Freshwater Atlas
Hierarchical Key Technical Documentation

Submitted To: Mark Sondheim and Stephanie Forbes
Base Mapping and Geomatic Services Branch
Ministry of Agriculture and Lands
Province of British Columbia

Submitted By: Refractions Research Inc.
400 - 1207 Douglas Street
Victoria, BC, V8W-2E7
Phone: (250) 383-3022
Fax: (250) 383-2140

Date: December 2005

Table of Contents

Figures

Tables

1 INTRODUCTION

Hierarchical keys provide the ability to process upstream/downstream queries without walking the stream network. They are based on the proportional distance along a stream where a child stream flows into its parent.

2 HIERARCHICAL KEY FORMAT

2.1 Hierarchical Key String Format

The hierarchical key is a 144 character string in the following format:

xxx	-	xxxxxx	-	xxxxxx	-	xxxxxx	-	xxxxxx	-	xxxxxx	...	xxxxxx
h1	-	h2	-	h3	-	h4	-	h5	-	h6	...	h21

The following table describes each of these 21 fields.

Table 1: Hierarchical Key Descriptions

Position	Case	Description
h1	All rivers.	Each hierarchical key has a three digit prefix representing the area of the province containing the stream. See section below for regions.
h2	If the river is on a coastal island (excluding Vancouver, Moresby, or Graham Island).	Unique island hierarchical key identifier. See Figure 8 below for imaginary reference line.
	If the river is on Vancouver, Moresby, or Graham Island.	Percent along the island where the river flows into the ocean. *Vancouver Island East* – percent from Church Point to Cape Scott eastwards (counter-clockwise). *Vancouver Island West* – percent from Church Point to Cape Scott westwards (clockwise) *Moresby Island* – percent around island from southern most point (clockwise) *Graham Island* – percent around island from Rose Spit (clockwise)

	If the river flows into the ocean from the BC mainland coast.	Percent along the coastline where the river meets ocean. *South Coast Rivers* – percent from 49°N (near Blaine WA) to Cape Caution *North Coast Rivers* – percent from Cape Caution to Hyder, BC *Alaska Rivers* – percent from Hyder, Alaska to 60°N *Washington Rivers* – percent down coastline from 49°N (near Blaine WA) to mouth of Columbia River
	If the river is a major river (Fraser, Columbia, etc.)	0 (Major rivers are identified by the hierarchical key prefix).
	All other rivers.	Percent along the river it flows into.
h3	If the river is on an island (excluding Vancouver, Moresby, or Graham Island).	Percent along island coastline (clockwise direction) from southern most point where the river hits the ocean.
	All other rivers.	Percent along the river it flows into.
h4 - ... - h21	All rivers.	Percent along the river it flows into.

2.2 Hierarchical Prefixes

Major Rivers

The following major rivers have unique hierarchical key prefixes. For these rivers, the prefix makes up the hierarchical key (i.e., the Hierarchical key for the Fraser River is 100).

Table 2: Hierarchical Key Prefixes of Major Rivers

Named River	Hierarchical Key Prefix
Fraser River	100
MacKenzie River	200
Columbia River	300
Skeena River	400
Nass River	500
Stikine River	600
Taku River	700
Yukon River	800
All Coastal	9**

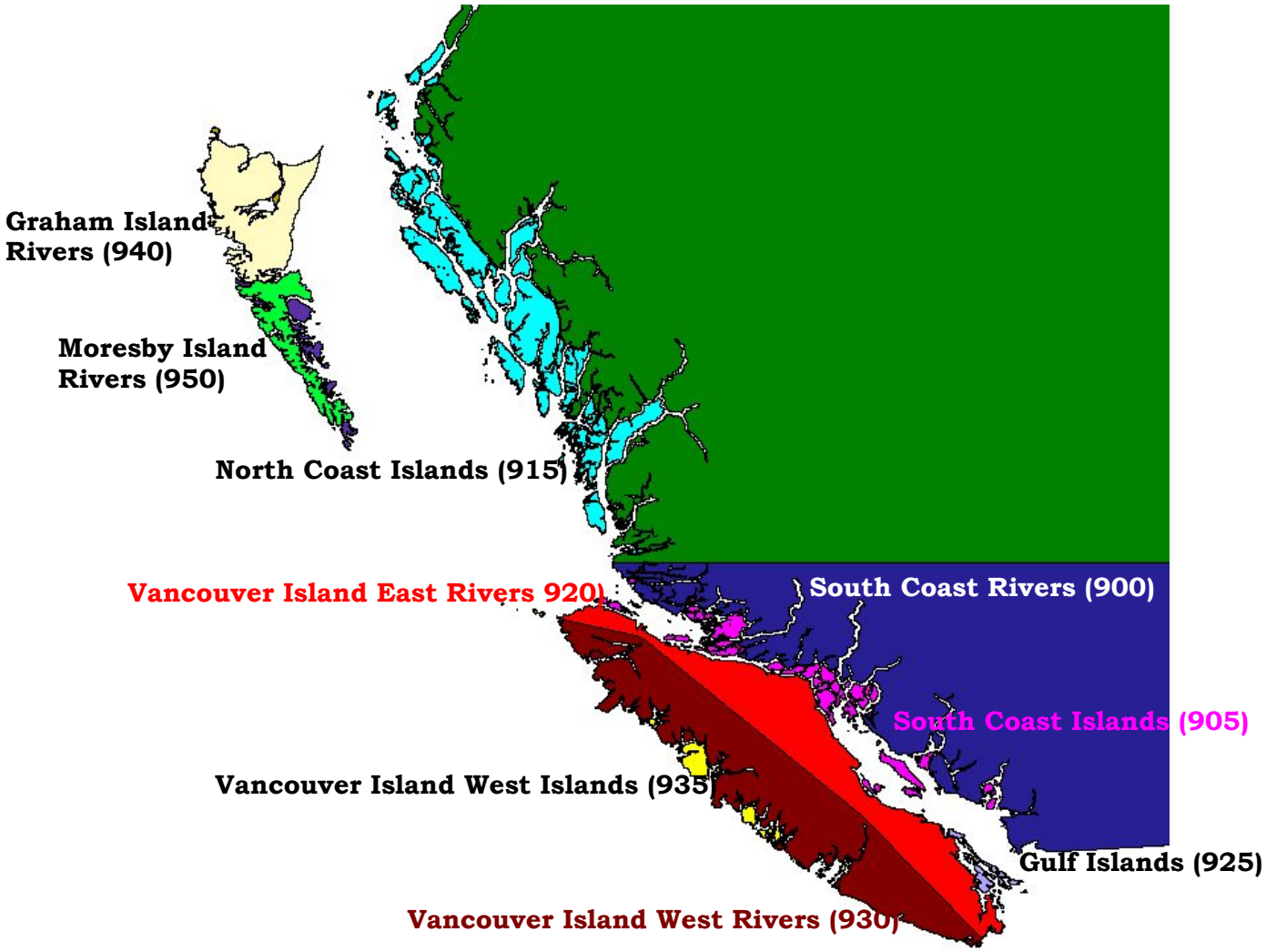
Coastal Regions

The following table lists the hierarchical key prefixes for the remaining coastal regions. The color column associates to the colors in figure 1.

Table 3: Coastal Hierarchical Key Prefixes

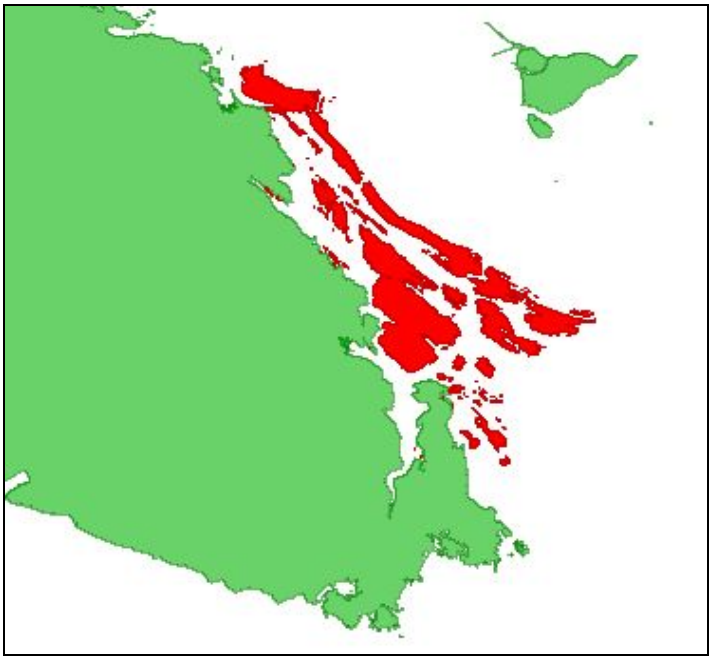
Region	Hierarchical Key Prefix	Location Description	Color
South Coast Rivers	900	South of Cape Caution	dark blue
South Coast Islands	905	South of Cape Caution	pink
North Coast Rivers	910	North of Cape Caution	dark green
North Coast Islands	915	North of Cape Caution	cyan
Vancouver Island East Rivers	920	Church Point to Cape Scott (East)	red
Vancouver Island East Gulf Islands	925	Gulf Islands	light blue
Vancouver Island West Rivers	930	Church Point to Cape Scott (West)	dark red
Vancouver Island West Islands	935	Church Point to Cape Scott (West)	yellow
Graham Island Rivers	940		cream
Graham Island Islands	945		brown
Moresby Island Rivers	950		light green
Moresby Island Islands	955		purple
Alaska Rivers	960	Hyder Alaska to south of the 60th parallel	n/a
Washington Coast Rivers	970	49°N (new Blaine, WA) to mouth of Columbia River	n/a
Alsek River	990		n/a

Figure 1: Hierarchical Prefixes



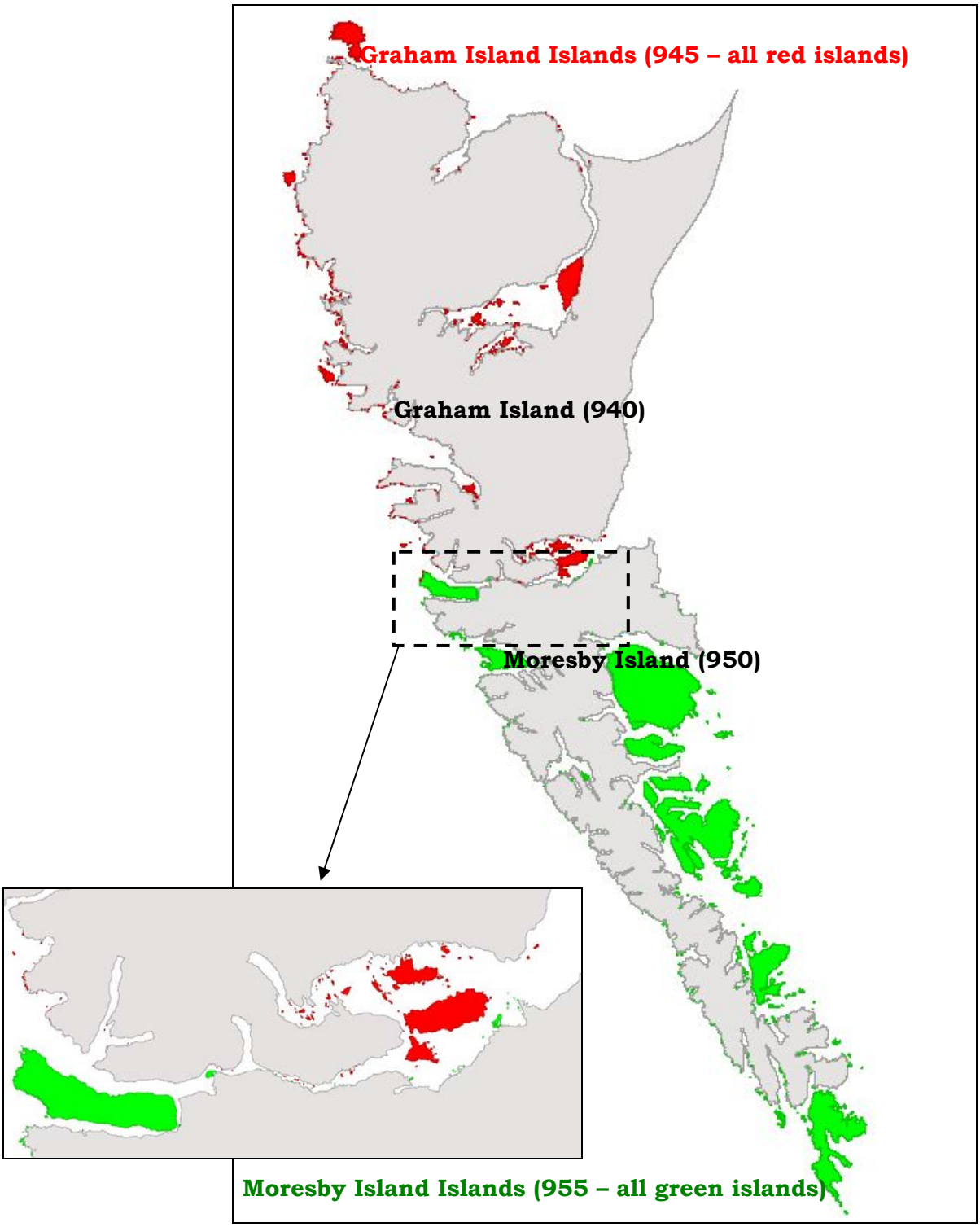
The following figure shows which islands are included as part of the Gulf Islands (prefix 925).

Figure 2: Gulf Islands (925)



The following figure shows which islands are a part of the Graham Island Islands group (red, prefix 945), and which are a part of the Moresby Island Islands group (green, prefix 950)

Figure 3: Moresby & Graham Island Islands



2.2.1 Hierarchical Key Prefix Requriements

The following is an email conversation with George Eade regarding the regions associated with salt water islands:

900 - South Coast Rivers - South of Cape Caution - All rivers that drain into the ocean in the following groups: SEYM, KNIG, KLIN, HOMA, TOBA, JERV, SQAM, LFRA – except for the Fraser River (prefix 100) in the LFRA group.

905 - South Coast Islands - South of Cape Caution - All coastal islands in the following mainland groups: SEYM, KNIG, KLIN, HOMA, TOBA, JERV, SQAM, LFRA, and the following Vancouver Island groups: COMX, CAMB, SALM, TSIT, NIMP, NEVI. Also any island in the PARK watershed group with it southern most point north of 485000 meters north (BC Albers). This is the approximate mouth of the Little Qualicum River.

910 - North Coast Rivers - North of Cape Caution - All rivers that drain into the ocean in the following groups: OWIK, NIEL, BELA, NECL, NASC, KTSU, KHTZ, LRDO, KITL, TSAY, LDEN, UDEN, ATNA, KITR, KEEC, MBNK, NBNK, KUMR, PORI, WORC, KSHR, LSKE.

915 - North Coast Islands - North of Cape Caution - All coastal islands in the following groups: OWIK, NIEL, BELA, NECL, NASC, KTSU, KHTZ, LRDO, KITL, TSAY, LDEN, LSKE, KITR, KEEC, MBNK, NBNK, KUMR, PORI, WORC, KSHR.

920 - East Coast Vancouver Island - All rivers in the following groups: VICT, COWN, PARK, COMX, CAMB, SALM, TSIT, NIMP, NEVI.

925 - Gulf Islands - All coastal islands in the VICT and COWN watershed groups. Also any island in the PARK watershed group with its southern most point south of 485000 meters north (BC Albers). This is the approximate mouth of the Little Qualicum River.

930 - West Coast Vancouver Island - All rivers in the following groups: HOLB, BRKS, TAHS, GOLD, CLAY, ALBN, SANJ.

935 - West Coast Coastal Islands - All coastal islands in the following watershed groups: HOLB, BRKS, TAHS, GOLD, CLAY, ALBN, SANJ.

940 - Graham Island

945 - Coastal Islands included in Graham Island (GRAI) watershed group

950 - Moresby Island

955 - Coastal Islands included in Moresby Island (MORI) watershed group

960 - Alaska

965 - Alaska Islands

970 - Washington State rivers

990 - Alsek River (TATR)

2.3 Hierarchical Keys and Side Channels/Distributaries

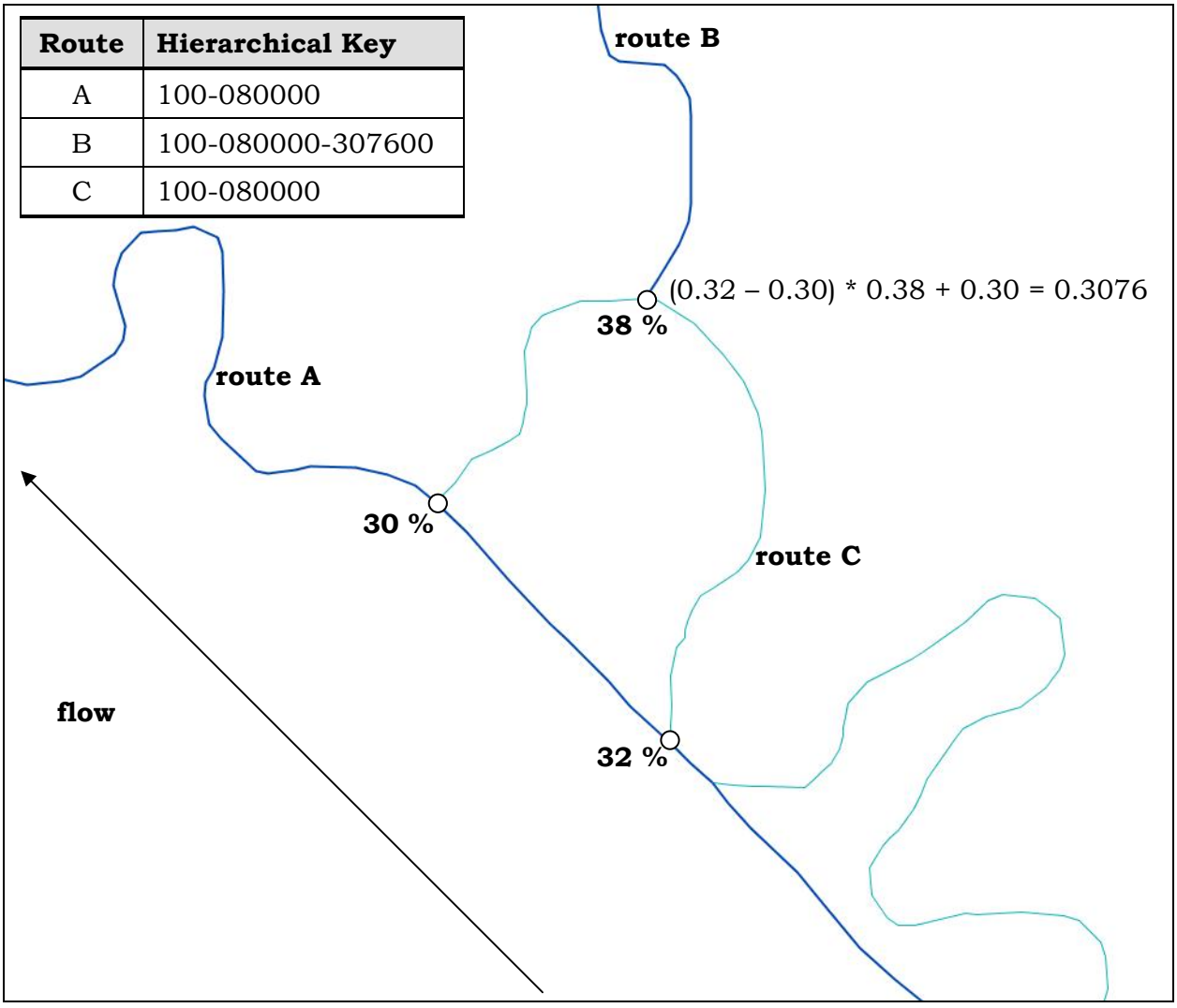
2.3.1 Side Channels

Side channels start and end on the same main flow; they are given the hierarchical key of their parent.

For main flows that flow into side channels, the hierarchical key is based upon both the percent along the side channel and where the side channel flows into the main flow.

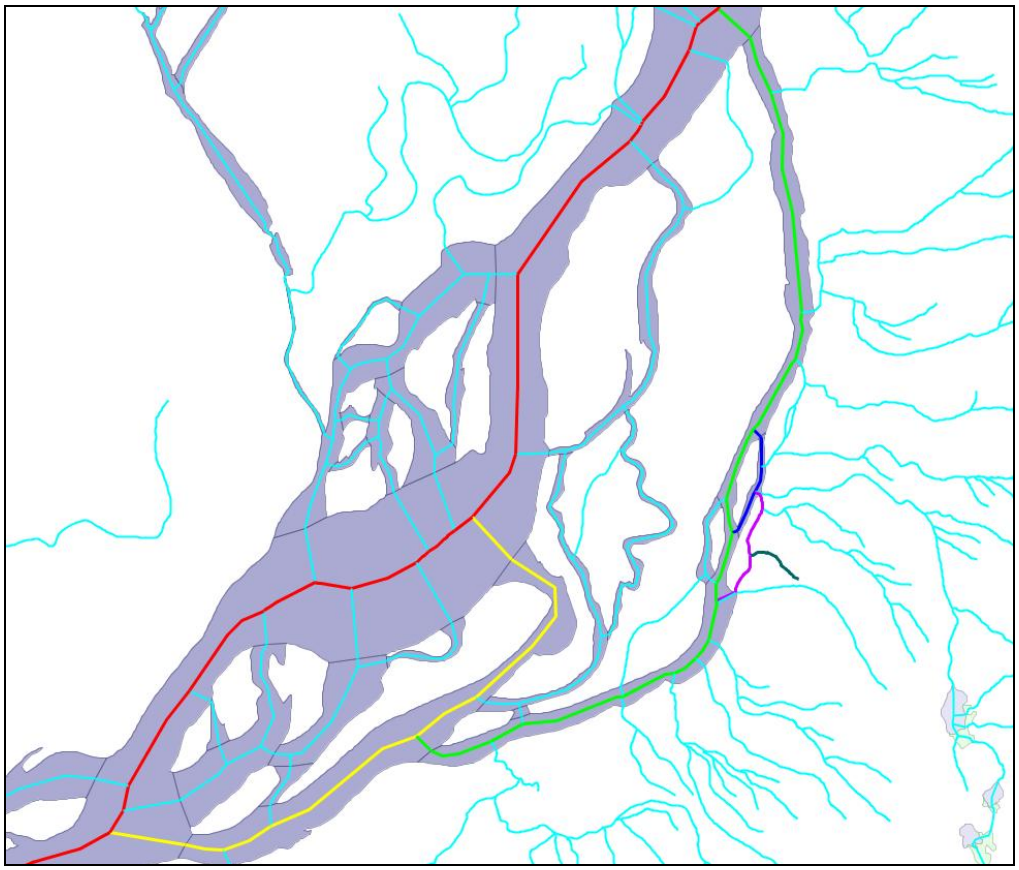
Figure 4: Side Channel Example I

Route	Hierarchical Key
A	100-080000
B	100-080000-307600
C	100-080000



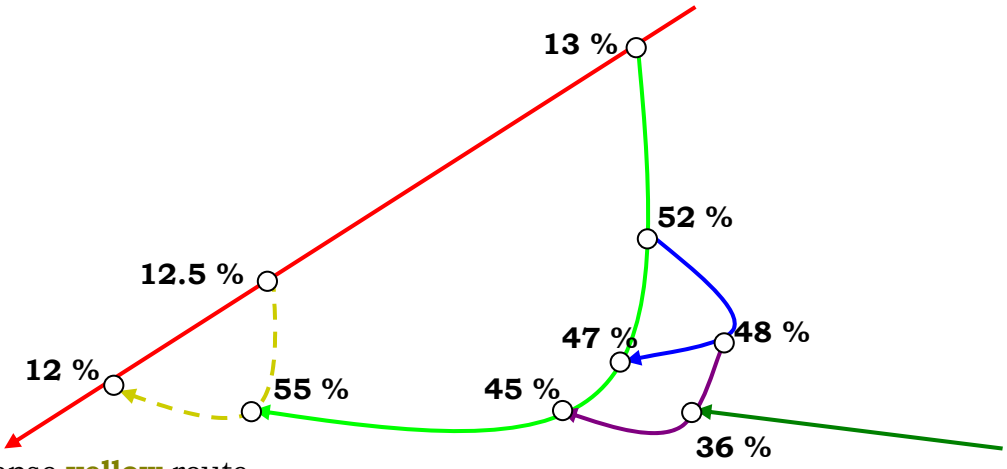
The following example (figures 5 and 6), outlines an example of how hierarchical keys are computer for streams that flow into side channels. This example outlines how the hierarchical key for the dark green primary flow is computed.

Figure 5: Side Channel Example II



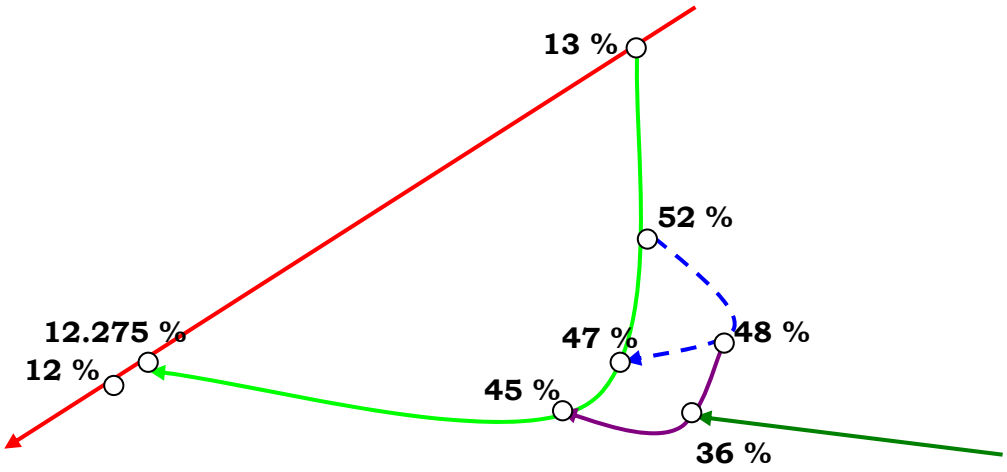
Route	Type	Hierarchical Key
red	primary	100-080000
yellow	secondary	100-080000
green	secondary	100-080000
blue	secondary	100-080000
purple	secondary	100-080000
dark green	primary	100-080000–126127

Figure 6: Side Channel Example II



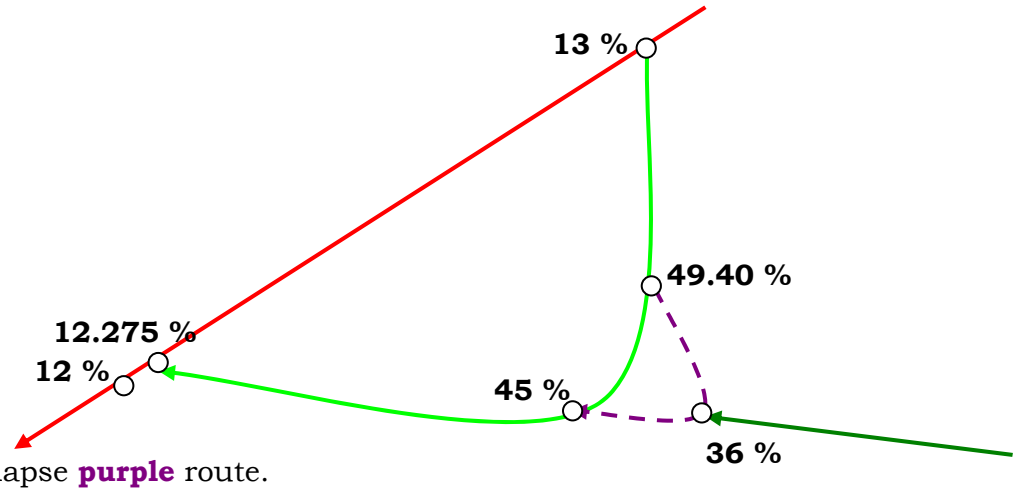
1. Collapse **yellow** route.

(0.125 – 0.12) * 0.55 + 0.12 = 0.12275



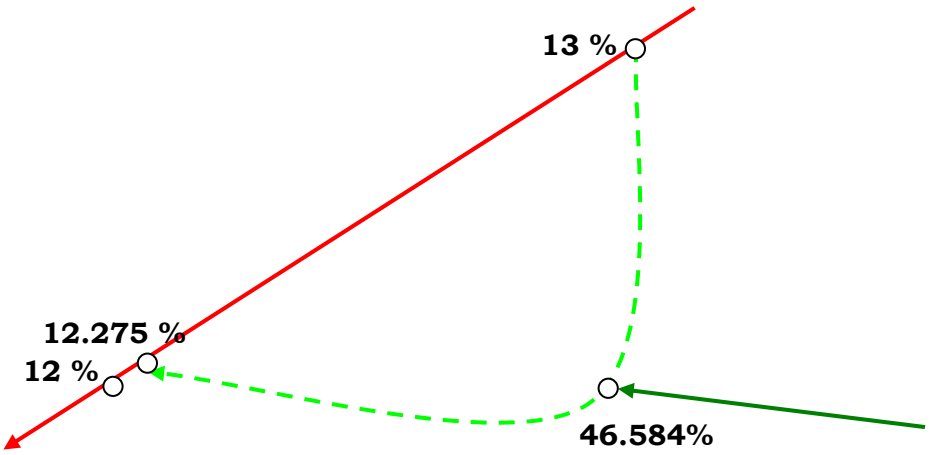
2. Collapse **blue** route.

(0.52 – 0.47) * 0.48 + 0.47 = 0.4940



3. Collapse **purple** route.

(0.4940 – 0.45) * 0.36 + 0.45 = 0.465840



4. Collapse **green** route for hierarchical keys for dark **green** route.

(0.13 – 0.12275) * 0.46584 + 0.12275 = 0.1261273400

2.3.2 Distributaries

Distributaries start on one mainflow and end on another; they are given the hierarchical key of their parent mainflow.

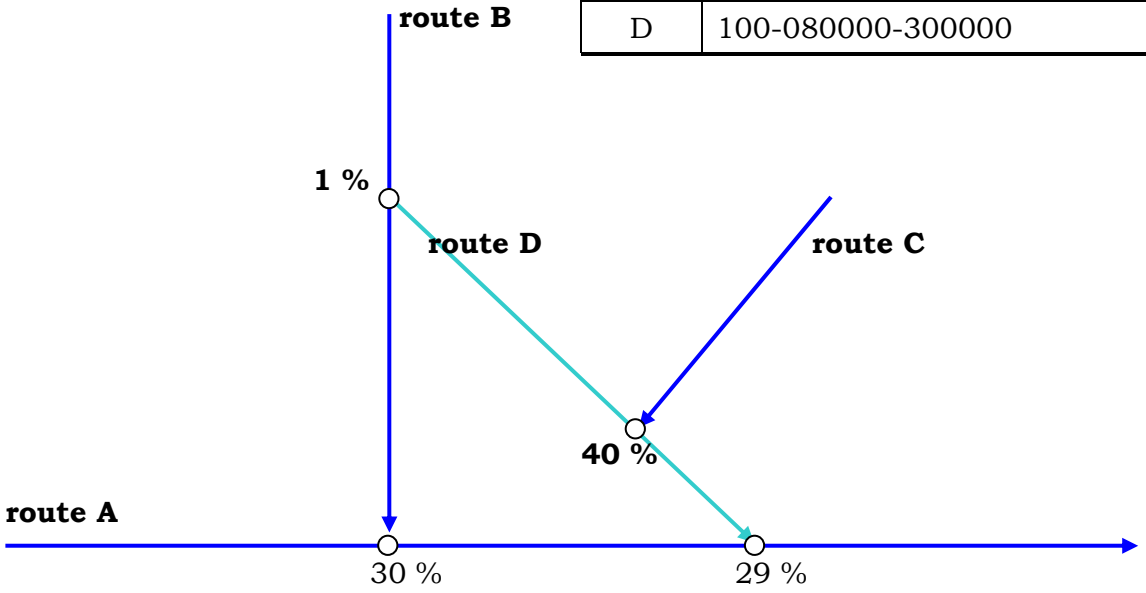
Main flows which flow into distributaries are given a hierarchical key based on the percent along the distributary and where the distributary leaves the main flow.

The following figures show how distributaries are collapsed to look like side channels. They are then computed in similar fashion to side channels (the distributary flows into the main flow at its sink).

Figure 7 below, outlines how Hierarchical Keys are computed for a simple single distributary.

Figure 7: Distributary Example I

Route	Hierarchical Key
A	100-080000
B	100-080000-300000
C	100-080000-300000-004000
D	100-080000-300000



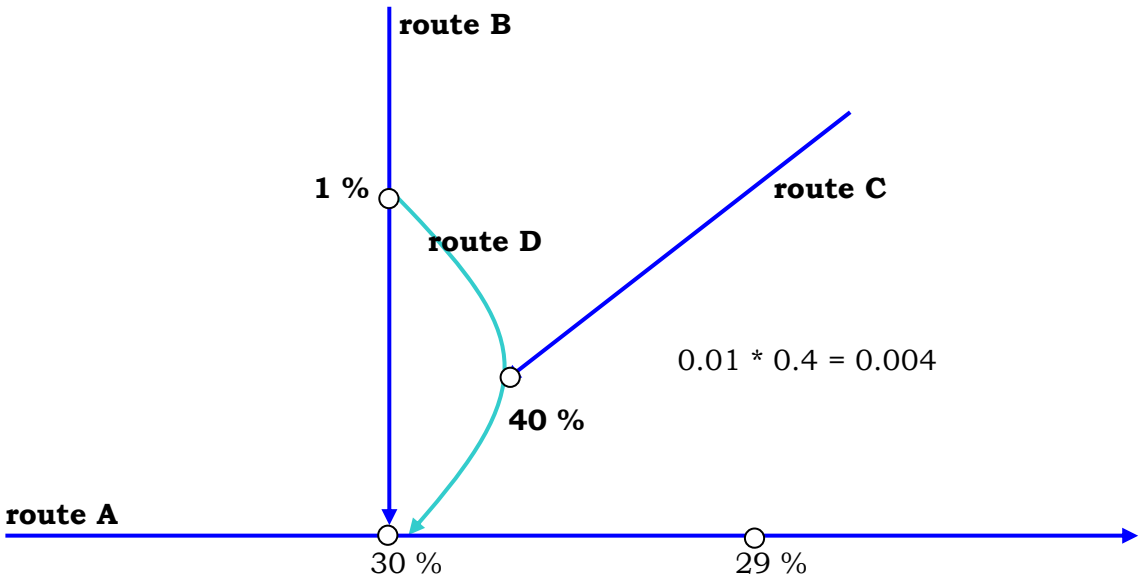
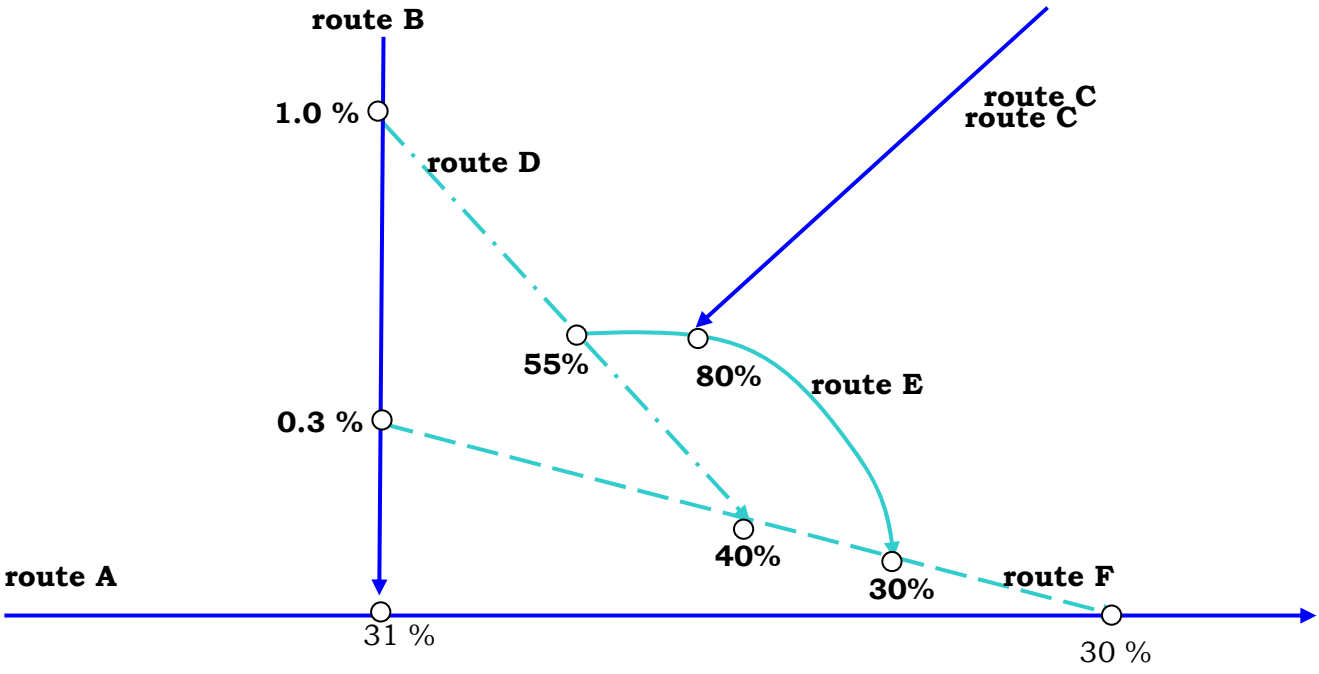
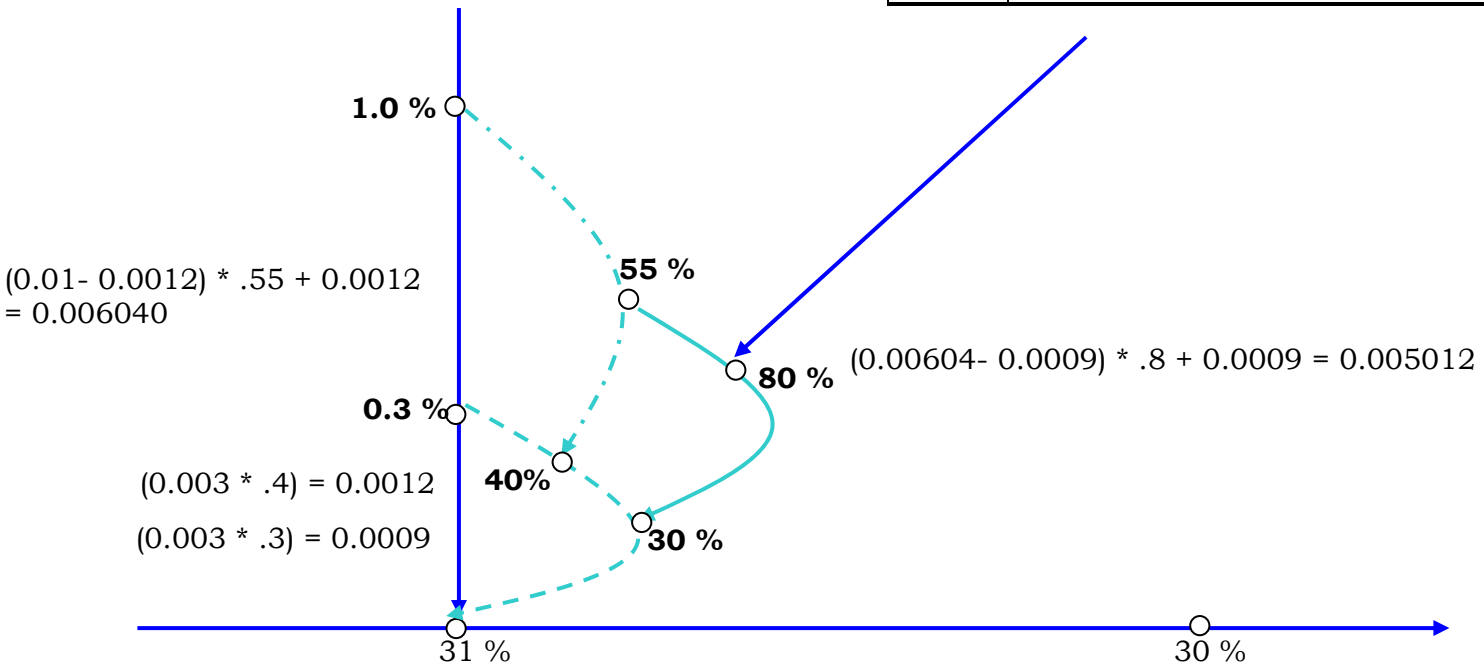


Figure 8 shows a more complex distributary example, involving multiple distributaries.

Figure 8: Distributary Example II



Route	Hierarchical Key
A	100-080000
B	100-080000-310000
C	100-080000-310000-005012
D	100-080000-310000
E	100-080000-310000
F	100-080000-310000



2.4 Island Hierarchical keys

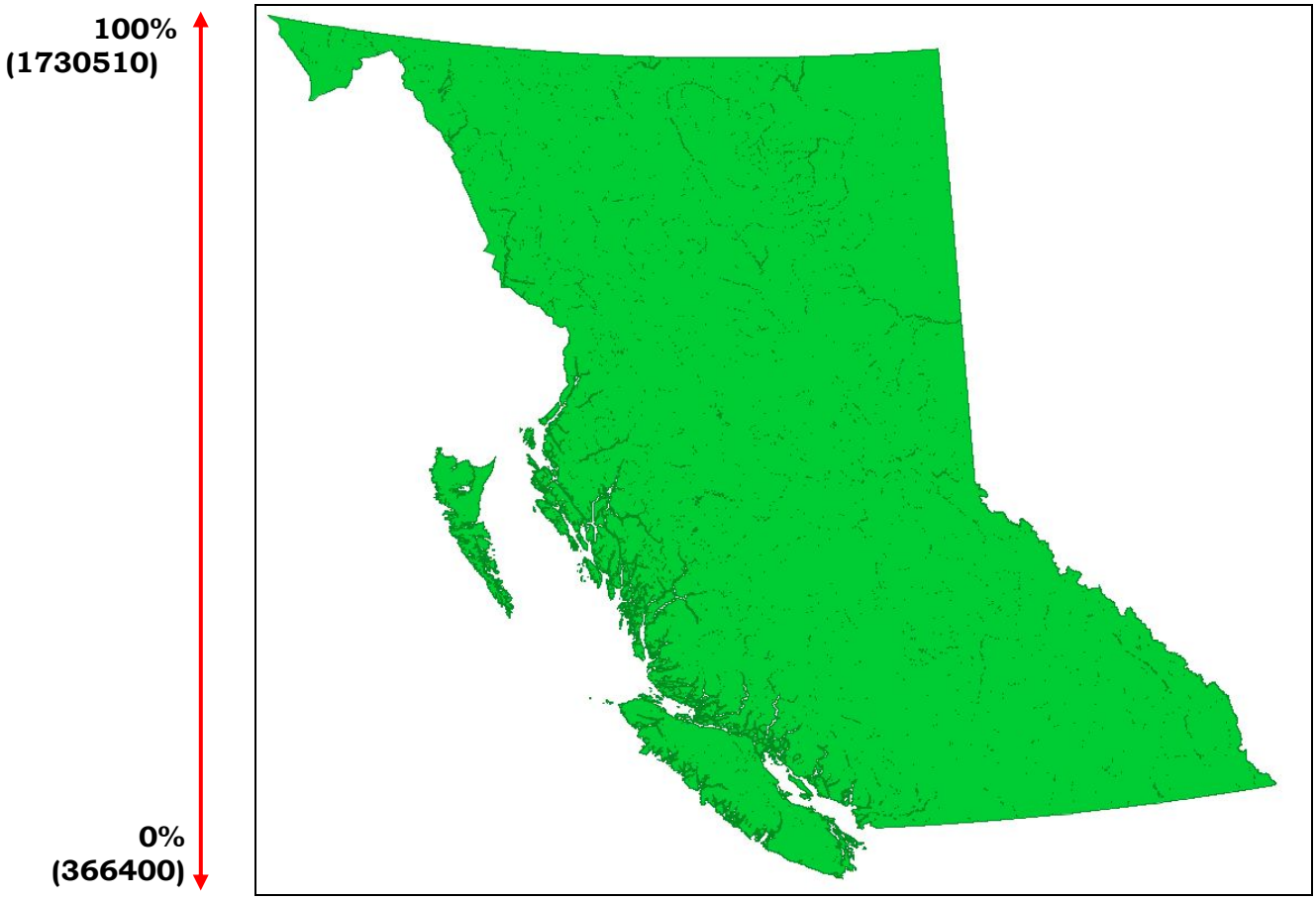
Islands are given unique hierarchical keys which are generated by calculating where the island is located in relation to a vertical sliding scale that starts at 0 in the south and reaches 100% at the northern part of the province. This is shown in figure 9.

Vancouver Island, Moresby Island, Graham Island are not given unique hierarchical keys. The rivers on these islands have unique hierarchical prefixes for identifying rivers on islands.

Southern Most Point (albers): 366400

Northern Most Point (albers): 173510

Figure 9: Island Hierarchical Keys



3 POSSIBLE ISSUES

1. The double precision[1] value is stored in the database for proportional distances. As a result, these numbers are highly unlikely to be the same; however, the formatted hierarchical key value must also be unique and in many cases rounding the proportional distances will result in non-unique values. This is dealt with by increasing the formatted hierarchical key of the route with the large proportional distance by one. This increase is propagated so that no two routes have the same formatted hierarchical key.

   This applies to both rivers and coastal islands (not including Vancouver Island, Moresby Island and Graham Island).

2. There are a few cases where a route flows into another route very close to the head of the river (within 0.003 meters from the headwater). In these cases the formatted hierarchical key value will be 100% along the route it flows into. There is no space for hierarchical keys greater than or equal to 100%; therefore, these values are decreased by one.

3. These are also cases where the route flows into another route very close to the mouth of the river. A hierarchical key can not have a formatted value of 0% so it is increased by one.

[1] double precision values range from 1E-307 to 1E+308 with a precision of at least 15 digits

4 DATABASE STORAGE

Hierarchical keys are stored in the database as a proportional distance in the *hkey* field of the *fwa_routes* table.

Each route (*fwa_routes*) has a proportional distance value (*hkey*) that represents either:

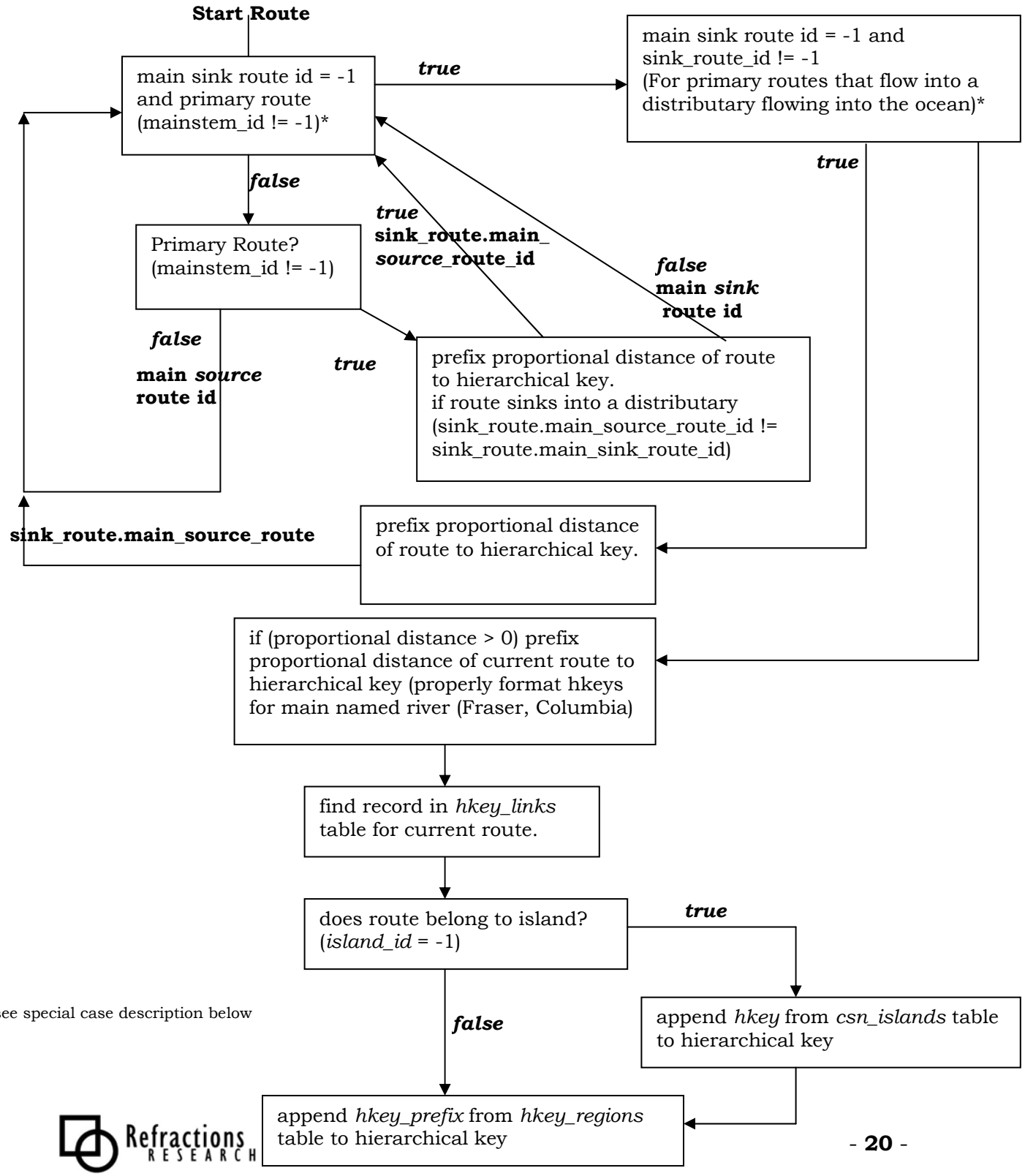
- the percent along the river it flows into; or
- the island it flows off of; or
- the coastline for rivers that flow off the mainland (or Vancouver, Moresby, Graham Island).

The *fwa_hkey_links* table links routes that sink into the ocean with the correct hierarchical prefix (*region_id*). There will be no entry in the table for rivers which sink into other rivers. This table also links routes on islands that flow into the ocean with the associated island the route is on (*island_id*).

The *mainstem_id* field from the *fwa_routes* table will identify primary and secondary routes. Routes with mainstems_ids > 0 are primary routes; routes with mainstem_id = -1 are secondary routes.

The derived hierarchical key is stored in the *fwa_routes* table for the route and the *fwa_islands* table for the islands.

5 DERIVING HIERARCHICAL KEYS FROM PROPORTIONAL DISTANCE

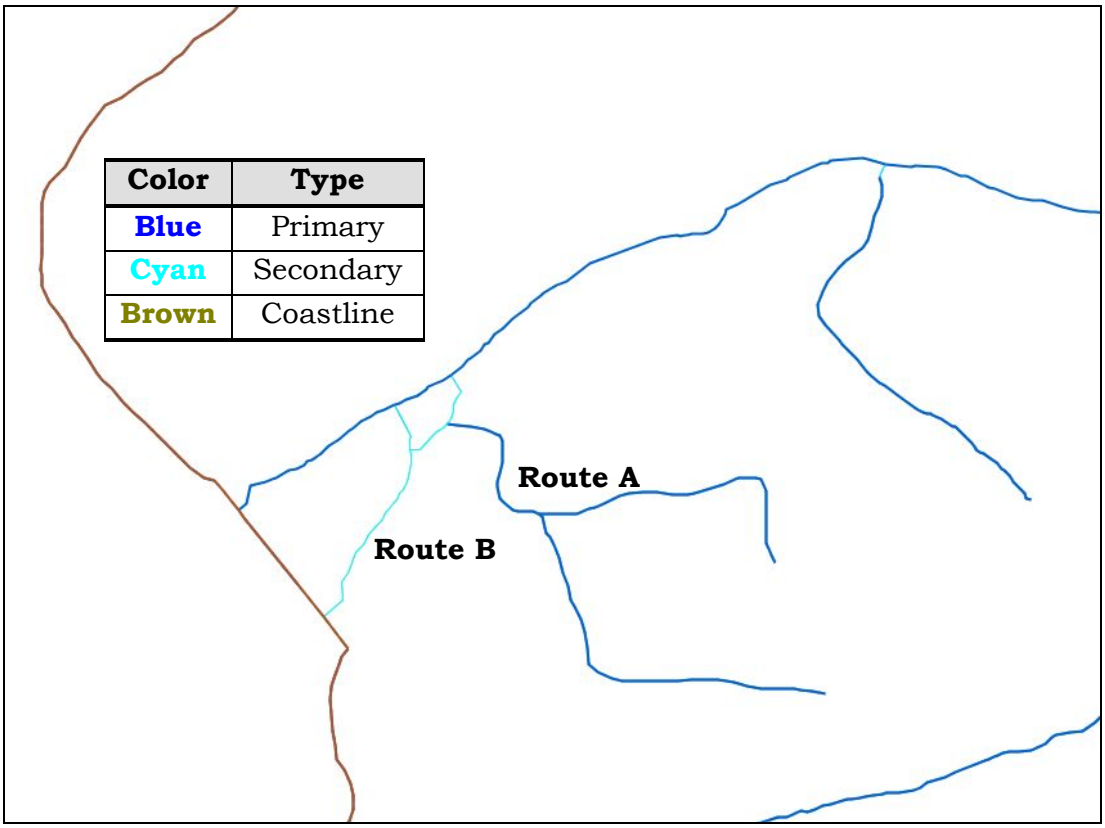


* see special case description below

Routes that are non-primary routes that flow into the ocean (such as Route B shown in figure 10), need to have the proportional distance of their parent added to the hierarchical key.

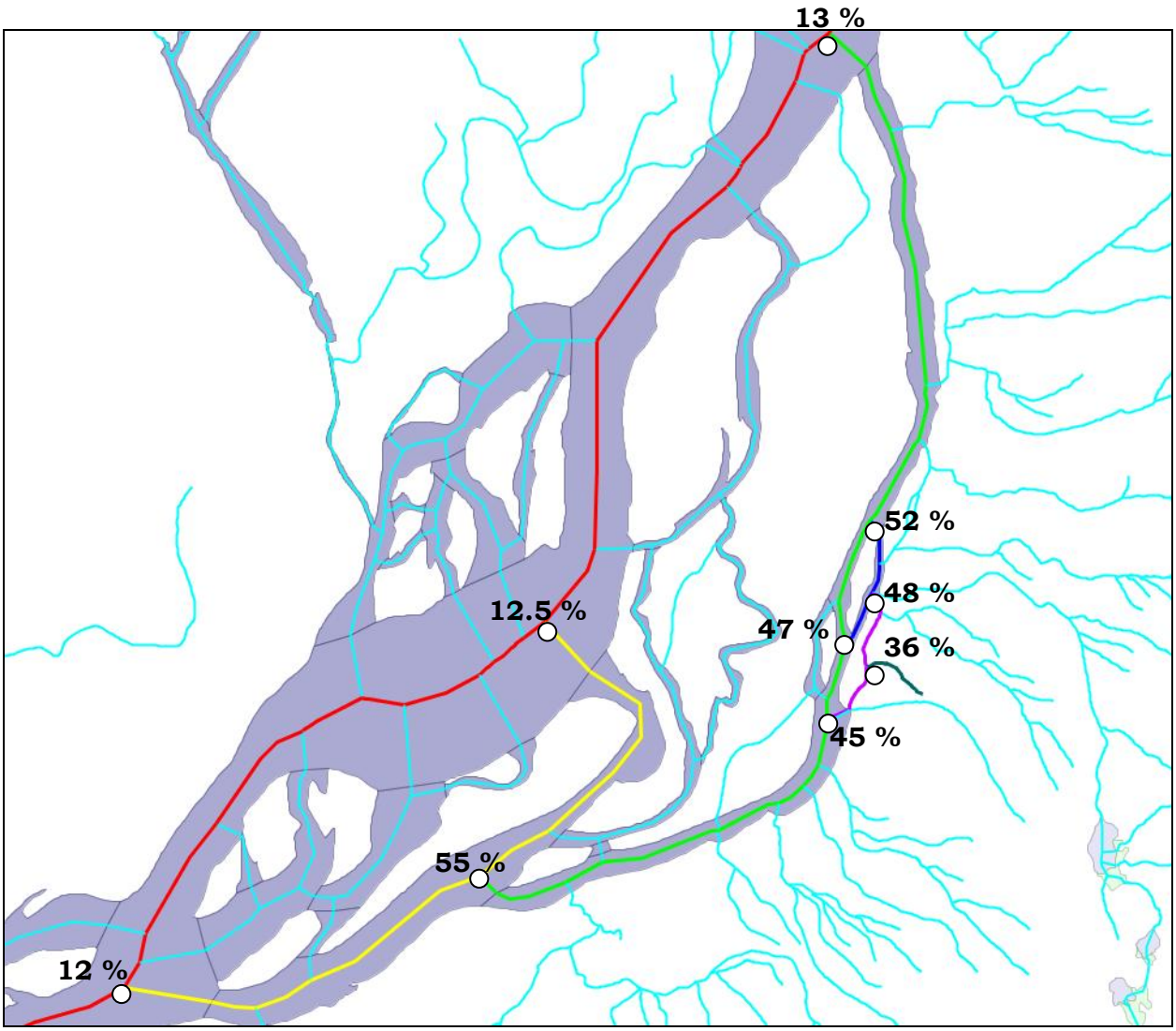
Routes that sink into a secondary flow which sinks into the oceans (Route A) need to have the proportional distance of the primary source route of the secondary flow added to the hierarchical key.

Figure 10: Derive Keys Special Cases



5.1 Deriving Hierarchical Keys Example I

The following figures and tables provide an example of how the formatted hierarchical keys are derived from the proportional upstream percentage and the route source/sink information.



Route	Type	Route Identifier	Hierarchical Key
red	primary	A	100-080000
yellow	secondary	B	100-080000
green	secondary	C	100-080000
blue	secondary	D	100-080000
purple	secondary	E	100-080000
dark green	primary	F	100-080000–126127

Assume that **route A** flows into the ocean at 45% along the southern part of the bc coastline.

fwa_routes

route_id	source route_id	sink route_id	main source route id	main sink route id	mainstem_id	hkey
A	-1	-1	-1	-1	1	0.45
B	A	A	A	A	-1	0.45
C	B	A	A	A	-1	0.45
D	C	C	A	A	-1	0.45
E	D	C	A	A	-1	0.45
F	-1	E	-1	A	2	0.1261273400

fwa_hkey_links

route_id	region_id	island_id
A	1	-1

fwa_hkey_regions

region_id	hkey_prefix	prefix_name	direction	start_location	finish_location
1	900	south coast rivers	northwards	49°N (near Blaine WA)	Cape Caution
2	905	south coast islands	clockwise		

To generate the hierarchical key for route F using these tables, the following steps are performed:

1. Find the sink/source/mainstem_id/hkey associated with route F.

route_id	source route_id	sink route_id	main source route id	main sink route id	mainstem_id	hkey
A	-1	-1	-1	-1	1	0.45
B	A	A	A	A	-1	0.45
C	B	A	A	A	-1	0.45
D	C	C	A	A	-1	0.45
E	D	C	A	A	-1	0.45
F	**-1**	**E**	**-1**	**A**	**2**	**0.126127340**

Route F is a main flow (mainstem_id != -1). Prefix the proportional distance associated with route F to the end of the hierarchical key.

Hierarchical Key: 126127

2. Find the sink/source/mainstem/hkey associated with route A (main sink route id of route F).

route_id	source route_id	sink route_id	main source route id	main sink route id	mainstem_id	hkey
A	**-1**	**-1**	**-1**	**-1**	**1**	**0.45**
B	A	A	A	A	-1	0.45
C	B	A	A	A	-1	0.45
D	C	C	A	A	-1	0.45
E	D	C	A	A	-1	0.45
F	-1	E	-1	A	2	0.126127340

Route A is a main flow (mainstem_id != -1). Prefix the proportional distance associated with route A to the end of the hierarchical key.

Hierarchical Key: 450000-126127

3. Route A has no sink route; therefore we look at *fwa_hkey_links* for route A.

fwa_hkey_links

route_id	region_id	island_id
A	**1**	**-1**

The *island_id* from *fwa_hkey_links* table is –1 therefore we know that route A is not on an island.

4. Find the *hkey_prefix* from the *fwa_hkey_regions* using the *region_id* from *fwa_hkey_links* table. Append this value to the front of the hierarchical key.

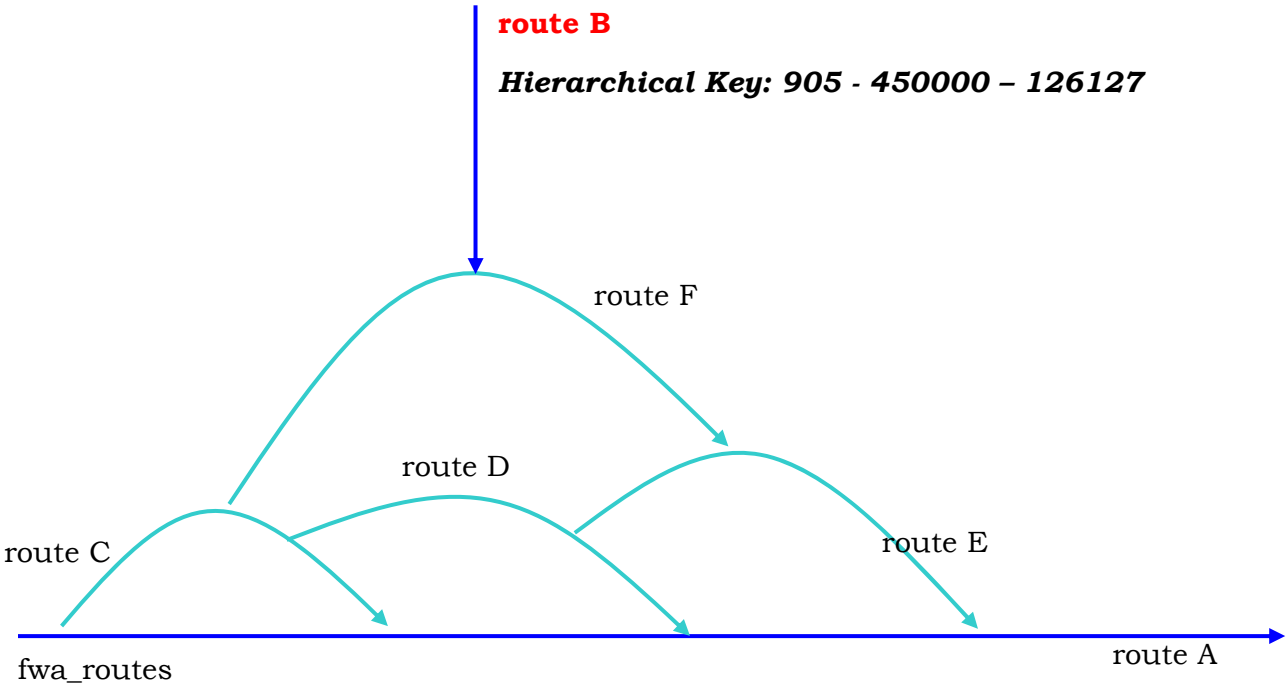
Hierarchical Key: 900 - 450000 – 126127

fwa_hkey_regions

region_id	hkey_prefix	prefix_name	direction	start_location	finish_location
1	**900**	**south coast rivers**	**northwards**	**49°N (near Blaine WA)**	**Cape Caution**
2	905	south coast islands	clockwise		

5.2 *Deriving Hierarchical Keys Example II*

The following figures and tables provide another example of how the formatted hierarchical keys are derived from the proportional upstream percentage and the route source/sink information.



fwa_routes

route_id	source route_id	sink route_id	main source route_id	main sink route_id	mainstem_id	proportional distance
A	-1	-1	-1	-1	1	0.45
B	-1	F	-1	A	2	0.60
C	A	A	A	A	-1	0.45
D	C	A	A	A	-1	0.45
E	D	A	A	A	-1	0.45
F	C	E	A	A	-1	0.45

fwa_hkey_links

route_id	region_id	island_id
A	2	707

csn_islands

island_id	island_hkey
707	002456

fwa_hkey_regions

region_id	hkey_prefix	prefix_name	direction	start_location	finish_location
1	900	south coast rivers	northwards	49°N (near Blaine WA)	Cape Caution
2	905	south coast islands	clockwise		

From these tables to generate the hierarchical key for route B:

1. Find the sink/source/mainstem_id/hkey associated with route B

route_id	source route_id	sink route_id	main source route_id	main sink route_id	mainstem_id	hkey
A	-1	-1	-1	-1	1	0.45
B	**-1**	**F**	**-1**	**A**	**2**	**0.60**
C	A	A	A	A	-1	0.45
D	C	A	A	A	-1	0.45
E	D	A	A	A	-1	0.45
F	C	E	A	A	-1	0.45

Route B is a main flow (mainstem_id != -1). Prefix the proportional distance associated with route B to the end of the hierarchical key.

Hierarchical Key: 600000

2. Find the sink/source/mainstem/hkey associated with route A (main sink route id of route B)

route_id	source route_id	sink route_id	main source route_id	main sink route_id	mainstem_id	hkey
A	**-1**	**-1**	**-1**	**-1**	**1**	**0.45**
B	-1	F	-1	A	2	0.60
C	A	A	A	A	-1	0.45
D	C	A	A	A	-1	0.45
E	D	A	A	A	-1	0.45
F	C	E	A	A	-1	0.45

Route A is a main flow (mainstem_id != -1). Prefix the proportional distance associated with route A to the end of the hierarchical key.

Hierarchical Key: 450000-600000

3. Route A has no sink route; therefore look in the *fwa_hkey_links* for route A.

route_id	region_id	island_id
A	**2**	**707**

4. The *island_id* from *fwa_hkey_links* table is 707 therefore we look in the *csn_islands* table to find the hkey associated with island 707 and prefix this to the hierarchical key.

island_id	island_hkey
707	**002456**

Hierarchical Key: 002456-450000-600000

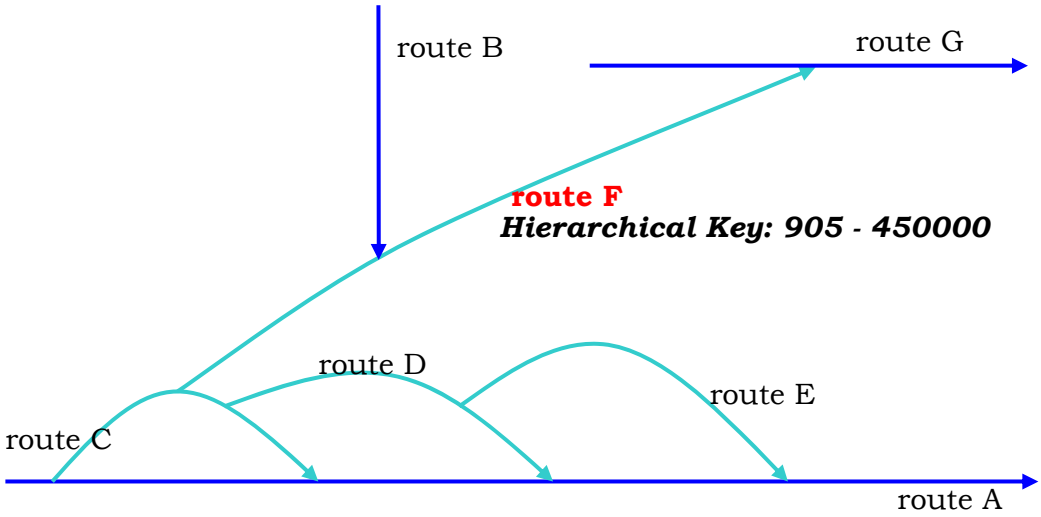
5. Find the *hkey_prefix* from the *fwa_hkey_regions* using the *region_id* from *fwa_hkey_links* table. Append this value to the front of the hierarchical key.

region_id	hkey_prefix	prefix_name	direction	start_location	finish_location
1	900	south coast rivers	northwards	49°N (near Blaine WA)	Cape Caution
2	**905**	**south coast islands**	**clockwise**		

Hierarchical Key: 905 - 450000 – 126127

5.3 *Deriving Hierarchical Keys Example III*

The following figures and tables provide another example of how the formatted hierarchical keys are derived from the proportional upstream percentage and the route source/sink information.



fwa_routes

route_id	source route_id	sink route_id	main source route_id	main sink route_id	mainstem_id	proportional distance
A	-1	-1	-1	-1	1	0.45
B	-1	F	-1	A	2	0.60
C	A	A	A	A	-1	0.45
D	C	A	A	A	-1	0.45
E	D	A	A	A	-1	0.45
F	C	G	A	G	-1	0.45
G	-1	-1	-1	-1	3	0.77

fwa_hkey_links

route_id	region_id	island_id
A	1	-1
G	1	-1

fwa_hkey_regions

region_id	hkey_prefix	prefix_name	direction	start_location	finish_location
1	900	south coast rivers	northwards	49°N (near Blaine WA)	Cape Caution

2	905	south coast islands	clockwise		

From these tables to generate the hierarchical key for route F:

1. Find the sink/source/mainstem_id/hkey associated with route B

route_id	source route_id	sink route_id	main source route_id	main sink route_id	mainstem_id	proportional distance
A	-1	-1	-1	-1	1	0.45
B	-1	F	-1	A	2	0.60
C	A	A	A	A	-1	0.45
D	C	A	A	A	-1	0.45
E	D	A	A	A	-1	0.45
F	**C**	**G**	**A**	**G**	**-1**	**0.45**
G	-1	-1	-1	-1	3	0.77

2. F is a secondary route (mainstem_id = -1), therefore next compare the main source route_id (A) to the main sink route_id (G). These are different therefore F is a distributary.

3. Find the sink/source/mainstem_id/hkey associated with route A (the main **source** route of route F)

route_id	source route_id	sink route_id	main source route_id	main sink route_id	mainstem_id	proportional distance
A	**-1**	**-1**	**-1**	**-1**	**1**	**0.45**
B	-1	F	-1	A	2	0.60
C	A	A	A	A	-1	0.45
D	C	A	A	A	-1	0.45
E	D	A	A	A	-1	0.45
F	C	G	A	G	-1	0.45
G	-1	-1	-1	-1	3	0.77

4. Append the proportional distance associated with route A to the hierarchical key.

Hierarchical Key: 45000000

5. Route A has no sink route; therefore look in the *fwa_hkey_links* for route A.

route_id	region_id	island_id
A	**1**	**-1**

G	1	-1

6. The island_id associated with route_id is –1, therefore route A is not on an island.

7. Find the *hkey_prefix* from the *fwa_hkey_regions* using the *region_id* from *fwa_hkey_links* table. Append this value to the front of the hierarchical key.

Hierarchical Key: 900-45000000

region_id	hkey_prefix	prefix_name	direction	start_location	finish_location
1	**900**	**south coast rivers**	**northwards**	**49°N (near Blaine WA)**	**Cape Caution**
2	905	south coast islands	clockwise		

6 STEPS FOR GENERATING HIERARCHICAL KEYS

1. Preprocess:
   a. Find which flow edges are on which island.
   b. Find which islands belong to which region of BC (south coast islands, west Vancouver island, etc.)
   c. Find Hierarchical Keys for everything that flows into the ocean.
      - For each island (except Vancouver, Moresby and Graham Islands) find the most southerly point and walk around the island in a clockwise direction finding all river mouths and computing the percent along the island the mouth it. Update the *hkey* value in the *fwa_routes* table for each route that flows into the ocean. Add a record to the *hkey_links* table for this route.
      - For Vancouver Island:
        - Walk counter-clockwise from Church Point to Cape Scott finding all river mouths and computing the percent along the path. Update the *hkey* value in the *fwa_routes* table for each of these routes and add a record to the *hkey_links* table for these route (region will be Vancouver Island Rivers East).
        - Walk clockwise from Church Point to Cape Scott finding all river mouths and computing the percent along the path. Update the *hkey* value in the *fwa_routes* table for each of these routes and add a record to the *hkey_links* table for these route (region will be Vancouver Island Rivers West).
      - For Graham Island:
        - Walk clockwise around the island from Rose Spit finding all river mouths and computing the percent along the path. Update the *hkey* value in the *fwa_routes* table for each of these routes and add a record to the *hkey_links* table for these route (region will be Graham Island Rivers).
      - For Moresby Island:
        - Walk clockwise around the island from Spit Point finding all river mouths and computing the percent along the path. Update the *hkey* value in the *fwa_routes* table for each of these routes and add a record to the *hkey_links* table for these route (region will be Graham Island Rivers).
      - Walk northwards starting from BC/WA border to Cape Caution, finding all the river mouths and computing the percent along the path. Update the *hkey* value in the *fwa_routes* table for each of these routes and add a record to the *hkey_links* table for these route (region will be South Coast Rivers). Point Roberts is included in the coastline.
      - Walk northwards from Cape Caution to Alaska/BC Border (Hyder, BC) finding all the river mouths and computing the percent along the path. Update the *hkey* value in the *fwa_routes* table for each of these routes and add a record to the *hkey_links* table for these route (region will be North Coast Rivers).

- Walk north from Hyder, BC to 60°N finding all the river mouths and computing the percent along the path. Update the *hkey* value in the *fwa_routes* table for each of these routes and add a record to the *hkey_links* table for these route (region will be Alaska Rivers).
- Walk south from BC/WA border to mouth of Columbia River, finding all the river mouths and computing the percent along the path. Update the *hkey* value in the *fwa_routes* table for each of these routes and add a record to the *hkey_links* table for these route (region will be Washington Coast Rivers).
- Process major rivers (Fraser, Columbia etc.). Add a record the *hkey_links* table for each of these routes.

2. Generate unique Hierarchical Keys for islands.
   - Find the southern most point of each island and the percent along the north south line from southern most point of BC Border, to northern most point. Update *hkey* field of *csn_islands* table. (Not applicable for Vancouver, Moresby, and Graham Islands).

3. Generate Hierarchical Keys for all other rivers.
   - Load Routes.
   - Find main source route and main sink route for each route. (These are the primary flow routes from which the water comes from or flows into).
   - Build Graph
   - Find all routes that already have defined hkeys (from preprocessing step).
   - Walk up each of these routes recording the percent along the route where another rivers flows into the route.
   - For each of these rivers that flow into this route:
     - If it's a secondary flow route then the proportional distance is the same as the parent
     - If it's a primary route, then collapse all side channels and distributaries to find which it flows into the main flow.
     - Add the route to the list of routes to process.