REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE Oct 1994

3. REPORT TYPE AND DATES COVERED Technical Paper

4. TITLE AND SUBTITLE
Hardcopy Extraction Considerations for Vector Product Format (VPF) Products

5. FUNDING NUMBERS
N/A

6. AUTHOR(S)

Kimberly H. Berger

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Defense Mapping Agency Aerospace Center
Digital Products Department
3200 So. Second Street
St. Louis, MO 63118-3399

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Defense Mapping Agency
8613 Lee Highway
Fairfax, VA 22031-2137

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
N/A

11. SUPPLEMENTARY NOTES
For presentation at the American Society of Photogrammetry & Remote Sensing National Conference, February 27-March 2,1995, Charlotte, NC

12a. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE: DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
Vector Product Format (VPF) is a standard format, structure, and organization developed by the Defense Mapping Agency (DMA) and intended to be used for large geographic product data bases. VPF product data-bases are often initially populated with data taken from existing hardcopy map source of the appropriate scale. Military Specifications are written for each new VPS product defining, among other things, the product's features, their attributes, and valid attribute values. The Military Specifications do not, however, address the issues introduced by the practice of feature collection from existing cartographic source. This paper addresses data collection and organizational issues from the production standpoint. Particular attention is given to VMap Level 1 experience.

14. SUBJECT TERMS
Vector Product Format (VPF); Geographic Information Systems (GIS), VMap Level 1.

15. NUMBER OF PAGES 13

16. PRICE CODE N/A

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

GENERAL INSTRUCTIONS FOR COMPLETING SF 298

The Report Documentation Page (RDP) is used in announcing and cataloging reports. It is important that this information be consistent with the rest of the report, particularly the cover and title page. Instructions for filling in each block of the form follow. It is important to *stay within the lines* to meet *optical scanning requirements*.

Block 1. Agency Use Only *(Leave blank)*.

Block 2. Report Date. Full publication date including day, month, and year, if available (e.g. 1 Jan 88). Must cite at least the year.

Block 3. Type of Report and Dates Covered. State whether report is interim, final, etc. If applicable, enter inclusive report dates (e.g. 10 Jun 87 - 30 Jun 88).

Block 4. Title and Subtitle. A title is taken from the part of the report that provides the most meaningful and complete information. When a report is prepared in more than one volume, repeat the primary title, add volume number, and include subtitle for the specific volume. On classified documents enter the title classification in parentheses.

Block 5. Funding Numbers. To include contract and grant numbers; may include program element number(s), project number(s), task number(s), and work unit number(s). Use the following labels:

C	Contract	PR	Project
G	Grant	TA	Task
PE	Program Element	WU	Work Unit Accession No.

Block 6. Author(s). Name(s) of person(s) responsible for writing the report, performing the research, or credited with the content of the report. If editor or compiler, this should follow the name(s).

Block 7. Performing Organization Name(s) and Address(es). Self-explanatory.

Block 8. Performing Organization Report Number. Enter the unique alphanumeric report number(s) assigned by the organization performing the report.

Block 9. Sponsoring/Monitoring Agency Name(s) and Address(es). Self-explanatory.

Block 10. Sponsoring/Monitoring Agency Report Number. *(If known)*

Block 11. Supplementary Notes. Enter information not included elsewhere such as: Prepared in cooperation with...; Trans. of...; To be published in.... When a report is revised, include a statement whether the new report supersedes or supplements the older report.

Block 12a. Distribution/Availability Statement. Denotes public availability or limitations. Cite any availability to the public. Enter additional limitations or special markings in all capitals (e.g. NOFORN, REL, ITAR).

- DOD - See DoDD 5230.24, "Distribution Statements on Technical Documents."
- DOE - See authorities.
- NASA - See Handbook NHB 2200.2.
- NTIS - Leave blank.

Block 12b. Distribution Code.

- DOD - Leave blank.
- DOE - Enter DOE distribution categories from the Standard Distribution for Unclassified Scientific and Technical Reports.
- NASA - Leave blank.
- NTIS - Leave blank.

Block 13. Abstract. Include a brief *(Maximum 200 words)* factual summary of the most significant information contained in the report.

Block 14. Subject Terms. Keywords or phrases identifying major subjects in the report.

Block 15. Number of Pages. Enter the total number of pages.

Block 16. Price Code. Enter appropriate price code *(NTIS only)*.

Blocks 17. - 19. Security Classifications. Self-explanatory. Enter U.S. Security Classification in accordance with U.S. Security Regulations (i.e., UNCLASSIFIED). If form contains classified information, stamp classification on the top and bottom of the page.

Block 20. Limitation of Abstract. This block must be completed to assign a limitation to the abstract. Enter either UL (unlimited) or SAR (same as report). An entry in this block is necessary if the abstract is to be limited. If blank, the abstract is assumed to be unlimited.

Hardcopy Extraction Considerations for Vector Product Format (VPF) Products

Kimberley H. Berger
Defense Mapping Agency Aerospace Center
Digital Products Department
3200 South Second Street
St. Louis, MO 63118-3399

Introduction

Vector Product Format (VPF) is a standard format developed by the Defense Mapping Agency (DMA) intended to be used for organizing large geographic databases. Part of what distinguishes products in this format from those traditionally produced by DMA is the fact that they have both attribution and the potential for full topology. This format allows the products to be used directly in Geographic Information Systems (GIS), thus allowing users much greater analytical capability.

Several VPF products have already been defined (see Table-1), though not all have been fully developed. In developing each VPF product, a Military Specification is written which defines, among other things, the themes or coverages into which the data are divided, the features to be found in each coverage, capture/portrayal criteria for particular features, attributes for features, and valid attribute values. Although the product specifications define the basic product structure, there are many collection and production issues which are not addressed.

Table-1 VPF Products

Product	Scale/Source
Digital Chart of the World (DCW)	1:1,000,000 (ONCs)
Vector Smart Map (VMap0)	1:1,000,000 (DCW reformatted)
Vector Smart Map (VMap1)	1:250,000 (JOGs) or 1:200,000 (ATCs)
Vector Smart Map (VMap2)	1:50,000 or 1:100,000 (TLMs)
Urban Vector Smart Map (UVMap)	Variable Scale - High Resolution (City Graphics)
Digital Nautical Chart (DNC)	Variable Scale (Harbor, Approach, Coastal and General)
Vector Product Interim Terrain Data (VITD)	1:50,000 or 1:100,000 (ITD)

One important issue is that of extraction source. Although the capability exists for image exploitation, the VPF product databases presently in production are being populated with data taken from existing hardcopy map source of appropriate scale. The use of cartographic source in building VPF product databases introduces issues concerning data consistency and source interpretation which should be considered before beginning full-scale production. This paper will address these and other more general data collection and organizational concerns for VPF products. Particular attention will be given to VMap Level 1 (VMap1) production experiences at the DMA Aerospace Center in St. Louis, Missouri.

Map Series

If cartographic source will be used it is preferable, for the sake of consistency, that one map series be chosen to populate the product's database. Map series' vary greatly in both collection/portrayal criteria for features and in classes of features portrayed.

In producing VMap1, DMA's Joint Operation Graphics (JOG) series' have been used as source. There are, however, several different types of JOGs: Ground (JOG-G), Air (JOG-A), Combined (JOG-C), and Radar (JOG-R); each having slightly different JOG Specifications. For example, roads on a JOG-A would specify the surface type and weatherability but not status (primary or secondary), whereas roads on a JOG-R may specify only status. For this reason, if a map series is further categorized, it is preferable to choose one type as the primary source.

Just as the VPF product is defined by a product specification, the map series chosen for the extraction source also has a specification. In order to code and attribute features correctly, personnel populating the VPF product database must understand the specifications of the source. Understanding the portrayal criteria for the map features will help the production operator correctly attribute the VPF product's features. Similarly, knowing the exceptions to these portrayal rules will be of benefit.

An example of how this background knowledge aided in making attribution decisions for VMap1 is in the case of bridges. In order to be portrayed on a JOG, a bridge must be at least 150 meters in length. The minimum size bridge symbol, however, represents 380 meters. Any bridge between 150 and 380 meters long, therefore, is given a 380 meter standardized symbol length. Any bridge greater than 380 meters long is symbolized to scale. The Draft Military Specification for VMap1 defines two types of bridge features: line bridges being greater than or equal to 125 meters in length and point bridges being less than 125 meters in length. Because on the JOG source all collected bridges are at least 150 meters long, there should never be a JOG bridge short enough to be collected as a VMap1 point bridge. If operator measurement indicates the standardized 380 meter length (allowing a buffer for scanning or digitizing error), the length for the VMap1 bridge is attributed as "unknown" as the operator has no way of knowing its actual length. Without understanding the JOG Specifications the operator would have coded the bridge with a length of 380 meters. Having this background information aided in making the correct attribution decision.

Once a map series has been decided upon, it should be kept in mind that there may be several editions of the specifications, each possibly having its own unique set of features and capture criteria and symbology used for those features. Many of the source maps may have been compiled or revised under different editions of the source product specifications. Figure-1, for instance, shows the difference in airport portrayal from the 1968 and 1976 JOG-A Specifications. JOGs produced after 1976 no longer depict runways within the circle to scale. Instead they have a standard symbol with only the runway orientation varying. The runway length, to the nearest hundred feet, and surface type are given following the airport's name. Even if the changes from one edition to another are small, identifying them in advance could help to avoid confusion later.

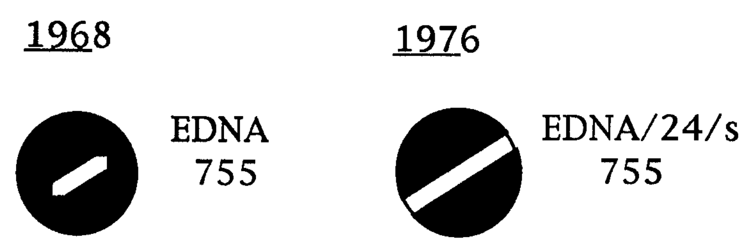

Figure-1

Source Media

Once the decision has been made to use existing hardcopy maps as source, the source media preference and availability must be determined. The preferred media will depend on the methods of data input and feature recognition. Primary source materials may come in the following forms: film positives or negatives, film feature separates, film color composites, and/or paper maps.

Regardless of input method, paper source is regarded by DMA to be the least desirable media because it is highly subject to expansion, shrinkage, and warping. Feature recognition from scanned paper maps has not proven to be effective and efficient due to color variations and feature density. If the source will be scanned, film feature separates or film color composites are preferred. Although training for automatic feature recognition is possible using color composites, DMA prefers to use feature separates instead as they allow for easier, more successful recognition training. If scanning resources are constrained and interactive line following algorithms will be used, color composites may be preferred.

Planning

Several details must be addressed prior to beginning data collection. Certain historical information, or metadata, about the source such as datum, ellipsoid, and projection should be identified in order to support any required coordinate transformations. Appropriate source materials (eg. film positives, film separates) may be determined by identifying the valid VPF product features contained on each. Feature input from hardcopy source may be accomplished using any of a variety of methods including: manual digitization, keyboard input, scanning, heads-up digitizing, vectorizing raster (scanned) data, and automatic feature recognition. Factors influencing the selection of methods include: the capabilities of the collection hardware/software, the distribution of VPF features on the source materials, source availability, and convenience for the production operator.

In producing VMap1, there were many instances where the outline of a feature would appear on one separate and the fill of that same feature would appear on another separate: cased roads, lakes, double line streams, and city tints to name a few. In most cases, if the feature outlines appeared on a separate with many other features, the fill separate need not be scanned. For cased roads, by scanning only the feature outline, the roads then could be heads-up digitized through the casing. Because the software used allowed for area features to be placed by identifying faces, the bounding lines of the area feature were sufficient to place area features such as lakes or double-line streams. This same method of area feature collection worked well for features whose limits were bound by the edges of other features (eg. a sand feature bounded by the edges of drainage features). In the case of city tints, portions of the outlines may appear on one separate, with the fill on another. In this instance, it was easier to delete the city outline fragments and scan the separate containing the area fill. Because of variation, however, it became quickly evident that each case must be reviewed individually.

Another issue to approach in advance is that of ancillary source. It must be decided what ancillary source is appropriate. Once deemed acceptable, the datum to which the ancillary source is referenced must be identified. This will determine the appropriate step during the data collection process (before or after datum transformation) to add the features. Also, guidelines for resolving likely conflicts between sources must be generated. The usage policy for primary and ancillary source should be documented both for the production operator (See "Extraction Guideline" below) and for the user (in metadata tables).

In order to consistently address this variety of issues at production start up, a planning group was formed to help streamline VMap1 production. This group examines the source materials for each entire library produced by DMA Aerospace Center to determine which materials and data input methods to use and to clarify ambiguous features found on the JOG source. The planning group also creates a checklist identifying on which piece of source specific VPF features could be found. In addition, the planning group prepares the separates to be scanned in ways that optimize automatic feature recognition and reduce editing time. For example, gaps may be closed on contour separates where the contour labels had been.

Having a planning group identify and resolve these issues upfront is highly beneficial. It should be noted, however, that possessing an understanding of the source, the VPF product, and the collection software functionality is fundamental in making good planning decisions.

Simple Versus Compound Features

VMap1 has been defined only to allow for simple features. In other words, when features within the same coverage intersect lines or cross areas, a node is dropped and the line or area feature is split. Consider, for example, a dam with a single line stream on one side and a reservoir on the other side (see Figure-2). All three features are in the Hydrography Coverage, therefore the dam is intersected three times and is split into four segments. Because VMap1 allows for only simple features, each one of those segments becomes a separate dam. Whereas a simple feature relates to only one primitive, a compound feature relates to more than one primitive of the same type. In this example, the entire dam made up of the four segments (primitives) would have been one compound feature.

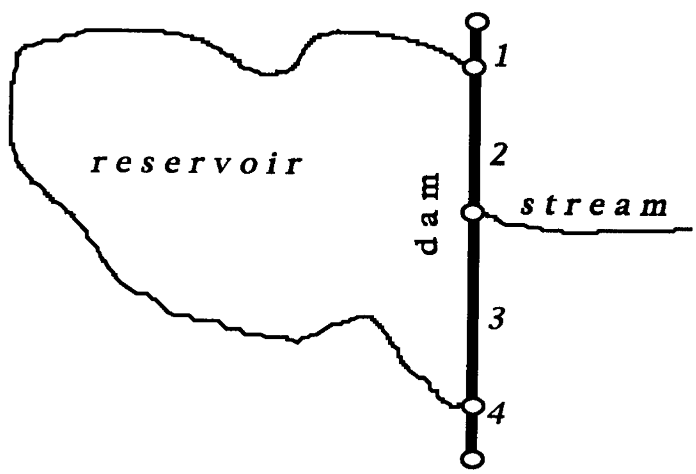

Figure-2

Although the decision to allow for compound (or even complex) features is made at the database design level, it is a decision which can have ramifications at the production level and in the final product. If a product is designed only with simple features, this limitation should be recognized and adhered to consistently. A problem may arise when the producer and/or user(s) later realize the desirability of the functionality allowed by compound features. At this point the producer has three choices: (1) redesign the product, (2) put the burden on the user, or (3) come up with a "workaround" and document it.

This situation arose in VMap1 production for the following features: runways, bridges, dams, tunnels, and piers. Each of these features has a length attribute present in the feature table. Ideally, if a length attribute exists, the graphic length of the feature will equal the value of its length attribute. Figure-3 shows two runways crossing. Runway-1, whose total length is 1000 meters is split by Runway-2 into 400 meter and 600 meter segments. According to the rules of simple features, we now have four runways. Logically then, Runway-1a, whose graphic length is 400 meters, would have a value of 400 meters in its length attribute. The burden to create the compound features would rest on the user if that functionality were desired. However, because both the user and producer realized that some compound feature functionality was needed, this was not the option chosen in the case of VMap1. Instead, a workaround was devised in which the length attribute reflected the cumulative length instead of the simple feature, or segment, length. In this example, both Runway-1a and Runway-1b would have length attributes of 1000 meters. Although this type of attribution procedure is documented within the product, a naive user could logically, but incorrectly, deduce that the total length of Runway-1 is 2000 meters.

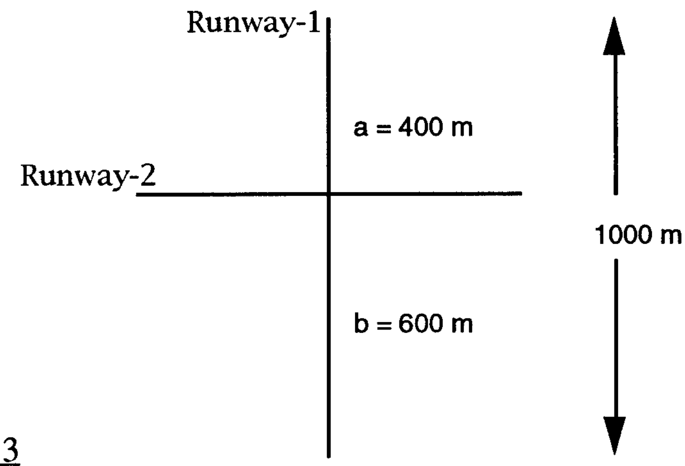

Figure-3

Although a product may be designed based on simple features, it is at the production level where this idea is implemented. Attribution decisions such as these at the production level affect the data consistency and useability. Any departure from the design's intent must be carefully documented.

Narrative Tables

Many collection/attribution decisions must be made by the producer. Because these are collection/attribution methods that are not outlined in the product specifications, or deviate from the design's intent as in the previous example, they must be documented carefully. VPF provides a means to do so through the use of narrative tables. These optional tables may be associated with any VPF table or VPF table column and provide miscellaneous comments of information pertinent to the associated table or column. Narrative tables are located at the same physical level of the table they describe and are referenced in the header of the table. Where in the header the narrative table is referenced depends on the entity being described. Within a feature table a narrative table may be associated with the feature class, an individual feature, or even a particular attribute.

Producing VMap1 has required the use of many narrative tables, several of which outline rules followed in collecting coincident features. Under the Early Data Capture guidance, for features associated with roads and railroads (eg. bridges, dams, tunnels, embankments, snowsheds, and rocksheds), the general rule is: those features with a Transportation Use Category (TUC) attribute will not be coincident with roads or railroads. The TUC attribute indicates whether a feature is associated with a road, a railroad, both, or neither. Those features without a TUC attribute (snowsheds, rocksheds, and embankments) will be coincident with roads and railroads. Narrative tables describe collection methods for these individual features.

VPF structure has two primitive types for point features: entity nodes, which are isolated points that may not be geometrically coincident with any edge in the same coverage, and connected nodes, which are points that must be coincident with an edge in the same coverage. Because of this VPF design characteristic, point features which have occurences of both types should be defined as two feature classes. Because this was not done for VMap1 point features, either the positional accuracy of the feature or the continuity of the line network on which the point fell had to be compromised. Examples of problem features in VMap1 are springs in linear drainage features, pumping stations connected to pipelines, and airports with linear runways. DMA decided that, for these examples, the linear network was more important than the positional accuracy of the point feature. As in the simple/compound feature situation discussed in the previous section, decisions made at the database design level can have repercussions in the final product. Narrative tables for these instances must be created to make the user aware of such collection methods.

Narrative tables are also created which reference particular attributes for features. For example, trees on JOGs are depicted either as *woods* or *scattered trees.* Trees have a Density Measurement (DMT) attribute which, when taken from cartographic source, cannot be determined. Because a distinction is made on JOGs between woods and scattered trees, a decision was made to assign in VMap1 the average JOG density requirement for each. As a result, the DMT equals 30 percent for scattered trees and 80 percent for woods. The reference for the narrative table describing this attribution rule would be found in the column description for the DMT attribute in the header of the TREESA.AFT feature table.

Some collection and attribution decisions which must be made are due to the fact that hardcopy cartographic source is being used, as in the example above. Situations concerning coincident features, however, would be encountered regardless of source. In both cases, narrative tables provide a means for the producer to describe collection and attribution methods employed.

Extraction Guidelines

Because of the many collection and attribution rules that must be decided outside the realm of a VPF product's specification, the development of an extraction guideline for the production operator is critical. In the previous section the importance of documentation for the user was stressed. It is equally important that the production operators have this information as well.

The extraction guideline may be created in a variety of forms. While no particular format is required, continuity between the extraction guideline and the product specification is preferred. Two different formats were developed for the VMap1 Extraction Guideline before one was chosen. Figures-4A and 4B depict the guidance for springs under the two formats. Format-A maintained the basic feature table structure (minus the header information) from the product specification and added general notes for the features below each table. Format-B addressed each feature individually, showing only those attributes applicable to each feature. In addition, Format-B tied each VMap1 feature to a symbol number from the JOG specification and defined the attribution combination for each. Format-B was eventually chosen by DMA as the official format for the VMap1 Extraction Guideline.

It has been suggested that the information in the extraction guideline be included as part of the VPF product specification itself. This, however, is not advisable since the extraction guideline is source specific. The VPF product may not always be compiled using the same primary source. For that matter, it may not even be

Figure-4A Format-A for VMap1 Extraction Guideline

TABLE 113 Well Spring Point Feature Table

Thematic Layer:	Hydrography
Coverage Name:	HYDRO
Feature Table Description:	Well Spring Point Feature Table
Table Name:	WELLSPRP.PFT
DQ Layer Number:	3

Column	Description	FACS Value	FACC Value	Value Meaning	Applicable F Code
ID	Row Identifier	Sequential beginning with 1			
F_CODE	FACS Feature Code				
		P1A050	{AA050}	Well	
		P2H170	{BH170}	Spring / Water-Hole	
		P2I010	{BI010}	Cistern	
EXS	Existence Category				
		-32767		Null	P2H170
		0		Unknown	P1A050, P2I010
		3		Reported	P1A050
		6		Abandoned {Abandoned / Disused}	P1A050
		28		**Operational**	**P1A050**
		31		**Isolated**	**P2I010**
		42	{61}	Not Isolated	P2I010
HYC	Hydrographic Category {Hydrological Category}				
		-32767		Null	P2I010
		0		Unknown	P1A050, P2H170
		3		Dry	P1A050, P2H170
		6		Non-Perennial / Intermittent / Fluctuating	P1A050, P2H170
		8		**Perennial / Permanent**	**P1A050, P2H170**
NAM	Name Variable length				
		text=0-length	Null	P2H170, P2I010	
		Character text string		P1A050	
		"UNK"		(no entry present for feature)	P1A050
PRO	Product Category				
		-32767		Null	P2H170, P2I010
		0		Unknown	P1A050
		27	{116}	Water	P1A050
SCC	Spring/Well Characteristic Category				
		-32767		Null	P2I010
		0		Unknown	P1A050, P2H170
		1		Alkaline	P1A050, P2H170
		4		Mineral	P1A050, P2H170
		9		**Freshwater / Potable**	**P1A050, P2H170**
WFT	Well Feature Type				
		-32767		Null	P2H170, P2I010
		0		Unknown	P1A050
		2		Walled-in Spring	P1A050
		3		Artesian Well	P1A050
		4		Fountain	P1A050
		5		**Dug or Drilled Well**	**P1A050**

General Notes

1: Hot springs and geysers may appear on a drainage separate symbolized as wells. They shall be collected as Geothermal features (P4B115).
2: Regardless of symbolization of a cistern (tank or well), if they are labeled as a cistern they will be collected as such.
3: If wells or springs fall on a linear drainage feature, the point feature shall be offset slightly to maintain the connectivity of the drainage network. If a well is defined as Brackish, Salt, Saline or Bitter Salt, use the Spring/Well Characteristic Category value Alkaline (SCC=1).

344 344˘	HYDRO	Spring/Water-Hole	2H170 *BH170*	Point	**HYC**	Hydrographic Category *Hydrological Category*	
						0	Unknown
						3	Dry
						6	Non-Perennial / Intermittent / Fluctuating
						8	**Perennial / Permanent**
					SCC	Spring/Well Characteristic Category	
						0	Unknown
						1	Alkaline
						4	Mineral
						9	**Freshwater / Potable**
					General Notes **1:** Hot springs and geysers may appear on a drainage separate symbolized as wells. They shall be collected as Geothermal features (P4B115). **2:** If wells or springs fall on a linear drainage feature, the point feature shall be offset slightly to maintain the connectivity of the drainage network. If a well or spring/waterhole is defined as Brackish, Salt, Saline or Bitter Salt, use the Spring/Well Characteristic Category value Alkaline (SCC=1).		

Figure-4B Format-B for VMap1 Extraction Guideline compiled using cartographic source. A VPF product specification should, therefore, be independent of guidance issued regarding source materials. The only items from the extraction guideline which might logically be included in the product specification would be those unrelated to source (coincident feature rules, for example).

The extraction guideline should pull together the additional information needed by the production operator about the primary source, any ancillary source(s), and collection/attribution decisions not addressed in the product specification. It may also be helpful to include, for in-house versions, the relationship of these rules to the collection software being used. The development of a thorough and well organized extraction guideline is a major step towards assuring uniform collection and overall product integrity.

Conclusions

Keeping the previously discussed issues in mind, one last major consideration is that the same VPF product may be produced by more than one organization. Co-producers, contractors, or different components within the same agency may be involved. In this situation, coordination is essential. In the case of VMap1 production, not only were two DMA components involved, but co-producers and contractors were involved as well. Due to many organizations using a variety of collection methods/software, it is imperative for product integrity that all involved have the same understanding of the final product, as was the case for the VMap1 product.

As mentioned in the previous section, a major step toward this goal is taken in the development of a common extraction guideline. Because the extraction guideline should include guidance on primary and ancillary sources, arbitrary collection/attribution decisions, and possibly how these relate to the collection software functionality, it is critical that the personnel making these decisions and compiling the guideline have a good understanding of the product and these issues. VPF product specifications do not cover many pertinent collection and attribution concerns, several of which are introduced through the use of cartographic source. While not always possible, it is strongly suggested that these issues be resolved prior to full-scale production to help to ensure quality and continuity. Also, the frustration factor runs high for personnel whose guidance, and even product specification, is in constant development and change.

Having a spatial product in the Vector Product Format will allow users a much wider range of analytical capabilities due to the ability for direct use within Geographic Information Systems. The accuracy of analysis performed on data in this format will heavily depend not only on the user's understanding of the product but also on the quality and consistency of the data itself. Resolving production issues before data collection begins will aid in assuring these characteristics for VPF product databases.

Bibliography

1. U.S. Department of Defense, MIL-STD-2407 Military Standard Vector Product Format,, 12 October 1993.

2. U.S. Department of Defense, MIL-V-89033 DRAFT Military Specification Vector Smart Map Level 1, 22 August 1994.

3. U.S. Department of Defense, DRAFT Vector Smart Map Level 1 Extraction Guideline, 1 March 1994.

4. U.S. Department of Defense, Product Specifications Joint Operations Graphics Series 1501 and 1501 Air, November 1976.