PFRA WATERSHED PROJECT

Current Version (7) - 2007.03.31

ABSTRACT

The Watershed Project is a long-term Prairie Farm Rehabilitation Administration (PFRA) undertaking that has entailed the creation and maintenance of a drainage area database (based on hydrometric gauging stations) for the Canadian Prairies. This database has evolved considerably since its inception in the early 1970s. Currently, it consists of hydrometric gauging stations and watershed boundaries, tabulated gross and effective drainage areas, and digital products generated for use in hydrological mapping and analysis. The spatial extent of the database covers all of Alberta, Saskatchewan and Manitoba, and portions of adjacent jurisdictions (British Columbia, the Northwest Territories, Nunavut, Ontario, and the United States) into which Prairie watersheds extend.

The majority of gauging stations in this database are federal stations established by Water Survey of Canada (Environment Canada). This database also includes a relatively small number of provincial, American and “fictitious” gauging stations. The locations of these gauging stations were determined from Dominion Land Survey descriptions or from published latitude/longitude coordinates.

The GIS database is the authoritative source for gross and effective drainage areas in the Prairie Provinces. It is composed of more than a dozen derivative output products that are available over the internet at http://www.agr.gc.ca/pfra/gis/gwshed_e.htm.

BACKGROUND

In 1970, as part of an International Hydrological Decade Study, the PFRA Hydrology Division undertook the task of delineating gross and effective drainage areas for catchments tributary to select active and discontinued hydrometric gauging stations in the Canadian Prairies. The resultant drainage area database was intended to provide the basis for updating regional flood and runoff studies.

Since the determination of drainage area is a fundamental basis for water resource assessments, government agencies and others involved in water resources were independently delineating drainage area boundaries to meet their individual needs. Not surprisingly, when such delineations were compared, they were often significantly different. Consequently, analyses based on such delineation discrepancies resulted in an added level of controversy. As the drainage delineation controversy increased, the need for a universally accepted drainage area database became more apparent.

In 1975, at the request of the Prairie Provinces Water Board, PFRA formally agreed to accept on-going responsibility for delineating the gross and effective drainage areas above gauging stations on streams covered by the Apportionment Agreement. Furthermore, PFRA agreed to be the custodian of the database from which a set of standardized drainage area mylars (1:250,000 scale) and a tabulation of gross and effective drainage area values would be produced and provided to all potential users. These delineations were made in consultation with the Water Survey of Canada (Environment Canada) and representative agencies from the Provinces of Alberta, Saskatchewan and Manitoba. Over the years, the areal extent of delineation was expanded to encompass the entire three Prairie Provinces.

In 1994, a decision was made to move the watershed delineations and the area calculation process into a digital environment. This decision was triggered by the time-intensive nature of the manual updating process, the deteriorating condition of the maps, and fiscal constraints. The process involved digitizing the drainage delineations and gauging station locations from nearly 3,000 maps, edge-matching the digital "pieces" into a single data layer and creating an automated process for calculating and summing the watershed areas (see Appendix A for details). This migration from paper maps and index cards to a Geographic Information System (GIS) environment was a significant milestone in improving the maintenance, accessibility, and usability of the database.

Subsequent to the GIS migration, a database shortcoming became evident – many PFRA sub-basins did not resemble Environment Canada sub-basins.. To correct this situation and to enhance the database, some "fictitious" stations were added, primarily at river mouths, so that PFRA sub-basins provided a better match to Environment Canada's sub-basin designations. As well, at Manitoba’s request in 2004, it was decided to include watershed boundaries within Manitoba (primarily northern Manitoba) as described by Fedoruk (1970). The Fedoruk delineations provided greater sub-basin definition, particularly in the station-sparse north, but they were not as accurate as the PFRA delineations because they were based on 1:250,000 scale topography. Consequently, although they were incorporated in the database, they were made accessible only to Manitoba.

The spirit of cooperation and commitment by all water resource agencies has created a unique and useful database that is used not only by government agencies, but also by a spectrum of non-government agencies, consultants and academia. Because of its wide acceptability, this database has been incorporated into a national product developed by Environment Canada.

CONCEPTS

The Watershed Project is based on the hydrologic concepts of gross, effective, and dead drainage areas. The gross and effective drainage concepts originated with a paper by Stichling and Blackwell (1957) who indicated that "contributing" drainage areas on the Canadian Prairies fluctuate by year, by season, and by event because of the glacial landscape and the climate. Godwin and Martin (1975) restated Stichling and Blackwell's concepts of gross and effective drainage areas as follows:

"The gross drainage area of a stream at a specified location is that plane area, enclosed by its drainage divide, which might be expected to entirely contribute runoff to that specified location under extremely wet conditions. The gross drainage boundary is the drainage divide (i.e. the height of land between adjoining watersheds)."

"The effective drainage area is that portion of a drainage basin which might be expected to entirely contribute runoff to the main stream during a flood with a return period of two years. This area excludes marsh and slough areas and other natural storage areas which would prevent runoff from reaching the main stream in a year of 'average runoff'."

The Prairie region, being relatively flat, does not completely drain even in very wet years. Thus, the concept of dead drainage area was proposed by Godwin and Martin (1975) as follows:

"Drainage is considered dead if there is no outflow from an area even under very wet conditions. This situation is common on the Canadian Prairies where major depressions having sloughs and shallow lakes with no outlets are usually associated with dead drainage. A dead drainage basin includes the entire area tributary to such a depression."

Both the gross and effective drainage boundaries are portrayed as definitive lines in the delineation process, but in reality they are not. Generally, a gross drainage boundary is distinct because it is based solely on topography. However, in areas of poor drainage, gross drainage boundaries become less distinct and other physiographic factors such as drainage patterns and depressional storage are used as visual cues in delineating the boundary. Effective drainage boundaries are more conceptual because they pertain to the natural average runoff (approximately the two-year flood event) and are based more on hydrologic factors rather than on topography. Because of the non-distinct nature of the boundaries, an appropriate workable method for delineation was developed. A complete discussion of the drainage boundary delineation methods can be found in Hydrology Report #104 (PFRA Hydrology Division 1983).

The non-contributing area is the area that lies outside of the effective drainage demarcation (i.e. the area between the effective and gross drainage delineations). The portion of the non-contributing area that contributes to runoff in a particular event varies with the frequency of that event.

In the process of migrating the database to a GIS environment, a major conceptual change was made which involved the consideration of dead drainage areas. Previously (Hydrology Report #104, 1983), the five major dead drainage basins (Maple Creek, Old Wives Lake, Pakowki Lake, Quill Lakes, and Sounding/Eyehill Creek) were not considered to be part of any adjacent major drainage basin. That is, their respective areas were not included in the tabulated gross drainage area values of gauging stations in the external basin into which they would ultimately drain if water levels rose high enough. However, it was found that many (but not all) less significant dead drainage areas were included in the tabulated gross drainage area values of gauging stations in the external basin into which they would ultimately drain. Thus, a decision was made to provide a consistent approach by including all dead drainage areas in the tabulated gross drainage area values of their associated drainage basin.

CASCADING NETWORK METHODOLOGY

Generating tables of gross and effective drainage areas by gauging station involves delimiting the catchment for each station, and then separating each catchment into its effective and non-contributing areas. One way to acquire these tabular calculations is via the concept of incremental drainage areas. An incremental drainage area is defined as the area of a gauging station's drainage basin (catchment) less that of the next upstream station(s). In dividing the Prairies into these small areas, it is necessary to track each station's upstream and downstream neighbours. To this end, a flow network was created. The following methodology details the process for developing the gross and effective drainage area calculations.

1) For each catchment in a selected area of interest, gather the gross watershed arcs and a single selected hydrometric gauging station to create a gross watershed polygon data layer, which supplies the gross (incremental drainage) watershed area for each gross polygon (catchment).

2) Create a second data layer of polygons of effective and non-contributing polygons by gathering together all the gross and effective arcs, and the same "selected" gauging stations as in Step 1. Identify each polygon as either effective (contributing) or non-contributing (non-effective).

3) Assign each effective and non-contributing polygon to its associated gross watershed polygon by combining the data layers of Steps 1 and 2.

4) Calculate gross, effective, and non-contributing incremental areas for each gross polygon, and transfer these areas to their corresponding primary gauging stations.

5) Initialize the station and network layers by assigning an order value to each primary station point and network line. Primary stations upstream are assigned lower values than stations downstream. For each network “chain” of stations, the station furthest upstream is assigned a value of 1, the next station downstream is assigned a value of 2, and so on. Where

more than one network chain converge downstream at a single station, that station will be assigned the next highest order value of the longest upstream chain.

6) Using the same logic as described in Step 5, assign order values to the network lines connecting the primary gauging stations.

7) Calculate the gross, effective, and non-contributing accumulated areas of each primary station by summing its incremental areas with the accumulated areas of the immediate upstream station(s) with the respective incremental areas of the primary station. The accumulated areas of stations with an order value of 1 is equal to its incremental area. For a station with an order value of 2, the accumulated area is equal to its incremental area plus the accumulated area of the immediate upstream station(s) with an order value of 1. In the case of dead drainage areas, only gross area calculations are summed.

8) Transfer the values of the primary gauging stations to the non-primary stations that are located within the same gross watershed basin.

DIGITAL WATERSHED PRODUCTS

The PFRA Watershed Project provides 13 digital watershed products available in a "GEOGRAPHIC" projection (latitude and longitude coordinates) in the North American Datum of 1983 (NAD83):

1. Gross and Effective Drainage Areas for Hydrometric Gauging Stations (table);
2. Hydrometric Gauging Stations;
3. Lines of Gross and Effective Drainage Area Boundaries;
4. Incremental Gross Drainage Areas;
5. Areas of Non-Contributing Drainage;
6. Effective Drainage Areas of the Incremental Effective Drainage Areas;
7. Effective Drainage Area;
8. Environment Canada 4-character Sub-basins;
9. Environment Canada 3-character Sub-basins;
10. PFRA Sub-basins;
11. Major Basins;
12. Major Drainage Systems; and
13. The Hydrometric Gauging Station Flow Network.

These products are downloadable from: http://www.agr.gc.ca/pfra/gis/gwshed_e.htm. They are derived from five source products currently maintained in an Albers Conic Equal-Area projection in the North American Datum of 1983 (NAD83). Details for all output products are found in Appendix B, along with general descriptions of the source products.

UPDATING PROCEDURE

When drainage pattern changes are noted or when hydrometric gauging stations are added or relocated, the database is updated to reflect those changes by editing with "head's-up digitizing" that uses digital NTS maps and/or ortho-rectified images as primary locational reference(s). As an example, digital 1:20,000 NTS maps and orthophotos, where available, were used to update basin delineations in Manitoba for Version 5. Occasionally, when digital reference products are unavailable, the traditional method is used, in which the revisions are first made on hard copy maps and then an editing application (that handles projection conversions) is utilized to integrate the changes back into the source product.

Once the linework has been edited and reassembled, the areas are recalculated and the output products are reconstructed.

SUMMARY

This database has evolved considerably since its inception in the early 1970s. Initially, the extent of the drainage area delineations pertained only to streams covered by the Apportionment Agreement – a portion of the Saskatchewan-Nelson River Basin. Over time, drainage area delineations were extended to include not only the entire Saskatchewan-Nelson River Basin but other major river systems that form part of the drainage landscape in the Prairie Provinces. Currently, the spatial extent of the database covers all of Alberta, Saskatchewan and Manitoba, and portions of adjacent jurisdictions (British Columbia, the Northwest Territories, Nunavut, Ontario, and the United States) into which Prairie watersheds extend.

Prior to the late 1990s, a tedious manual process was used to maintain and update the database. However, with the availability of GIS technology, the initiative was taken in 1994 to migrate the database to a GIS environment. This migration process was completed in 2001.

Many changes and improvements have been made to the database over the years. The majority of these have occurred in the last few years due to the capabilities of GIS to easily manipulate and display the data. The GIS database is now the authoritative source for the gross and effective drainage areas in the Prairie Provinces. It is composed of more than a dozen derivative output products that are available over the internet at http://www.agr.gc.ca/pfra/gis/gwshed_e.htm.

REFERENCES

Fedoruk, Alex N., 1970, Proposed Watershed Divisions of Manitoba, Manitoba Department of Mines and Natural Resources, Canada Land Inventory, Report #10, Winnipeg, Manitoba, 89 pp.

Godwin, R. B. and F. R. J. Martin, 1975, Calculation of Gross and Effective Drainage Areas for the Prairie Provinces, Canadian Hydrology Symposium - 1975 Proceedings, Winnipeg, Manitoba, 5 pp.

Martin, F. R. J., 2001, Addendum No. 8 to Hydrology Report #104, Agriculture and Agri-Food Canada, PFRA Technical Service, Regina, Saskatchewan, 109 pp.

PFRA Hydrology Division, 1983, The Determination of Gross and Effective Drainage Areas in the Prairie Provinces, Hydrology Report #104, Agriculture Canada, PFRA Engineering Branch, Regina, Saskatchewan, 22 pp.

Stichling, W. and S. R. Blackwell, 1957, Drainage Area as a Hydrologic Factor on the Glaciated Canadian Prairies, IUGG Proceedings, Volume 111, Toronto, Ontario, 12 pp.

APPENDIX A: MANUAL TO DIGITAL MIGRATION

MANUAL CREATION/UPDATING PROCEDURE

The manual process for delineating drainage basins and tabulating their gross and effective areas was very time-consuming and laborious. The hydrometric gauging stations were marked on a paper topographic mapsheet (usually 1:50,000 scale), and the gross and effective drainage basin boundaries were delineated. The resultant areas were carefully planimetered and validated. An index card was kept for each planimetered mapsheet where components of the gross and effective areas were recorded. The stations and drainage area boundary representations were transferred to 1:250,000 scale mapsheets. The areas from the index cards were ascribed to the respective polygons on the 1:250,000 scale mapsheet. (The use of 1:250,000 mapsheets permitted viewing sixteen 1:50,000 mapsheets at a glance which provided a better overview of the gauging station basins.) Tabulation sheets were set up for each gauging station. The gross and effective drainage area values from the 1:250,000 scale mapsheets were listed on the tabulation sheets and then summed. Since each gross and effective polygon area is part of the drainage area for all downstream gauging stations, it was recorded on each of their respective tabulation sheets as well.

The gross and effective drainage areas for each gauging station were published in Hydrology Report #104 and subsequent addenda (Martin 2001). In addition, gross and effective area boundary representations were traced onto 1:250,000 scale mylars and distributed to interested parties.

Updates, resulting from a change in gauging station location or a change in drainage, required that the gauging station(s) boundaries be redrawn on the paper maps and the entire process redone. The revised values were incorporated into an addendum to the Hydrology Report #104. With the emergence of GIS technology in the early 1990s, it was felt that this labour-intensive manual process could be automated and substantially shortened by moving the database into the digital environment.

MIGRATION TO THE GIS ENVIRONMENT

The gross and effective drainage boundaries were converted (digitized) into digital format for the development of a GIS database to provide a more automated process. Before digitizing commenced, an accounting of all required mapsheets was done. Most of the mapsheets were Canadian 1:50,000 scale National Topographic Survey (NTS) maps, but the project also included some 1:250,000 scale NTS maps, and American United States Geological Survey (USGS) 1:24,000, 1:62,500, and 1:250,000 scale maps. Digital index map coverages (Canadian and American) of the outlines of all project mapsheets were created.

Most Saskatchewan maps were digitized by Saskatchewan Water Corporation personnel using PC ArcInfo. All other maps (from Alberta, Manitoba, British Columbia, Ontario, NWT and United States) were digitized by PFRA Hydrology Unit personnel using UNIX ArcInfo 7.x. All subsequent GIS work was done with ArcInfo 7.x and 8.x.

A digitizing RMS error standard was set at 0.003. However, some mapsheets failed the standard because of their poor condition. Digitizing information (consisting of mapsheet number, name, edition, publication year, projection and datum, tic numbers, who digitized the map, date digitized, and RMS error) were recorded in a binder and later transferred to a spreadsheet.

Digitizing was done in each map's native projection. Most were Universal Transverse Mercator (UTM) projections in the North American Datum of 1927 (NAD27). Many others, mostly American, were either Transverse Mercator or Lamberts Polyconic (State Quadrangle maps). Some of the newer maps, or ones that were re-digitized, were NAD83.

To allow all the data to be placed into one large coverage, a common projection was needed. As well, minimal distortion of areas is very important for watershed area calculations. An Albers Conic Equal-Area projection was chosen because it preserves the property of area well in mid-latitude land masses that are predominantly oriented east-west. All coverages were projected into Albers from their digitized projection.

Edge-matching combined all the maps into one seamless coverage. It was an arduous process because arcs of adjacent mapsheets often did not match. This discontinuity was attributable to low relief topography, digitizing being done without the context of the adjacent mapsheet, different scales of adjacent sheets, and the thickness of the hand-drawn lines. Hand-drawn boundaries on the mapsheets range in thickness from 0.5 mm to 1 mm. A 1 mm thick line represents 24 metres on the ground at a scale of 1:24,000; 50 metres at 1:50,000; and 250 metres at 1:250,000. The edge-matching process resulted in a seamless coverage of arcs and points requiring quality checks. It was decided that quality checks would best be handled during the creation of data products.

The manually-generated database provided a very useful basis for both checking the GIS process methodology and validating the network of linkages between hydrometric gauging stations. Major differences between manually-generated and digitally-generated drainage area values indicated network linkage errors that were subsequently corrected. However, after all network linkage problems were resolved, there were still discrepancies, albeit rather small ones in most cases. Initially, these small discrepancies were attributed to digitizing inaccuracies and projection distortions in the digital environment. After extensive investigation, the discrepancies were determined to have resulted primarily from planimetering errors in the manual database. These differences between the manually-generated and digitally-generated values of gross and effective drainage areas were quite small, generally much less than 1%.

POST-MIGRATION DEVELOPMENTS

Two “locations” are included in the source data: one containing the latitude and longitude coordinates of the station, and the other containing the legal land description, where available. Where digital 1:50,000 and 1:20,000 hydrography is available, the locations provided indicate the point where the water exits the gross drainage basin (the location used to define the drainage basin outlet). Note: these locations may not necessarily coincide with the point location representing the station in these data products.

APPENDIX B: WATERSHED PRODUCT DETAILS

SOURCE PRODUCTS

Source products were originally stored in two ESRI coverages – ARCPNT and NET – but have since been converted to three ESRI ArcSDE source products:

1. STATIONS – a point feature class containing hydrometric gauging stations and their corresponding watershed basin attribute information
2. LINEWORK – a line feature class containing effective and gross drainage area boundaries
3. NETWORK - a line feature class that "connects" the hydrometric gauging stations using a network of downstream-oriented straight-line segments

All three source products are ESRI ArcSDE feature classs in an Albers Conic Equal-Area projection in the North American Datum of 1983 (NAD83). In Version 5, there was a conversion of all the source products from NAD27 to NAD83. See Appendix C for details.

OUTPUT PRODUCTS

All output products are generated from the three source products - STATIONS, LINEWORK, and NETWORK. They include 12 ESRI coverages and one data file supplied in both ASCII and INFO formats. All output coverages are in the "GEOGRAPHIC" projection (latitude and longitude coordinates) in the North American Datum of 1983 (NAD83). They are downloadable from: http://www.agr.gc.ca/pfra/gis/gwshed_e.htm.

1. GROSS AND EFFECTIVE DRAINAGE AREAS FOR HYDROMETRIC GAUGING STATIONS OF THE PFRA WATERSHED PROJECT (two files [HY0TB.*/Areas.*]: a comma-delimited ASCII text file, and an INFO file). Each file is fashioned after Hydrology Report #104, Addendum No. 8. It contains the station number, station name, station location, gross and effective drainage areas, location by region, whether a station has been relocated, and whether the effective drainage areas are carried forward to downstream stations.

2. HYDROMETRIC GAUGING STATIONS OF THE PFRA WATERSHED PROJECT (point coverage [hy1/stations]) - approximately 3900 actual or fictitious hydrometric gauging stations. Each station has 21 pieces of information: number (STN_NUMBER), name (STN_NAME), two location fields (LAT_LONG and LOCATION (legal land description)), type (STN_TYPE; stream, lake, shoreline, etc.), user-defined identifier (-ID), five levels of small- to medium-scale watershed identification (SUB_4C, SUB_EC, SUB_PF, MAJ_BAS & MAJ_SYS), regional location (REGION), naming authority (AGENCY), an outlet designation for lake stations within a subdivided lake basin (OUTLET), six station associated area values (incremental gross area : AREAG; incremental effective (contributing) area : AREAC; incremental non-contributing area : AREAN; sum of gross upstream areas : AGSUM; sum of effective (contributing) upstream areas : ACSUM; sum of non-contributing upstream areas : ANSUM), and a "selection" identifier (PRIMARY). (See SOURCE PRODUCTS Section above, STATIONS)

3. LINES OF GROSS AND EFFECTIVE DRAINAGE AREA BOUNDARIES OF THE PFRA WATERSHED PROJECT (line coverage [hy2/linework]) - production boundary lines from the source product LINEWORK. Lines delineating the incremental gross drainage areas of the hydrometric gauging stations have their BND_TYPE = 3 while the boundaries between the effective and non-contributing portions of those areas have their BND_TYPE = 2.

4. INCREMENTAL GROSS DRAINAGE AREAS OF THE PFRA WATERSHED PROJECT (polygon coverage [hy3/gross]) - the collection of incremental gross drainage areas (gross polygons) of the project's extent (See CONCEPTS Section). These gross polygons are built from the incremental drainage area lines of the drainage area boundaries and

the primary hydrometric gauging stations. In developing these gross polygons, several hydrometric gauging stations may share the same polygon. For calculation purposes and topologic reasons, only one station may link the gross polygon downstream via the network.

5. AREAS OF NON-CONTRIBUTING DRAINAGE OF THE PFRA WATERSHED PROJECT (polygon coverage [hy4/non]) - the collection of all non-contributing areas of the project's extent. Each area "knows" to which catchment (gross polygon) it belongs.

6. EFFECTIVE DRAINAGE AREAS OF THE INCREMENTAL DRAINAGE AREAS OF THE PFRA WATERSHED PROJECT (polygon coverage [hy5/effect]) - the collection of areas of effective drainage of the incremental gross drainage areas (gross polygons) of the project's extent (See CONCEPTS Section). These polygons are built by removing the non-contributing areas from the gross polygons. For analysis purposes, all information found in these polygons, except the two related to non-contributing areas, is retained.

7. EFFECTIVE DRAINAGE AREA OF THE PFRA WATERSHED PROJECT (polygon coverage [hy6/eff]) - the area of effective drainage of the project's extent. These polygons are built by joining (dissolving) all the effective drainage areas (hy5/effect) polygons. Many non-contributing pockets remain. In fact, the coverage is, in essence, the spatial complement of the non-contributing polygons for the project's extent. This product was created primarily for mapping purposes, and as such a mask, it retains no attributes.

8. ENVIRONMENT CANADA SUB-BASINS OF THE PFRA WATERSHED PROJECT (polygon coverage [hy7/sub_ec]) - The Environment Canada sub-basins are 51 agglomerations of the project's gross drainage areas whose "station numbers" share the same first 3 characters. The Environment Canada convention for hydrometric gauging stations is hierarchical, in that all stations having "station number" starts with "05" would fall into the same basin, as would those with the first 4 letters (e.g. "05HA") fall in the same sub-basin. Sometimes the stations were mistakenly numbered as being in one sub-basin when in fact, they lay in another. Those "mis-numbered" stations, along with the American stations, have been reassigned to their proper 3-character sub-basin (example "05H") while their 'numbers' have remained unchanged. The sub-basins follow EC's convention. They average around 55,000 km2 in size.

9. PFRA SUB-BASINS OF THE PFRA WATERSHED PROJECT (polygon coverage [hy8/sub_pf]) - The PFRA sub-basins are agglomerations of the project's incremental gross drainage areas into 47 PFRA-tailored sub-

basins. Like the SUB_EC polygons, these average around 55,000 km2 in size. These match the Environment Canada sub-basins except in areas of PFRA interest, where the sub-basins are refined, and in areas of less interest, where EC sub-basins are fused.

10. MAJOR BASINS OF THE PFRA WATERSHED PROJECT (polygon coverage [hy9/maj_bas]) - The major basins are agglomerations of the project's gross drainage areas into 23 basins of major river or lake reaches (of the Saskatchewan or Athabasca River scale) for the project's extent. They average around 160,000 km2 in size.

11. MAJOR DRAINAGE SYSTEMS OF THE PFRA WATERSHED PROJECT (polygon coverage [hya/maj_sys]) - The major drainage systems are agglomerations of the project's incremental gross drainage areas into the sub-continental sized basins of the project's extent. It consists of the three major drainage systems: Arctic Ocean, Hudson Bay and the Gulf of Mexico.

12. HYDROMETRIC GAUGING STATION NETWORK OF THE PFRA WATERSHED PROJECT (line coverage [hyb/network]) - production network lines extracted from the source product, NETWORK ((See SOURCE PRODUCTS Section above, NETWORK)). It is a network of 'flow' for hydrometric gauging stations and drainage basin area calculations that is provided to help explain how upstream/downstream connectivity is handled. It is NOT a river system network!

13. ENVIRONMENT CANADA 4-CHARACTER SUB-BASINS OF THE PFRA WATERSHED PROJECT (polygon coverage [hyc/sub_4c] - The Environment Canada 4-character sub-basins are 324 agglomerations of the project's gross drainage areas whose station numbers share the same first four characters. The Environment Canada convention for hydrometric gauging stations is hierarchical (see #8 above). Sometimes the stations were mistakenly numbered as being in one sub-basin while in fact they lay in another. Those "mis-numbered" stations have been reassigned to their proper 4-character sub-basin (example "05HC") while their station 'numbers' have remained unchanged. The sub-basins follow EC's convention. They average around 8,200 km2 in size.

APPENDIX C: CONVERSION OF SOURCE PRODUCTS FROM NAD27 TO NAD83

Source products before Version 5 were maintained in Albers Conic Equal-Area projection in the NAD27 datum to match the original NTS mapsheets. The source products have since been converted to the

NAD83 datum for Version 5. The following steps were used in the conversion:

1) Watershed basins, stations and network lines were divided into components within Canada and components within United States, using a Canadian/USA border derived from Statistics Canada Census Consolidated Subdivisions 2001 boundaries.
2) The United States components were converted from NAD27 to NAD83 using the NADCON datum transformation.
3) The Canadian components were converted using the NTV2 datum transformation.
4) At the border, United States lines were snapped to their corresponding Canadian lines. In most cases, the snapping distance was less than one metre.
5) Pseudo-nodes were removed from the network (NET) but maintained for the ARCPNT lines to record the location of the border division.

The datum transformation resulted in minor incremental area changes within the watershed basins, the majority being less than one hectare or 3/1000 of a percent of the incremental basin area.