APPLICATION FOR GATEWAY EARTH STATION

I. OVERVIEW

The Commission has authorized Space Exploration Holdings, LLC ("SpaceX") to launch and operate its first-generation ("Gen1") constellation of 4,408 non-geostationary orbit ("NGSO") satellites (call sign S2983/S3018) using Ku- and Ka-band spectrum.[1] In May 2019, SpaceX began launching satellites to populate the Gen1 constellation. In May 2020, SpaceX filed an application to launch and operate a constellation of second-generation ("Gen2") NGSO satellites (call sign S3069) using Ku-, Ka-, and E-band spectrum.[2] The Commission granted the Gen2 application in part on December 1, 2022.[3] In so doing, the Commission found that granting the Gen2 application would "help to address the pressing need for improved broadband connectivity, including in unserved and underserved areas of the United States," and "further the US leadership in space-based services, facilitating coverage globally and helping the efforts to close the digital divide around the world."[4]

This application, filed by a sister company, SpaceX Services, Inc. ("SpaceX Services"), seeks authority to operate a Ka-band gateway earth station that SpaceX will use to deliver broadband data between the satellites of its NGSO systems and terrestrial Internet exchange points. Specifically, SpaceX Services seeks authority for 32 technically identical 1.85-meter antennas in Prosser, Washington (the "Prosser Gateway"). Consistent with SpaceX's space station authorizations, these antennas will simultaneously communicate with up to eight Gen1 satellites and up to thirty-two Gen2 satellites and will transmit in the 27.5-29.1 GHz and 29.5-30.0 GHz bands and receive in the 17.8-18.6 GHz and 18.8-19.3 GHz bands.

Below, we discuss certain spectrum sharing issues relevant to the operation of this earth station. We then demonstrate that grant of this application would serve the public interest. Lastly, we provide technical information to supplement the information provided in Form 312. To support its ambitious timetable for launching satellites and deploying broadband services, SpaceX Services requests that the Commission grant the requested license as expeditiously as possible.

II. SPECTRUM SHARING ISSUES

Under the Commission's spectrum allocations and the plan adopted for the Ka-band in particular,[5] SpaceX Services will need to share with a variety of other systems operating in its

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1 *See Space Exploration Holdings, LLC*, 33 FCC Rcd. 3391 (2018); *Space Exploration Holdings, LLC*, 36 FCC Rcd. 7995 (2021) ("*SpaceX Authorization"*), *aff'd sub nom. Viasat, Inc. v. FCC*, 47 F.4th 769 (D.C. Cir. 2022). These authorizations anticipate that Ka-band spectrum would be used for gateway communications.

2 Initial filing (May 2020): SAT-LOA-20200526-00055; Subsequent amendment (August 2021): SAT-AMD-20210818-00105

3 *See Space Exploration Holdings, LLC*, FCC 22-91 (rel. Dec. 1, 2022) ("*Gen2 Authorization*").

4 *See id.* ¶ 21.

5 *See Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, 32 FCC Rcd. 7809, App. B (2017) ("*NGSO Update Order*").

bands. Below we demonstrate that the proposed Prosser Gateway will comply with all relevant sharing requirements.

A. Uplink Bands

FSS is primary throughout the 28.35-29.1 GHz band, with NGSO designated as secondary to GSO in the 28.35-28.6 GHz portion and NGSO designated as primary in the 28.6-29.1 GHz portion. FSS is co-primary with Mobile Satellite Service ("MSS") in the 29.5-30.0 GHz band, with NGSO designated as secondary to GSO.[6]

The 27.5-28.35 GHz band has been designated for use by the Upper Microwave Flexible Use Service ("UMFUS") on a primary basis, with a secondary designation for FSS. The Technical Appendix in this document demonstrates that the Prosser Gateway will satisfy the criteria set forth in Section 25.136(a)(4) of the Commission's rules such that it may operate without providing additional interference protection to terrestrial UMFUS systems operating in the band.[7]

The Comsearch Report submitted with this application confirms that SpaceX Services has coordinated with existing terrestrial licensees in these bands in compliance with the Commission's rules and can operate without causing harmful interference to any such deployments. SpaceX Services makes no claim of interference protection from U.S.-licensed GSO FSS systems in the 28.35-28.6 GHz and 29.5-30.0 GHz bands. In addition, SpaceX Services will comply with the applicable equivalent power flux-density ("EPFD") limits set forth in Article 22 and Resolution 76 of the ITU Radio Regulations, which the Commission has found to be sufficient to protect GSO systems against harmful interference.[8] SpaceX has demonstrated that its NGSO systems will comply with these EPFD limits, and doing so is a condition of its authorizations.[9]

B. Downlink Bands

The Commission has allocated the 17.8-18.3 GHz band on a primary basis to the terrestrial fixed service ("FS") and on a secondary basis for FSS. The 18.3-18.6 GHz band is allocated on a primary basis to FSS, with NGSO secondary to GSO and subject to international EPFD limits. The 18.8-19.3 GHz band is allocated to FSS on a primary basis, with NGSO designated as primary.

SpaceX has previously demonstrated that its NGSO systems will protect terrestrial fixed stations in the 17.8-18.6 GHz and 18.8-19.3 GHz bands, in compliance with a condition placed on its license.[10] Moreover, the Comsearch report submitted with this application confirms that there should be no additional limitations placed on operations of the Prosser Gateway. Similarly, SpaceX has demonstrated that its NGSO systems will comply with the relevant EPFD limits in the 18.3-

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6 *See id.*

7 *See* 47 C.F.R. § 25.136(a)(4).

8 *See, e.g.*, 47 C.F.R. § 25.289 (NGSO satellite systems that comply with EPFD limits will be deemed not to cause unacceptable interference to any GSO network). SpaceX believes that the EPFD limits designed to protect GSO FSS systems will also protect GSO MSS systems in the band.

9 *See SpaceX Authorization*, ¶¶ 32, 97(b), (d), (e), and (l); *Gen2 Authorization* ¶¶ 31, 55, 135p; 47 C.F.R. § 25.115(f)(1) (incorporating certification requirement in 47 C.F.R. § 25.146(a)(2)).

10 *See SpaceX Authorization* ¶ 52; *Gen2 Authorization* ¶ 24.

18.6 GHz band, which the Commission considers sufficient to protect GSO networks from unacceptable interference.[11]

III. GRANT OF THIS APPLICATION WOULD SERVE THE PUBLIC INTEREST

Granting this application would serve the public interest by helping to speed high-capacity, low-latency broadband deployment throughout the United States by authorizing the ground-based component of SpaceX's satellite systems. U.S. and worldwide demand for broadband services and Internet connectivity continues to increase with escalating requirements for speed, capacity, and reliability and ongoing adaptations for usage. The volume of traffic flowing over the world's networks has exploded, with one report estimating that annual global Internet protocol traffic reached 1.5 zettabytes in 2017 – meaning that approximately 1,500 billion gigabytes of data were exchanged worldwide that year.[12]

Yet, as the Commission has recognized, many communities across the United States and the world still lack access to reliable broadband connectivity, preventing them from fully participating in economic, social, and civic activities.[13] To help close this digital divide, SpaceX is designing, constructing, and deploying innovative, cost-effective and spectrum-efficient satellite systems capable of delivering robust broadband service to customers around the world. SpaceX has already secured U.S. authority for the space station components of its NGSO systems. This application takes the next step by seeking authority for one of the gateway earth stations that will connect the satellite systems to the terrestrial Internet. Accordingly, an expeditious grant of this application would serve the public interest.

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[11] *See SpaceX Authorization* ¶ 34; *Gen2 Authorization* ¶¶ 31, 54.

[12] *See* Cisco Visual Networking Index: Forecast and Methodology, 2017-2022, at 1, CISCO (Nov. 26, 2018), https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paperc11-741490 html.

[13] *See, e.g., Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion*, 33 FCC Rcd. 1660, ¶ 50 (2018) (noting that "over 24 million Americans still lack fixed terrestrial broadband at speeds of 25 Mbps/3 Mbps," and that "the gap in rural and Tribal America remains notable: 30.7 percent of Americans in rural areas and 35.4 percent of Americans in Tribal lands lack access to fixed terrestrial 25 Mbps/3 Mbps broadband"). Internationally, the disparities between broadband access and absence are even greater, with 4.2 billion people (or 57% of the world's population) offline. *See* BROADBAND COMMISSION FOR SUSTAINABLE DEVELOPMENT, "Open Statement from the Broadband Commission for Sustainable Development to the UN High-Level Political Forum (HLPF)" (July 11, 2016), http://broadbandcommission.org/Documents/publications/HLPF-July2016.pdf. *See also* BROADBAND COMMISSION FOR SUSTAINABLE DEVELOPMENT, "The State of Broadband 2015," at 8 (Sep. 2015), http://www.broadbandcommission.org/Documents/reports/bb-annualreport2015.pdf ("A large body of evidence has now been amassed that affordable and effective broadband connectivity is a vital enabler of economic growth, social inclusion and environmental protection."

TECHNICAL APPENDIX

In this Technical Appendix, SpaceX Services provides additional information on the proposed operations of its gateway earth station to supplement the data provided in Schedule B to Form 312 filed with this narrative application.[1]

A. Minimum Elevation Angle

SpaceX Service's gateway earth stations will communicate only with those SpaceX satellites that are visible on the horizon above a minimum elevation angle. This angle may be as low as 25 degrees, and thus SpaceX Services has used this minimum elevation angle in its analysis in order to capture the full potential range of service.

B. UMFUS Coordination - Section 25.136(a)(4)

Section 25.136(a)(4) of the Commission's rules defines four elements that, if met, permit an earth station licensee to operate without providing additional interference protection to terrestrial systems in the Upper Microwave Flexible Use Service ("UMFUS") operating in the 27.5-28.35 GHz band.[2] As demonstrated below, the proposed Prosser Gateway satisfies these criteria, and the Commission should authorize this earth station without requiring additional protection for future UMFUS systems.

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[1] To the extent relevant, SpaceX Services hereby incorporates the technical information submitted with SpaceX's space station applications. *See* IBFS File Nos. SAT-LOA-20161115-00118, SAT-LOA-20170726-00110, SAT-MOD-20181108-00083, SAT-MOD-20200417-00037, SAT-LOA-20200526-00055, and SAT-AMD-20210818-00105.

[2] *See* 47 C.F.R. § 25.146(a)(4).

Summary of 25.136(a)(4) Compliance

	Section	SpaceX Compliance Details
✓	**25.136(a)(4)(i)** Number of gateways per county	There is one earth station authorized to operate in 27.5-28.35 GHz in Benton County (E202123). Therefore, the Prosser Gateway does not exceed the limit of 3 earth stations per county.
✓	**25.136(a)(4)(ii)** Population coverage	The PFD contour of the Prosser Gateway is contained entirely within the PFD contour of the previously authorized earth station in Benton County. It therefore does not contribute any additional population coverage in Benton county.[3]
✓	**25.136(a)(4)(iii)** Roadways and other "protected" areas	The PFD contour of the Prosser Gateway does not contain any major event venue, urban mass transit route, passenger railroad, or cruise ship port. In addition, it does not contain any roadways defined in this section.
✓	**25.136(a)(4)(iv)** Frequency coordination	SpaceX Services has successfully completed frequency coordination in compliance with the Commission's rules. See Comsearch report submitted with this application for detail.

Detail on 25.136(a)(4) Compliance

Section 25.136(a)(4)(i)

A search of the International Bureau Filing System shows one authorized earth station in Benton County operating in the 27.5-28.35 GHz band, and no pending applications for such an earth station.

Section 25.136(a)(4)(ii)

Section 25.136(a)(4)(ii) provides that an earth station operator need not provide interference protection to future UMFUS systems if, in a UMFUS license area with a population between 6,000 and 450,000 people, no more than 450 people will be within the aggregate PFD contour that is equal to or exceeds -77.6 dBm/m^2/MHz of all earth stations that are authorized per Section 25.136(a) in that UMFUS license area. The PFD contour of the Prosser Gateway is contained entirely within the PFD contour of a previously-authorized earth station (E202123),and therefore does not contribute towards the 450-people population-coverage limit in Benton County. This threshold is based on a population of 206,873 people in Benton County.[4]

In order to conduct a technical analysis to determine the region around the Prosser Gateway site that would fall within the PFD contour defined by Section 25.136(a)(4), SpaceX used proprietary software, which implements the standard ITU-R Rec. P.452.16 propagation and clutter

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[3] *See* Public Notice, *International Bureau Issues Guidance On Siting Methodologies For Earth Station Seeking To Operate In The 24.75-25.25 GHz, 27.5–28.35 GHz, 37.5–40 GHz, 47.2-48.2 GHZ, AND 50.4-51.4 GHz Frequency Bands To Demonstrate Compliance With Section 25.136*, 35 FCC Rcd. 6347 (IB 2020).

[4] See QuickFacts Benton County, Washington, United States Census Bureau. https://www.census.gov/quickfacts/fact/table/bentoncountywashington/PST045221

models,[5] consistent with guidance issued by the Commission.[6] The ITU P.452 clutter category used in the analysis for this earth station was found to be the most appropriate category based on satellite and street view imagery in Google Earth, as well as in-person surveys at the proposed earth station location. SpaceX will be using the Time-Variant Gain (TVG) method from ITU RR Appendix 7. The TVG method calculates the area in which the PFD limit is not exceeded for a certain percentage of time.[7] As each of the 32 antennas of the Prosser Gateway would track a different SpaceX satellite, SpaceX determined the aggregate 99th percentile EIRP density for the given azimuth angle between the SpaceX site and the incumbent receiver.[8] Next, SpaceX defined a reference antenna at 10 meters height above ground with 50.24 dBi gain pointed toward the Prosser Gateway. This is necessary because SpaceX proprietary software performs its calculations using receive power density rather than PFD. The 50.24 dBi gain effectively converts the receive power density value to a PFD value so that results can displayed in terms of PFD. [9] SpaceX also loaded information on the surrounding terrain at a 1-arc second resolution (approximately 30 meters by 30 meters) from NASA's SRTM Digital Terrain Elevation Data profile. Table 1 below summarizes the parameters used for the analysis.

With the inputs listed in Table 1 and an omni-directional pattern centered at the gateway site, SpaceX ran the proprietary software implementing the ITU propagation model to develop a composite PFD contour for simultaneous operation of as many as 8 antennas associated with the Gen1 constellation and as many as 32 antennas associated with the Gen 2 constellation, with a threshold of -107.6 dBW/m^2/MHz[10] at 10 meters above ground, as required under Section 25.136. The simulation works by moving the reference antenna in small steps all around the area surrounding the Prosser Gateway to measure the value of received power at each location step. The figures within this Technical Appendix show the PFD contour as calculated by SpaceX proprietary software, superimposed on Google satellite imagery.

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5 The PFD contours created by SpaceX's proprietary software have been compared with the Visualyse Professional software (from Transfinite Systems Ltd) to ensure consistency.

6 *See* Public Notice, *International Bureau Issues Guidance On Siting Methodologies For Earth Station Seeking To Operate In The 24.75-25.25 GHz, 27.5–28.35 GHz, 37.5–40 GHz, 47.2-48.2 GHZ, AND 50.4-51.4 GHz Frequency Bands To Demonstrate Compliance With Section 25.136*, 35 FCC Rcd. 6347 (IB 2020).

7 The TVG method has previously been approved by FCC for SES-LIC-20180727-02075; SpaceX has elected to use a conservative value of 99% for this percentage.

8 This data is based on 32 earth station antennas with -10 dBi gain toward the horizon, each operating at -29.7 dBW/MHz EIRP density toward the horizon, based on -19.7 dBW/MHz input power density.

9 This is the gain of a meter square antenna at 27.5 GHz ($G = 10*\log10(4\pi/\lambda^2)$), where λ=1.09 cm at 27.5 GHz). This is a physical quantity corresponding to an antenna with one-meter square effective area, necessary to convert receive power density into power flux density.

10 This is equivalent to the -77.6 dBm/m2/MHz value used in Section 25.136(a)(4).

Table 1: Prosser Gateway Parameters

Site location	Prosser, Washington
County	Benton County, Washington
Site coordinates	46° 7' 36.7" N, 119° 41' 2.4" W
Simulation frequency	27.5 GHz
Maximum antenna sidelobe level toward horizon[11]	-10 dBi
Input power density[12]	-19.7 dBW/MHz
Number of active antennas	32
Height to midline of antenna	1.7
ITU P.452 clutter category	High crop fields
99th percentile aggregate EIRP toward horizon	Minimum: -20.43 dBW/MHz Maximum: -19.141 dBW/MHz

Section 25.136(a)(4)(iii)

The Prosser Gateway complies with this section of the Commission's rules because its PFD contour does not contain any "major event venue, urban mass transit route, passenger railroad, or cruise ship port." In addition, the PFD contour does not cross any roadways classified as "Other Freeways and Expressways or Other Principal Arterials."

To make the certification regarding roadways, SpaceX conducted an analysis of a comprehensive dataset of roadways obtained from the 2017 release of the HPMS ARNOLD[13] dataset, belonging to the Federal Highway Administration of the Department of Transportation. To ensure compliance with 47 CFR § 25.136(a)(4)(iii), SpaceX analysis considers the following categories within the dataset: "Interstate," "Principal Arterial – Other Freeways and Expressways," and "Principal Arterial – Other." SpaceX uses the comprehensive dataset of roadways to ensure that the PFD contour does not cross any roads classified as "Other Freeways and Expressways or Other Principal Arterials." According to the website from which the dataset is obtained, the dataset "derives and is collected from State DOT road data. ARNOLD consists of locations of all roads in the U.S."[14]

C. Antenna Patterns

SpaceX will comply with a mask similar to the one in Section 25.209(a)(3) applicable to earth station antennas operating in the 24.75-25.25 GHz and 28.35-30.0 GHz bands with

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[11] There have been changes over time in the antenna sidelobe level toward the horizon used in SpaceX's earth station applications. The changes are due to improvements in SpaceX earth station antenna design.

[12] For this application, SpaceX conservatively uses worst-case input power density and does not change maximum power during rain fade conditions. Clear-sky maximum power is the same as during rain fade for this application.

[13] These acronyms refer to the Highway Performance Monitoring System and All Road Network of Linear Referenced Data.

[14] U.S. Department of Transportation, *Bureau of Transportation Statistics* (Dec. 5, 2022), https://www.bts.gov/geography/geospatial-portal/NTAD-direct-download.

geostationary satellites but will improve that pattern to -10 dBi (rather than 0 dBi) beyond 25 degrees off-axis. The mask can be stated as follows:

$29-25\log_{10}\theta$	dBi	for $2° \leq \theta \leq 7°$.
8	dBi	for $7° < \theta \leq 9.2°$.
$32-25\log_{10}\theta$	dBi	for $9.2° < \theta \leq 25°$.
-10	dBi	for $25° < \theta \leq 180°$.

Consistent with Section 25.209(a)(3), "[t]his envelope may be exceeded by up to 3 dB in 10% of the range of θ angles from ±7-180°, and by up to 6 dB in the region of main reflector spillover energy."[15] In addition, the half power beamwidth for the proposed antenna is 0.5 degrees at 30 GHz.

[15] 47 C.F.R. § 25.209(a)(3).

Figure 1. Wide-Area View Showing Census Blocks and County Boundaries

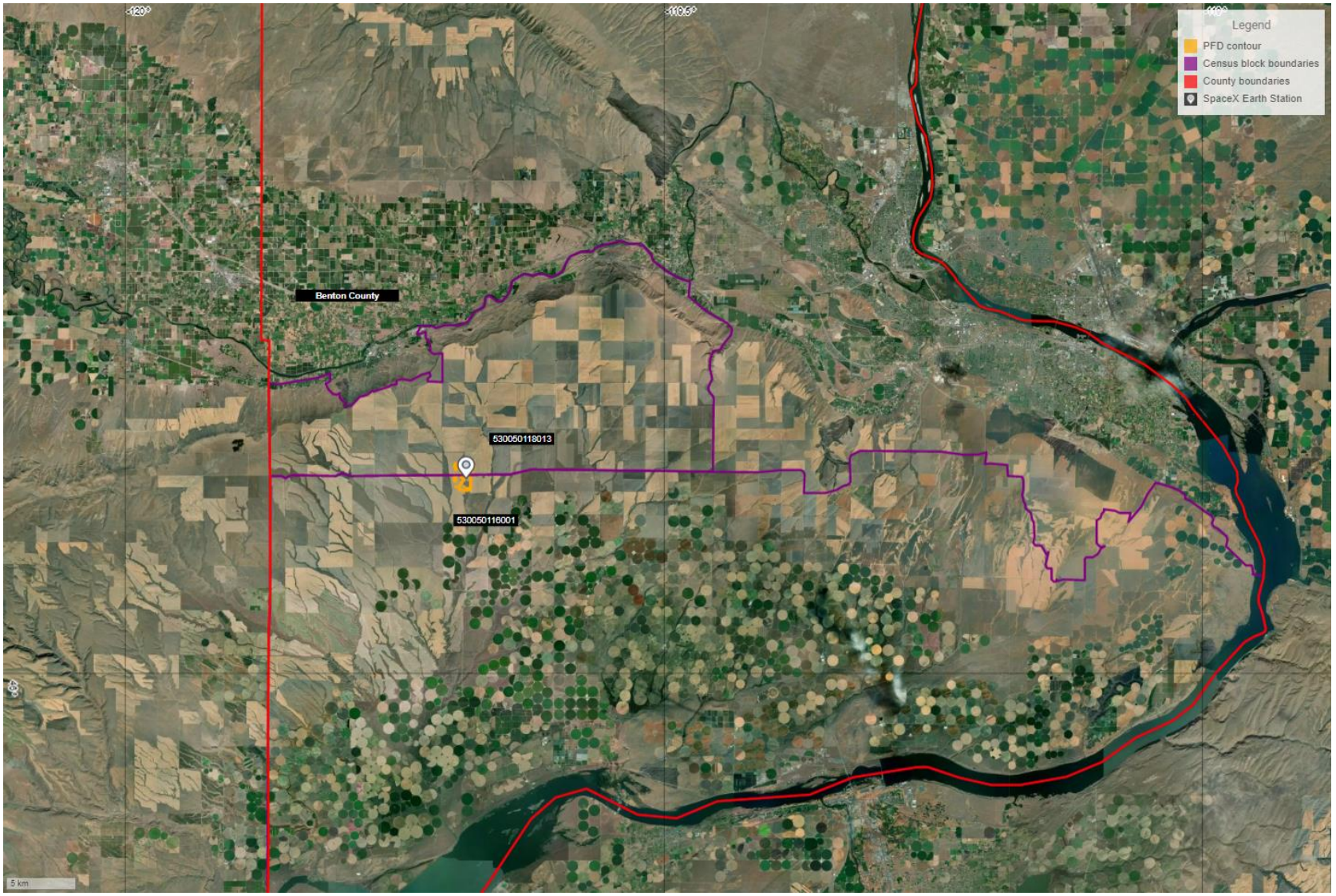

Figure 2. Close-up view of PFD contour and census blocks

Figure 3. Contour of Prosser Gateway (orange) contained entirely within contour of previously authorized gateway (magenta)

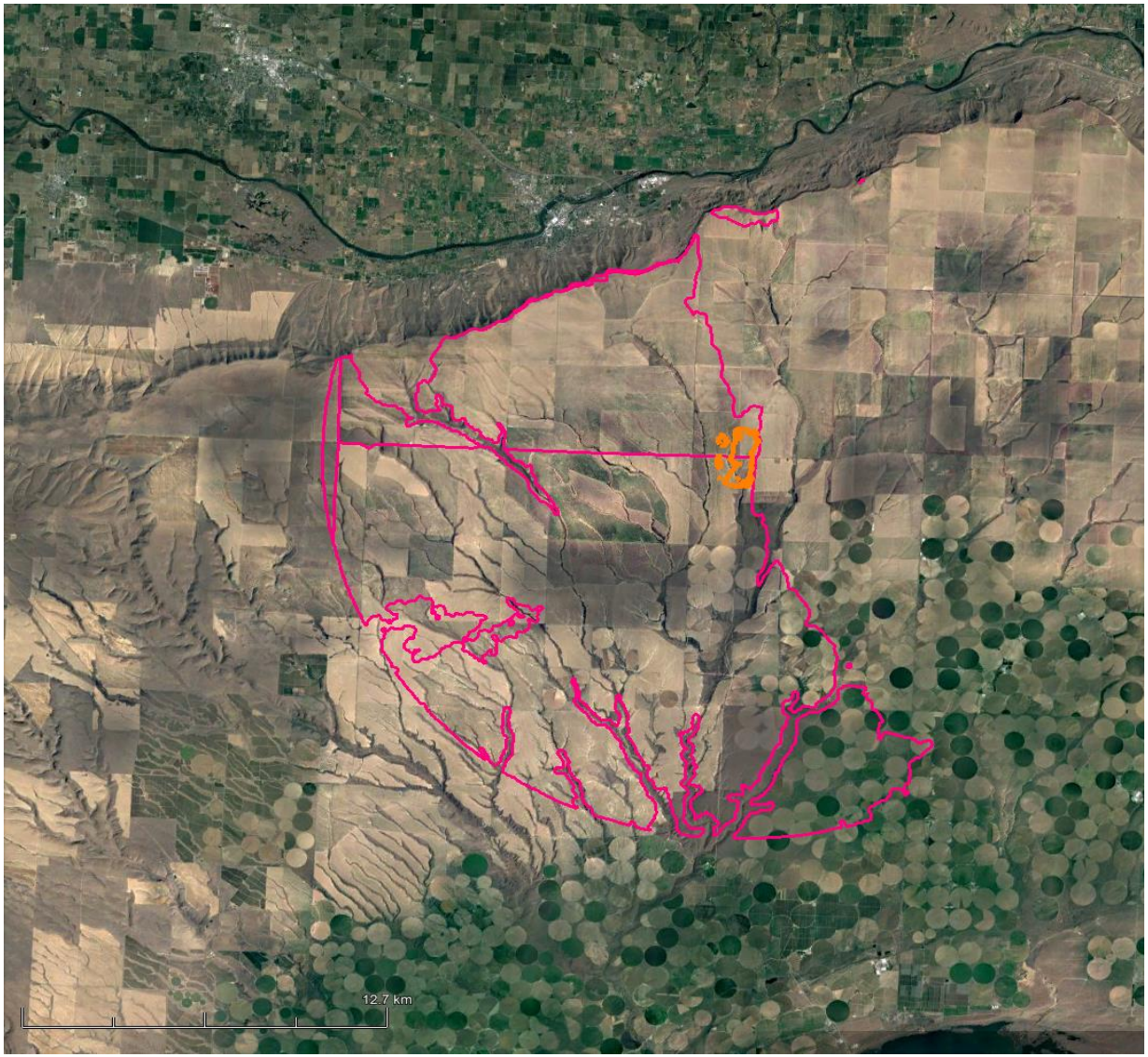

Figure 4. Contour of Prosser Gateway (orange) contained entirely within contour of previously authorized gateway (magenta)