CHANNEL CALCULATIONS FOR WHITE SPACES GUIDELINES

Revision 1.0

08/09/2011

This interface specification was developed by the White Space Database Administrator Group.

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Revision History

Draft Revision 0.1 – Initial Draft 3/28/2011

Draft Revision 0.2 – Incorporated changes in the week of 3/28/2011 – 4/04/2011

Draft Revision 0.3 – Incorporated comments received in the week of 04/04/2011 and comments made at the teleconference on 04/11/2011

Draft Revision 0.4 – Incorporated comments received on 04/12/2011

Draft Revision 0.6 – Including Telcordia's Comments of 4/13/11 and redacting questionable items

Draft Revision 0.7 – Consensus previous to meeting in Baltimore 4/19/11

Draft Revision 0.8 – Consensus from meeting in Baltimore to present to FCC OET 4/20/11

Draft Revision 0.9 – Added FCC OET DTS protection suggestions

Draft Revision 0.91 – Modified FCC OET DTS protection graphic, added template for other TV protection criteria. corrected several typos

Draft Revision 0.92 – Added TV protection tables, Offshore Radio protection table and Canadian Diagram, changed Canadian Terrain Data source

Draft Revision 0.93 – Offshore Radio protection table corrected, added provisional URL's for Canadian and Mexican borders, deleted sections on Update times and Attachments

Draft Revision 0.94 – Changed focus to "Channel Calculation" from "Contour Protection", added several other protection specifications and Polygon Definition

Draft Revision 0.95 – Added protection descriptions for various TV receive antenna systems, polygon definition added.

Draft Revision 0.96 – Revised polygon definition, made several corrections.

Draft Revision 0.96b – Reformatted subsections in Sections 4 and 6; added reference to terrain database boundaries; clarified Section 6.2.3   Polygon Description for Wireless Microphone Protection.

Draft Revision 0.97 – Updated Sections 2.1 – cleaned up CDBS codes used and 6.4 – added the list of the protected sites

Draft Revision 0.98 – Updated Sections 5 and 6.1 and 6.23 with explanations of underlying rules

Draft Revision 0.98b – reformatted the document, updated section 6.4 – added sites in Sugar Grove, WV, Boulder, CO and Socorro, NM

Release Candidate 1.0 – added figures to section 6.3.3 MVPD Headends, numerous editorial corrections

Table of Contents

1. Definition of Scope

This specification covers precise implementation of calculations of protection contours and distances to these contours as defined by FCC rules.

The intent of this specification is to establish, ensure and validate consistency between WSDBA members. It is developed by the following currently provisional database providers: Airity, Inc., Comsearch, a CommScope Company, Frequency Finder, Inc., Google Inc., LS telcom AG, Neustar, Inc., Spectrum Bridge, Inc., and Telcordia Technologies, Inc.

This document is correct as of the date of release. All information contained within is subject to change.

2. Input Data Sources

The following shall be the default data sources used for all contour-related calculations:

2.1 FCC CDBS Database

The CDBS database shall be retrieved from:

http://www.fcc.gov/mb/databases/cdbs

The source file names shall be "tv_eng_data.dat", "ant_pattern.dat", "application.dat", "app_tracking.dat" and "facility.dat".

For current ordering of data fields within the file, refer to:

http://www.fcc.gov/ftp/Bureaus/MB/Databases/cdbs/_readme.html

The data fields retrieved for each protected site shall include:

1. Service (vsd_service)
2. Channel
3. Directional Antenna (DA) or NonDirectional (ND)
4. Effective Radiated Power (kW)
5. N (North) or S (South) Latitude
6. Degrees Latitude
7. Minutes Latitude
8. Seconds Latitude
9. W (West) or (E) East Longitude
10. Degrees Longitude
11. Minutes Longitude
12. Seconds Longitude
13. Height of Antenna Radiation Center Above Mean Sea Level (RCAMSL)
14. Directional Antenna Pattern Rotation (degrees)
15. Antenna Radiation Center Height Above Ground Level
16. Antenna ID

17. From ant_pattern.dat, all fields corresponding to the Antenna ID

Coordinate data in the CDBS is projected using the NAD27 datum.

Data identified with following database keys shall be ignored:

Database keys: vsd_service =   LM|Land Mobile| or

NM|NTSC Channel Change| or

NN|New NTSC Allotment| or

TR|Proposed Rulemaking to Amend the Table of Assignments| or

DM|DTV Channel Change| or

DN| DTV New Allotment| or

DR|DTV Channel Substitution| or

DS | Digital TV STA | or

TS| Analog Special Temporary Authority| or

TA|TV Allotment|

The data retrieved shall be identified as belonging to one of the following categories, as classified by the vsd_service database key:

2.1.1 Digital TV Stations
Database keys: vsd_service =   DT|Digital TV|

2.1.2 Digital and Analog Class A TV Stations
Database key: vsd_service   =   CA|Class A TV Station| or

DC |Digital Class A TV Station |

2.1.3 Low Power, TV Translator and Booster Stations
Database key: vsd_service   =   TX|TV Translator or LPTV Station| or

LD | Digital TV Translator or LPTV Station | or

DD | DTV Distributed Transmission System (DTS) |

2.1.4 Canadian and Mexican Border Stations
Database key: vsd_service   =   TV|Television

2.2 FCC ULS Database

The ULS database shall be retrieved from:

http://wireless.fcc.gov/uls/index.htm?job=transaction&page=weekly

Coordinate data in the ULS is projected using the NAD83/WGS84 datum.

The following files shall be retrieved from the website:

- l_LMbcast.zip
- l_LMcomm.zip
- l_LMpriv.zip
- l_micro.zip
- l_paging.zip

These files contain all necessary data for protected areas.

The following shall be the sources for information for respective protected stations:

2.2.1 Broadcast Auxiliary Service Stations (Including Receive Only Sites), Except Low Power Auxiliary Stations

- File: l_LMbcast.zip
- File: l_micro.zip

2.2.2 PLMRS Base Stations Located More than 80 Km from the Geographic Centers of the Metropolitan Areas and on the Channels 14 Through 20

- Files: l_LMpriv.zip

2.2.3 CMRS Base Stations Located More than 80 Km from the Geographic Centers of the Metropolitan Areas and on the Channels 14 Through20

- Files:l_LMcomm.zip

2.2.4 Other Protected Entities

- File: (to be described)

2.3 Terrain Database

A new, NAD83/WGS84 projected terrain database shall be generated using the publicly available National Elevation Database available at seamless.usgs.gov and Canadian data from http://www.geobase.ca.

Database shall include area necessary to provide for contour calculation of any Canadian or Mexican stations near the border.

The Canadian database shall be used within the boundaries of Canada, as defined by the border file in Section 4.3.

The NED database shall be used everywhere else.

3. Used Algorithms

The following algorithms shall be used in all pertinent calculations.

3.1 Formula for Distance Calculations

The distance between any two points shall be calculated according to the Vincenty method. The method and equations can be found at:

http://www.ngs.noaa.gov/PC_PROD/Inv_Fwd/

3.2 NAD27 to NAD83 Coordinate Translation

All geographic coordinates sent by the database shall be projected in the NAD83 or WGS84 format.

For CDBS TV station location data received in NAD27 format, the NADCON translation algorithm to NAD83 shall be used.

3.3 Power Determination

No mechanical or electrical beam tilt shall be included in the contour calculations or Effective Radiated Power ("ERP") determination. ERP shall be obtained by linearly interpolating the field values between directional pattern azimuths in CDBS.

3.4 Contour Calculation

Contours shall be defined as 360 straight lines connecting 360 calculated contour vertices. Vertices shall be calculated at one degree increments around the station location, using the Radial HAAT method in Section 3.6 for each radial.

The FCC-supplied algorithm as derived from FCC "F" Fortran code, with FCC extracted tables representing the propagation charts from §73.699 shall be used to calculate the R-6602 contour vertex locations. These must be accurate to within ten meters.

3.5 Distances to Contours

A distance between any point and given contour is determined as the shortest distance to any contour line or vertex.

To illustrate, see Figure 1: Contour Distance Calculation. Contour C is approximated by the contour points C1 through C360. Two points P1 and P2 are external to the contour C. The distance of P1 to the contour is defined as the perpendicular distance from P1 to the line segment C4-C5, as no other line or vertex is closer. The distance of P2 to the contour is defined as the distance of P2 to the contour vertex C6, as it is shorter than the distance of P2 to any point on either of the two line segments C5-C6 and C6-C7.
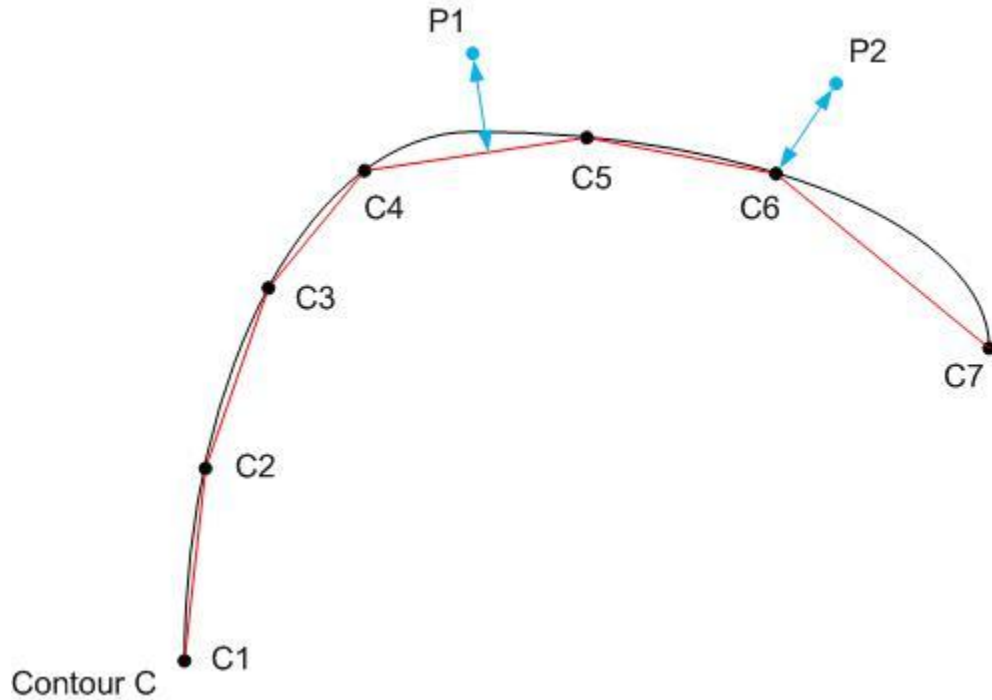
Figure 1: Contour Distance Calculation

3.6 Radial HAAT Calculations

To calculate a radial HAAT for a given azimuth from a pair of coordinates, a set of 130 elevations of points at 100 meter intervals beginning at 3.2 kilometers and ending at 16.1 kilometers from the station shall be extracted and averaged. The two endpoints shall be determined using the method of section 3.1, and the intervening coordinate pairs obtained by linear interpolation. The elevation at each point shall be linearly interpolated from the four adjacent tiles. In addition, each radial HAAT shall be calculated from elevations along the radial regardless of borders and bodies of water. In cases of islands or continental coasts where no data is returned by the terrain databases, zero elevation shall be presumed.

3.7 Station HAAT Calculations

Station HAAT is an average of 8 radial HAAT values taken in 45° steps: 0° True, 45°, 90°, 135°, 180°, 225°, 270°, and 315°. To calculate station HAAT the entire radial lengths from 3.2 to 16.1 kilometers, of all eight radials, regardless of borders and water, shall be used.

4. TV Protection Criteria

4.1 TV, Class A TV, LPTV, Translator Outputs

Protected TV contour values are:

Table 1

(units in dBµV/m)	Low (2 - 6)	High VHF (7 - 13)	UHF (14 - 52)
Analog F(50,50)	47	56	64
Digital F(50,90)	28	36	41

Protection distances are:

Table 2

(units in kilometers)	Co-channel	Adjacent Channel
Antenna height up to 3 meters	6.0	0.1
Antenna height up to 10 meters	8.0	0.1
Antenna height up to 30 meters	14.4	0.74

4.1.1 Translator Inputs

See section 5, "Other protected Entities"

4.2 DTS

The population served by Distributed Television Service stations shall be the population within the station's combined coverage contour, excluding the population in areas that are outside both the DTV station's authorized service area and the Table of Distances area, as follows:

Table 3

Channel	Zone	F(50,90) Field Strength	Distance from Reference Point (km)
2 - 6	1	28	108
2 - 6	2 and 3	28	128
7 - 13	1	36	101
7 - 13	2 and 3	36	123
14 - 61	1, 2 and 3	41	103

For DTS records the reference point coordinates are in the CDBS tv_eng_data table; they are in the first row designated as site_number = 0, and must be converted from NAD 27.

Figure 2: Distributed Television Service Protection

4.3 Canadian TV

Canadian TV service shall be protected to the contour values of §4.1 at the US-Canadian Border identically to US TV facilities, except that the area within the Canadian contour but inside the USA is unprotected, which is illustrated in the figure below.

The file describing the US-Canadian border is available at the following URL:

http://transition.fcc.gov/oet/info/maps/uscabdry/uscabdry.zip
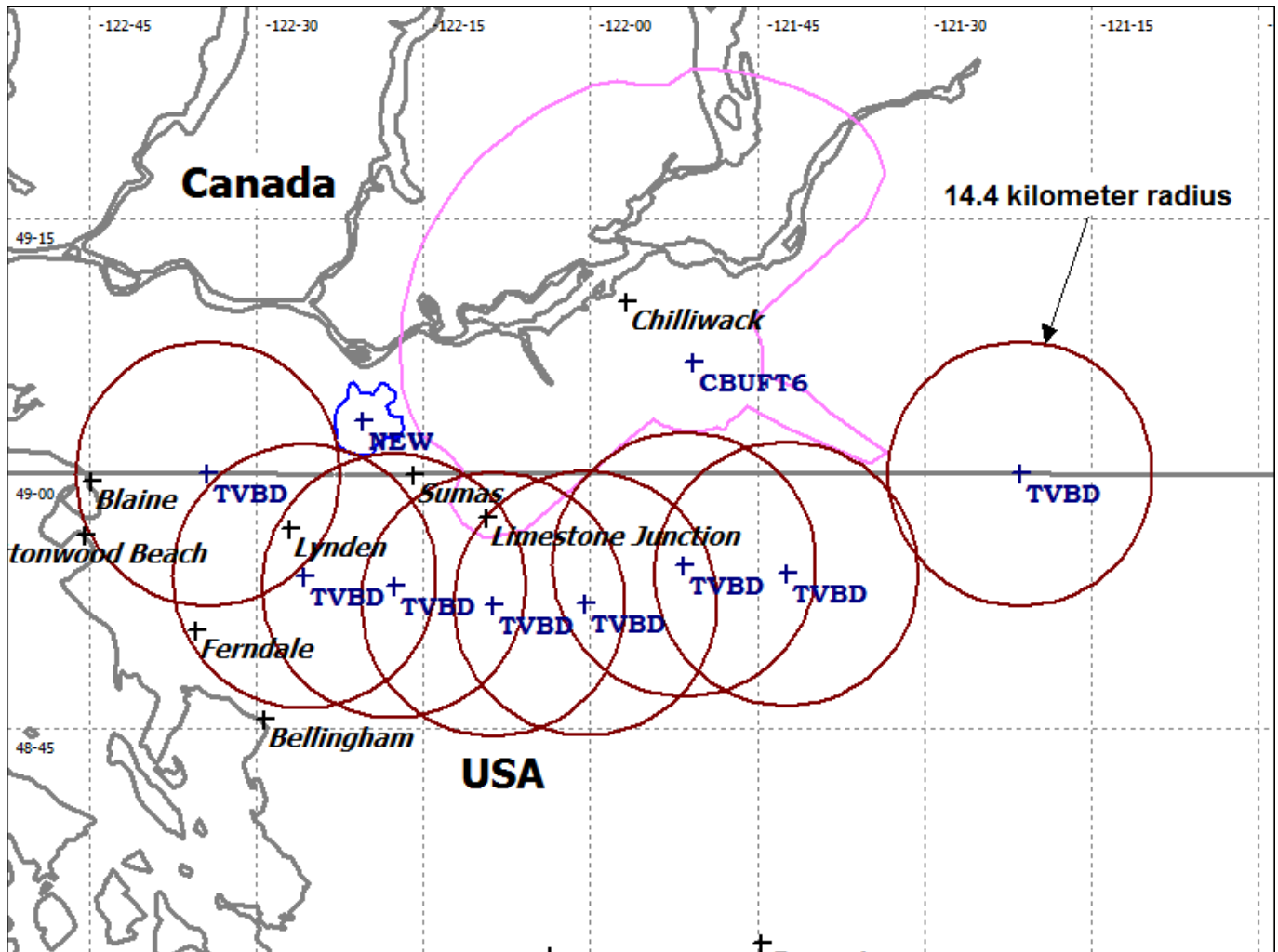
Figure 3: Canadian Border Protection

This example shows allowed fixed TVBD locations near the Canadian border protecting two Canadian TV facilities. This assumes like protection requirements as to US facilities, and omits many other records for clarity.

4.4 Mexican TV

Mexican TV service shall be protected to the contour values of §4.1 at the US-Mexican Border using values identical to US TV facilities, except that the area within the Mexican contour but inside the USA is unprotected.

The file describing the US-Mexican border is available at the following URL:

http://transition.fcc.gov/oet/info/maps/usmxbdry/usmxbdry.zip

5. CMRS/PLMRS UHF "T-Band" Protection

The eleven metropolitan areas in which T-Band services exist are follows:

City	Latitude	Longitude	Channels
Boston, MA	42-21-24.4 N	71-03-23-2 W	14, 16
Chicago, IL	41-52-28.1 N	87-38-22.2 W	14, 15
Dallas/Fort Worth, TX	32-47-09.5 N	96-47-38.0 W	16
Houston, TX	29-45-26.8 N	95-21-37.8 W	17
Los Angeles, CA	34-03-15.0 N	118-14-31.3 W	14, 16, 20
Miami, FL	25-46-38.4 N	80-11-31.2 W	14
New York, NY	40-45-06.4 N	73-59-37.5 W	14, 15, 16
Philadelphia, PA	39-56-58.4 N	75-09-19.6 W	19, 20
Pittsburgh, PA	40-26-19.2 N	79-59-59.2 W	14, 18
San Francisco, CA	37-46-38.7 N	122-24-43.9 W	16, 17
Washington, DC	38-53-51.4 N	77-00-31.9 W	17, 18

These locations are to be protected by 134 kilometers for co-channel operation and 131 kilometers for adjacent channel operation. Protection of PLMRS/CMRS UHF T-Band base stations outside the 80 kilometer prescribed radii/channel combinations in the table, granted by waiver, are to be protected by 54 kilometers for co-channel operation and 51 kilometers for adjacent channel operation.   The remaining two areas in the Rules (for Cleveland and Detroit) were never implemented due to Canadian concerns.

6. Other Protection

6.1 Offshore Radio Service
The Offshore Radio Service will be protected by prohibiting TVWS devices within the following areas:

	NW corner	NE corner	SE corner	SW corner
TV channel 15	N 30.5, W 96	N 30.5, W 92	N 28, W 92	N 28, W 98.5
TV channel 16	N 31, W 95	N31, W 86° 40'	N 29.5, W 86° 40'	N 29.5, W 96.5
TV channel 17	N 31.5, W 94	N 31, W 86.5	N 29.5, W 86.5	N 29.5, W 96
TV channel 18	N 31, W 95	N 31, W 87	N 29.5, W 87	N 29.5, W 95

The quadrilateral vertices are from §74.709(e), with the southern boundary of adjacent channel 18 protection defined by FCC as coincident with the southern boundary of channel 17.

Lines between points will be drawn on great circles.

6.2 Wireless Microphones
Wireless microphones operating in the TV spectrum may register their intended use so as to be protected, during the times and on the day of such registered use, from TVDB's according to §15.712(f).

6.2.1 Licensed Wireless Microphones
Licensed wireless microphone registrants, as for example Broadcasters, may register directly with the WSDBA of their choice. Registrations will be promptly shared with all other WSDBA's. Due to the

infrequent (daily) requirement for TVDB's to reaffirm a channel list, protection will be guaranteed only when entered at least 48 hours prior to known event times. Emergent wireless microphone use must take place on one of the channels reserved for that use or risk interference.

6.2.2 Unlicensed Wireless Microphones

Unlicensed wireless microphone registrants, as for example churches or entertainment venues, must register with FCC, which will then share registration information with WSDBA's. The additional time required for dissemination from ULS is unknown at present, but will be at least 24 hours.

6.2.3 Polygon Description for Wireless Microphone Protection

15.712(f) allows only for a single protected point. In order to protect areas in addition to points, polygons for protection of Wireless Microphone registrants may be entered in one of three forms:

1. *A point, specified by geographic coordinates in NAD 83;*
2. *A circle, or point (as above) and radius, with the radius limited to no more than 0.75 kilometers (750 meters); or*
3. *A quadrilateral, represented by four points as above, limited in size to three kilometers between any pair of vertices.*

In each case, a protected buffer of one kilometer (fixed TVBD's) and 400 meter (personal/portable TVBD's) will be created around the protected area by each recipient database.

Entities requiring larger areas may assemble them from any of the three types, provided that not more than twenty-five are included in a single registration.

6.3 TV receiving Antenna Protection

Area protected for TV receive antenna channels shall be a "keyhole" sized depending on co-channel or adjacent channel protection. If co-channel, the circle extends eight kilometers and the "keyhole" at most eighty kilometers, at plus and minus thirty degrees of arc from the azimuth toward the radiating TV station. If adjacent, the radius shall be two kilometers and keyhole at most twenty.

6.3.1 TV Translator Inputs

Sites receiving TV translator, LPTV and Class A signals which are within the protected contour of the station being received are not eligible for registration in the databases, as the contour will already be protected.

6.3.2 Broadcast Auxiliary Services

Permanent BAS sites from ULS and temporary BAS site registrations will be protected by keyhole as above save that the protection extends only as far as the transmitting station. These include TV Pickup, TV STL, TV Relay, TV Translator Relay and TV Microwave Booster stations.

6.3.3 MVPD Headends

Headend receive locations will be protected for each TV receive antenna using the keyhole above, which however is limited to either its maximum value above or to the distance to nearest point of

intersection with the TV station's protected contour, whichever is less. Figures 4 and 5 illustrate co-channel protection, with an assumed 14.4 kilometer protection radius around the TVBD to the TV station, and adjacent channel protection, where the CATV Headend protection is limited to 20 kilometers and the WSBD must remain 740 meters from the protected TV contour.
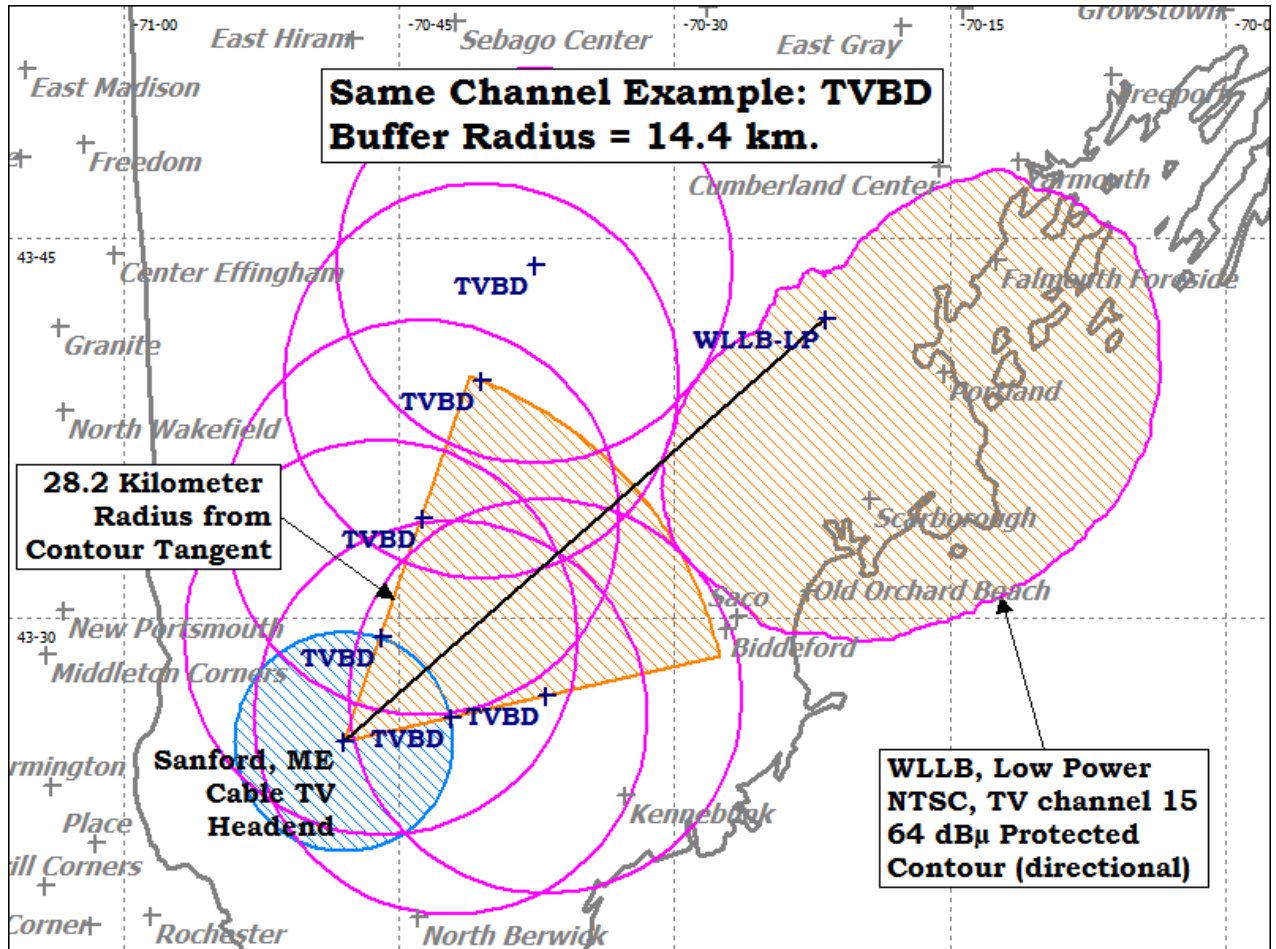
Figure 4: MVPD Receive Antenna Protection, Co-Channel

This example was drawn using real records near the actual Sanford, Maine CATV receive antenna location, but it is not known whether WLLP, Portland is actually received there or protected. It was chosen to illustrate the fact that the point of tangency which defines the protected radius of 28.8 kilometers in this case may not lie on or even close to the inter-site radial, which is drawn in black . In this example it would not be possible to operate a TVBD much less than the proscribed 30° (from §15.712), though that may not always be true. If the test was to operate the TVDB on either TV channel 14 or 16 (adjacent), devices could be operated even on the inter-site radial, as shown in Figure 5.
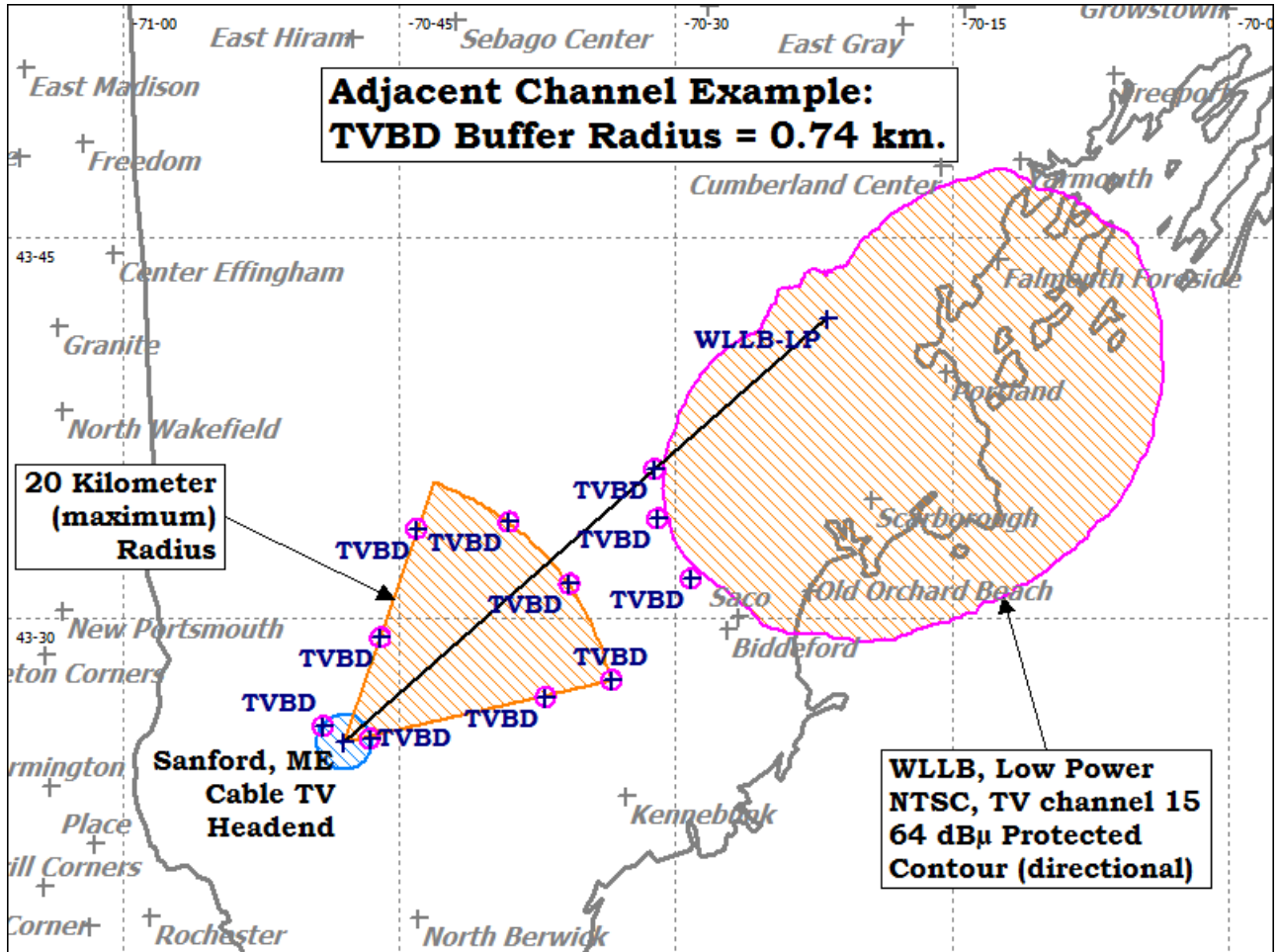
Figure 5: MVPD Receive Antenna Protection, Adjacent Channel

6.4 Radio Astronomy Sites

The following are the locations of the Radio Astronomy sites to be protected on all channels, as updated by NTIA:

Telescope	Name	City	State	LatDMS	LonDMS
Allen Telescope Array	Allen Telescope Array	Hat Creek	CA	40-49-4	-121-28-24
National Astronomy and Ionosphere Center (NAIC), Arecibo Observatory	Arecibo Observatory	Arecibo	PR	18-20-37	-66-45-11
National Radio Astronomy Observatory (NRAO), Robert C. Byrd Green Bank Telescope	Green Bank Telescope	Green Bank	WV	38-25-59	-79-50-23
National Radio Astronomy Observatory (NRAO), Very Long Baseline Array Station	VLBA - Brewster, WA	Brewster	WA	48-7-52	-119-41-00

Telescope	Name	City	State	LatDMS	LonDMS
National Radio Astronomy Observatory (NRAO), Very Long Baseline Array Station	VLBA - Fort Davis, TX	Fort Davis	TX	30-38-6	-103-56-41
National Radio Astronomy Observatory (NRAO), Very Long Baseline Array Station	VLBA - Hancock, NH	Hancock	NH	42-56-1	-71-59-12
National Radio Astronomy Observatory (NRAO), Very Long Baseline Array Station	VLBA - Kitt Peak, AZ	Kitt Peak	AZ	31-57-23	-111-36-45
National Radio Astronomy Observatory (NRAO), Very Long Baseline Array Station	VLBA - Los Alamos, NM	Los Alamos	NM	35-46-30	-106-14-44
National Radio Astronomy Observatory (NRAO), Very Long Baseline Array Station	VLBA - Mauna Kea, HI	Mauna Kea	HI	19-48-5	-155-27-20
National Radio Astronomy Observatory (NRAO), Very Long Baseline Array Station	VLBA - North Liberty, IA	North Liberty	IA	41-46-17	-91-34-27
National Radio Astronomy Observatory (NRAO), Very Long Baseline Array Station	VLBA - Owens Valley, CA	Owens Valley	CA	37-13-54	-118-16-37
National Radio Astronomy Observatory (NRAO), Very Long Baseline Array Station	VLBA - Pie Town, NM	Pie Town	NM	34-18-4	-108-7-9
National Radio Astronomy Observatory (NRAO), Very Long Baseline Array Station	VLBA - Saint Croix, VI	Saint Croix	VI	17-45-24	-64-35-1
Naval Radio Research Observatory (NRRO), Navy Information Operations Command (NIOC)	Sugar Grove Research Station	Sugar Grove	WV	38-30-53.99	-79-16-48.01
Table Mountain Radio Receiving Zone of the Research Laboratories of the Department of Commerce	Table Mountain	Boulder	CO	40-7-50	-105-14-40
National Radio Astronomy Observatory (NRAO), Very Large Array	Very Large Array	Socorro	NM		Rectangle (no 2.4 km radius) between latitudes 33 58 22 N and 34 14 56 N, and longitudes 107 24 40 W and 107 48 22 W