Sitka Spruce are also prevalent. Salmonberry and Sitka Alder shrub communities are common, occurring on 46% of the sites sampled.

Plant Association Series	% cover
Western Hemlock	38%
Non forest	27%
Sitka Spruce	17%
Mixed Conifer	12%
Shore Pine	2%

**Channel Type Phases**

**HCMh – Shrub Phase,** riparian vegetation consists of brush vegetation.

## Management Considerations

**Hydrologic Function:** HCM channels function as sediment transport systems. If situated on an alluvial/colluvial footslope, stream bank erosion can introduce significant sediment loads. Most sediment is rapidly transported downstream. Some retention of fine sediment occurs in small pools behind woody debris jams. Stream flow responds quickly to intense rainfall and rain on snow events.

Aquatic Habitat Capability	
Large Wood	4200ft <sup>3</sup> /1000 linear ft
Available Spawning Area	Low
Available Rearing Area	Low

Indicator Species Ratings		
MIS	ASA	ARA
Coho	Low	Low
Pink	Negligible	Negligible
Chum	Negligible	Negligible
Sockeye	Negligible	Negligible
Dolly Varden	Moderate	Moderate
Steelhead	Negligible	Negligible

Due to high streamflow velocities, HCM channels are only occasionally accessible to anadromous species. Lower reaches near the confluence with accessible valley channels have the best fish habitat potential. HCM channels have marginal spawning potential and limited rearing capability. Over-wintering capability is insignificant. They are used primarily by Dolly Varden char. Due to their

location in sediment source areas of a watershed, they can affect downstream fish habitat productivity.

## Riparian Management Considerations

HCM channel have high woody debris loading. Maintenance of this large wood source is important in that the wood traps bedload sediment and forms pool habitat for resident fish (BMP 12.6)

Unconsolidated alluvial bank material in some channel segments makes the streams moderately susceptible to bank erosion and lateral channel migration (BMPs 13.16, 13.9, 14.17).

Concern of Management for:	
Large Wood	Moderate
Sediment Retention	Low
Stream Bank Sensitivity	Moderate
Sideslope Sensitivity	Low
Flood Plain Protection	N/A
Culvert Fish Passage	Low

Fish passage through road culverts located near the confluence of HCM channels with lower gradient channels can be a concern (BMP 14.7).

**Stream Class:** HCMs are classified as Class II or III streams. A minimum 100 ft timber harvest buffer is occasionally required where significant resident fish populations occur (Tongass Timber Reform Act, 1991).

If stream harvest buffers are not required (Class III channels), harvest unit design should account for water quality protection requirements for these streams (BMPs 13.2, 13.3).

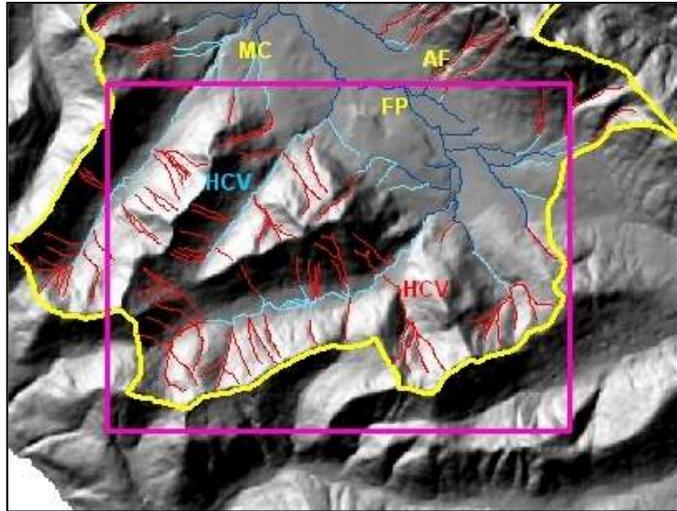
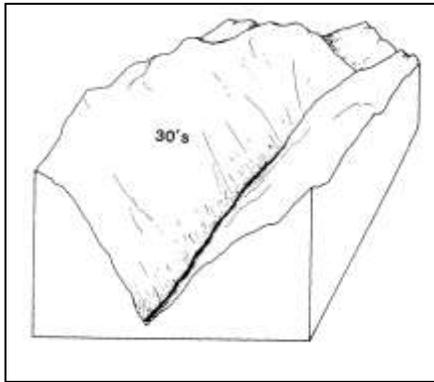
## **Riparian Management Opportunities**

Sport Fish Potential.....N/A

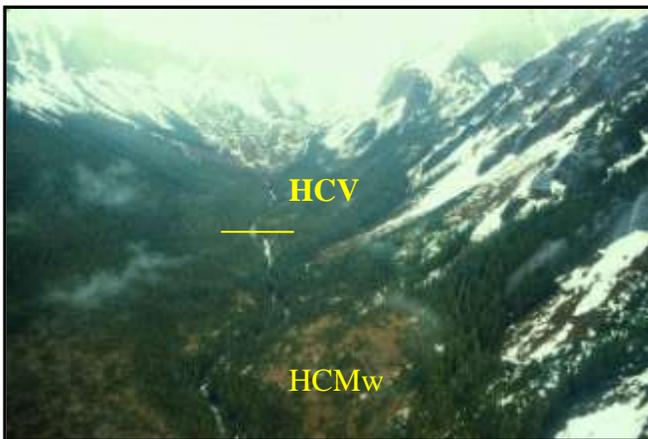
Enhancement Opportunities..... Large wood placement

Stream segments which are tributary to low gradient flood plain channels can provide opportunities for large wood placement to create pool habitat for resident or anadromous fish, particularly Dolly Varden char, cutthroat, and steelhead.

**High Gradient Upper Valley Channel – HCV**  
(Formerly - HC3 and HC8)

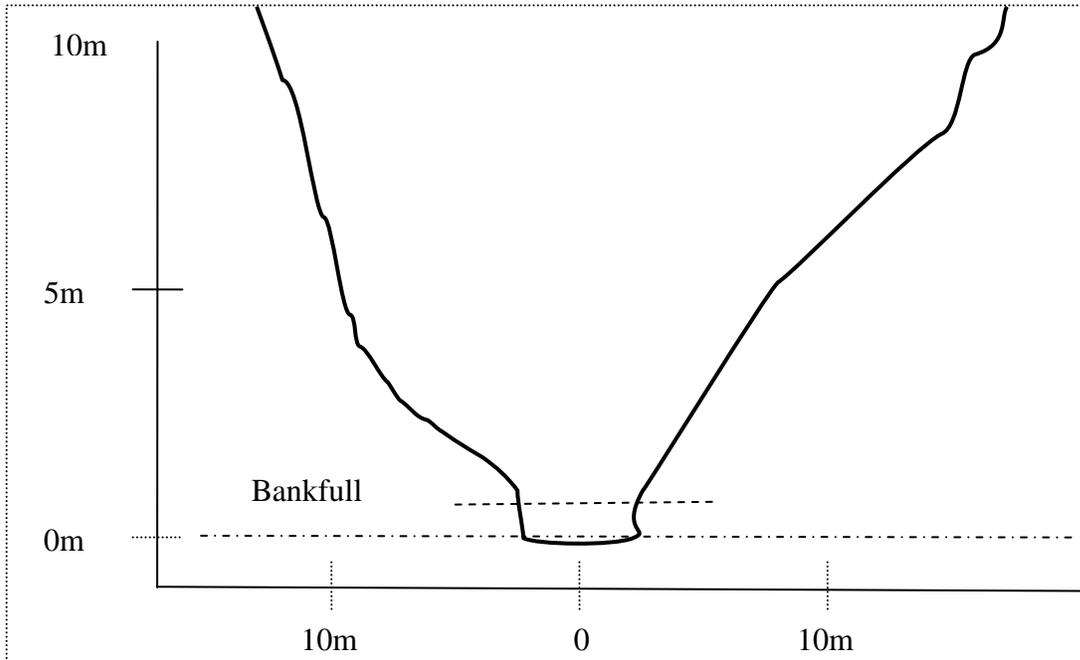


**Geomorphic Setting:** The HCV channel is found in steep sided narrow V-shaped, valleys. HCvs are typically upper valley tributaries. Valley sideslopes often extend immediately to the stream's edge, but can be separated by short, steep upper bank sideslopes. Flow containment is excellent, due to the deep incision and proximity of valley sideslopes. Cascades, low vertical falls and bedrock knickpoints are common features. HCVs can also be found in broken hilly or rolling terrain. In these situations, the stream is straight, moderate to deeply incised and directly controlled by steep hillslopes or bedrock fault lines.



The HCV is the upper section of the photo. Cascades and falls dominate the stream bed. The segment in the foreground is a HCMw.

**Channel Structure:**



**Channel Characteristics:**

- Stream Class..... II, III
- Stream gradient:..... greater than 6%,
- Incision Depth:..... Variable, valley sideslopes form upper banks
- Bankfull Width:..... Variable, mean = 7m (23 ft)
- Dominant Substrate:..... Small cobble to bedrock
- Streambank composition:..... Bedrock, alluvium or colluvium
- Sideslope Length:..... Variable , mean = 21m (69ft)
- Sideslope angle:..... Variable, mean = 62%;
- Channel Pattern:..... Singular, linear
- Drainage basin area:..... < 2.6 -13km<sup>2</sup> (1-5mi<sup>2</sup>)

**Riparian Vegetation:** The riparian plant communities are dominated by Western Hemlock series, non-forested salmonberry and Sitka alder shrub communities.

Plant Association Series	% cover
Western Hemlock	46%
Non-forest	16%
Sitka Spruce	13%
Western Hemlock-Alaska Cedar	12%
Western Hemlock-Red Cedar	5%
Mixed Conifer	4%

### Management Considerations

**Hydrologic Function:** HCV channels are sediment transport systems. Steep mountainslopes may contribute significant amounts of sediment from mass wasting. Steep channel gradients and high stream power limit sediment storage, therefore, sediment is rapidly delivered to downstream channels. Stream flow responds quickly to intense rainfall events.

Aquatic Habitat Capability	
Large Wood	2100ft <sup>3</sup> /1000 linear ft
Available Spawning Area	Insufficient data
Available Rearing Area	Insufficient data

Due to high streamflow velocities, HCV channels are generally not accessible to anadromous species. These channels contain very little spawning habitat for anadromous fish species, and, where accessible, minimal rearing habitat. Resident Dolly Varden char inhabit these streams to some extent. HCV channels typically affect downstream anadromous fish habitat through transport of sediment, large woody debris, nutrients and aquatic insects.

Indicator Species Ratings		
MIS	ASA	ARA
Coho	Low	Low
Pink	Negligible	Negligible
Chum	Negligible	Negligible
Sockeye	Negligible	Negligible
Dolly Varden	Low	Moderate
Steelhead	Negligible	Negligible

### Riparian Management Considerations

Maintenance of in channel large wood to trap sediments is a moderate riparian management concern (BMP 12.6)

These channels have moderate stream bank sensitivity, due to reaches with unconsolidated alluvium. Measures to protect stream bank sensitivity should be incorporated into riparian timber harvest prescriptions (BMPs 13.16, 13.9)

Concern of Management for:	
Large Wood	Moderate
Sediment Retention	Low
Stream Bank Sensitivity	Moderate
Sideslope Sensitivity	Moderate to High
Flood Plain Protection	N/A
Culvert Fish Passage	Low

Steep sideslopes are also frequently associated with the more deeply incised channel segments, therefore, road construction and timber yarding activities on these channels may pose a risk for mass erosion (BMPs 13.5, 13.9, 13.16, 14.2, 14.3, 14.7-14.9).

High sediment bed loads and debris loads transported by these streams present a significant risk to stream crossing structure and downstream fish habitat (BMPs 14.7, 14.20).

**Stream Class:** HCVs are Class II and III streams. A minimum 100 ft timber harvest buffer is occasionally required where significant resident fish populations occur (Tongass Timber Reform Act, 1991).

If stream harvest buffers are not required (Class III channels), harvest unit design should account for water quality protection requirements for these streams (BMPs 13.2, 13.3).

### **Riparian Management Opportunities**

Sport Fish Potential.....Low

Enhancement Opportunities..... Large wood placement

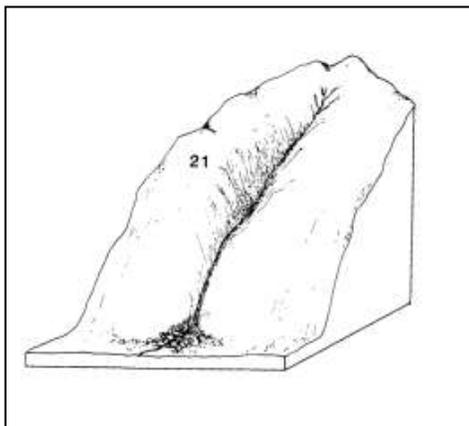
Placement of large wood structures can provide pool for Dolly Varden rearing, and increase spawning area.

### **Channel Type Phases:**

**HCVi – Glacial phase.** Formerly labeled as HC8. The HCVi emanates from a small upper valley glacier. Therefore glacial silt is carried by this channel. Riparian vegetation is dominated by non-forested plant communities such as salmonberry, willow and Sitka alder. No anadromous fish accessibility due barriers, as falls and cascades are common features. If connected to a larger Glacial Outwash river system, some Class I habitat may be present in transitional lower gradient reaches near the confluence with the main valley river. Peak flow occurs during the spring/summer melt season and again in the fall during the heavy rainfall season.



**High Gradient Contained Deeply Incised – HCD**  
(formerly HC4, HC6 and HC9)

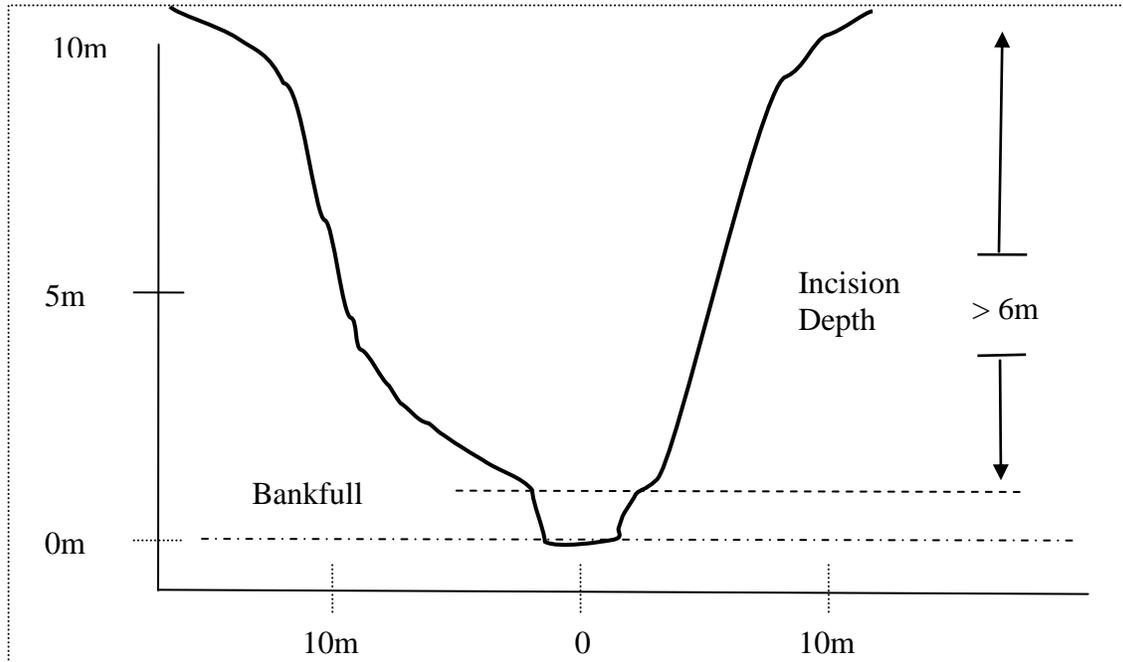


**Geomorphic Setting:** HCD channels are found on mountainslopes and hill landforms. They occur in large ravines, with a consistent sideslope length greater than 10m (33ft). They usually begin as first order streams and commonly extend to ridge tops and summits. HCDs may extend from the alpine zone to the footslope or valley floor landforms. Snow avalanche chutes may be associated with HCD channels. On steep mountainslopes along inlets and straits, these channels may extend directly to saltwater.

**Riparian Vegetation:** The riparian plant communities are dominated by Western Hemlock series, non-forested communities, which occur on disturbed channel sideslopes, are also common.

Plant Association Series	% cover
Western Hemlock	41%
Non-forest	15%
Western Hemlock-Alaska Cedar	12%
Mixed Conifer	12%
Sitka Spruce	11%
Western Hemlock-Red Cedar	7%

## Channel Structure



### Channel Characteristics:

Stream Class: III

Stream gradient: > 6% mean = 27%

Incision Depth: > 6m, mean = 22m (73ft)

Bankfull Width: Variable, mean = 6m

Dominant Substrate: Bedrock, boulders, cobble

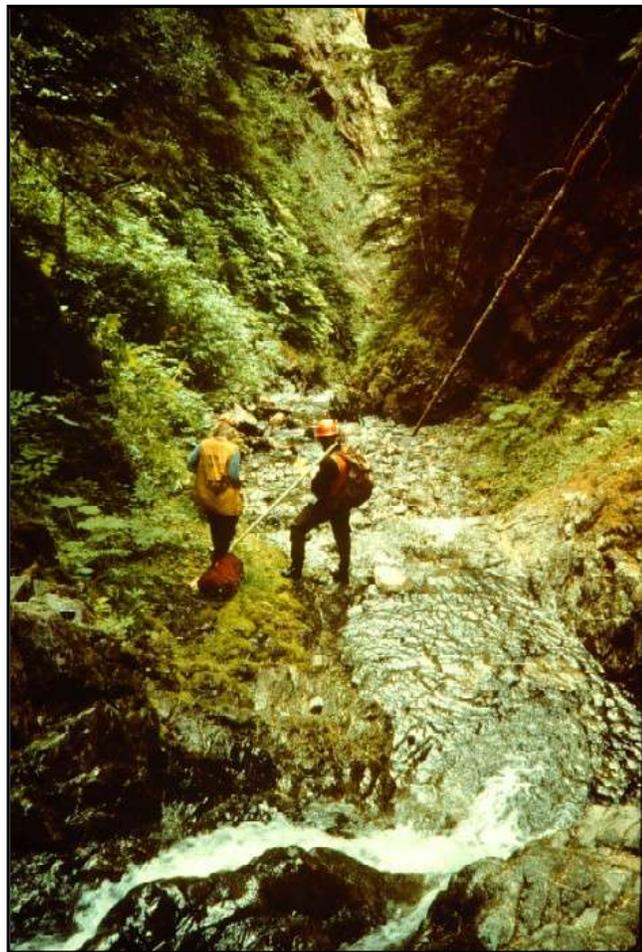
Streambank composition: Bedrock, alluvium or colluvium

Sideslope Length: > 10m (33ft), mean = 15m (50ft)

Sideslope angle: Very steep, mean = 115%

Channel Pattern: Singular, linear

Drainage basin area: < 2.6 km<sup>2</sup> (1mi<sup>2</sup>)



## Management Considerations

**Hydrologic Function:** HCD channels are sediment transport systems. Channel sideslopes are often highly unstable, with a high sediment input potential. Landslides entering the channel may result in debris torrents that scour a significant length of stream. Steep gradient channels rapidly deliver sediment to downstream reaches. Stream flow responds quickly to intense rainfall events. Short term entrapment of minor volumes of sediment is provided by large wood. These deposits rapidly become mobile during high flow events.

Aquatic Habitat Capability	
Large Wood	4500ft <sup>3</sup> /1000 linear ft
Available Spawning Area	Insufficient data
Available Rearing Area	Insufficient data

HCD channels are generally not accessible to anadromous or resident fish species because of high stream gradient, high flow velocity in seasonally low water and migration barriers. These channels contain negligible spawning habitat.

Indicator Species Ratings		
MIS	ASA	ARA
Coho	Negligible	Negligible
Pink	Negligible	Negligible
Chum	Negligible	Negligible
Sockeye	Negligible	Negligible
Dolly Varden	Negligible	Negligible
Steelhead	Negligible	Negligible

## Riparian Management Considerations

Large woody debris is a relatively important factor controlling the routing of sediment through HCD channels. Considerable in-channel storage of sediment occurs behind log steps and small debris jams, however, retention of fine sediment is low due to high stream flow energy. Excessive amount of large wood in these channels can be a factor in the initiation of destructive debris torrents (BMP 12.6)

Concern of Management for:	
Large Wood	Moderate
Sediment Retention	Low
Stream Bank Sensitivity	Moderate
Sideslope Sensitivity	High
Flood Plain Protection	N/A
Culvert Fish Passage	Low

Sideslope sensitivity and erosion potential are high in HCD channels due to over steepened slopes (BMPs 13.5, 13.9, 3.16, 14.2, 14.3, 14.7-14.9, 14.17). Stream bank and sideslope disturbance associated with road cuts and timber yarding may result in mass wasting and significant sediment delivery to downstream channels.

High bed load sediment and debris loads carried in these streams can pose a high risk to stream crossing structures and downstream fish habitat (BMPs 14.17, 14.20).

**Stream Class:** HCDs are Class III streams. A minimum 100 ft timber harvest buffer is occasionally required where significant resident fish populations occur (Tongass Timber Reform Act, 1991).

**Riparian Management Opportunities**

Sport Fish Potential.....N/A

Enhancement Opportunities..... N/As

## HCD Channel Type Phases

**HCDw – Wetland Phase** (formerly HC4);

**HCDi – Glacial Phase** (formerly HC9)

### **HCDw - High Gradient Deeply Incised wetland phase**



#### **Geomorphic Setting:**

**HCDw** channels are situated in wide valley footslopes lowlands with undulating terrain dominated by muskegs, muskeg plateaus and bench lands. Typically the landform slope is less than 60%. HCD channels draining steep mountainslopes are often immediately upstream of HCDw channels.

**Riparian Vegetation:** The riparian plant communities are dominated by Mixed Conifer series. Other common riparian plant communities include Shore pine, non-forested and Western Hemlock/blueberry series.

<b>Plant Association Series</b>	<b>% cover</b>
Mixed Conifer	40%
Shore Pine	15%
Non-forest	12%
Western Hemlock	10%
Western Hemlock-Red Cedar	10%



In-channel view of HCDw.

**Stream Class:** HCDw channels are Class II or III streams.

**HCDi – High Gradient Deeply Incised Glacial Phase**



**Geomorphic setting:**

HCDi is situated in upper valley or mountainslope and emanates from alpine glaciers.

**Function:**

The HCDi functions as sediment transport channels, glacial silt load is high. Peak flow occurs during the spring/summer melt season and again in the fall during the heavy rainfall season.

**Riparian Vegetation:** The riparian plant communities are dominated by non-forested Sitka alder and willow shrub and the Mountain Hemlock series.

Plant Association Series	% cover
Non-forest	62%
Mountain Hemlock	24%
Sitka Spuce-Cottonwood	8%
Western Hemlock	3%

**Aquatic Habitat**

These channels are inaccessible to anadromous and resident fish species due to high streamflow velocities and presence of local and downstream barriers.

**Riparian Management Considerations**

Stream bank and sideslope sensitivity are moderate for HCDi channels. Sideslope mass wasting of glacial till or shallow soils can contribute to sediment loads, however, sediment contributions from glacial meltwater tend to greatly overshadow in-channel sediment sources.

Concern of Management for:	
Large Wood	Low
Sediment Retention	Low
Stream Bank Sensitivity	Moderate
Sideslope Sensitivity	Moderate
Flood Plain Protection	N/A
Culvert Fish Passage	Low

High bedload sediment transport poses a significant risk to stream crossing structures (BMPs 14.17, 14.20).

**Stream Class:** HCDi are Class III streams.

**Riparian Management Opportunities**

Sport Fish Potential.....N/A  
 Enhancement Opportunities..... N/As

