The Enhanced Human Footprint Inventory (HFIe) for the Oil Sands Monitoring (OSM) Region [Administrative] 2020

Version 1.2

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1   Overview

1.1   Summary

This dataset represents the enhanced Human Footprint Inventory for the Oil Sands Monitoring (OSM) Region for 2020 conditions, version 1.2 – HFIeOSA2020 (v1.2). The HFIeOSA2020 (v1.2) maps human footprint features across the OSM administrative boundary in northeastern Alberta, Canada. The current updated version includes the addition of anthropogenic noise attribution for some features in the dataset. The dataset is intended to aid human footprint and land use inquiries.

1.2   Description

The Alberta Biodiversity Monitoring Institute (ABMI) uses existing available datasets (Alberta Base Features, Inventories, Road/Railway Networks, etc.) as the starting point for this product. The dataset is then further updated using imagery from the Satellite pour l'Observation de la Terre 6 (SPOT6) to interpret anthropogenic disturbances on the land surface. Thematic mapping or image interpretation requires professional judgment, skill, knowledge and expertise to create the human footprint dataset in a very complex land use environment. It is expected that the final dataset has an element of thematic accuracy. The list of expected thematic accuracies depending on data source is available in the Appendix of this document.

The 2020 SPOT6 mosaic contains approximately 2.59% of imagery acquired in 2018, and approximately 6.91 % of imagery acquired in 2019, therefore this dataset comprises 90.5% imagery acquired in 2020. This SPOT6 mosaic circa 2020 was used for human footprint updates. Figure 1 displays spatial distribution of satellite imagery coverage for years 2020, 2019 and 2018.
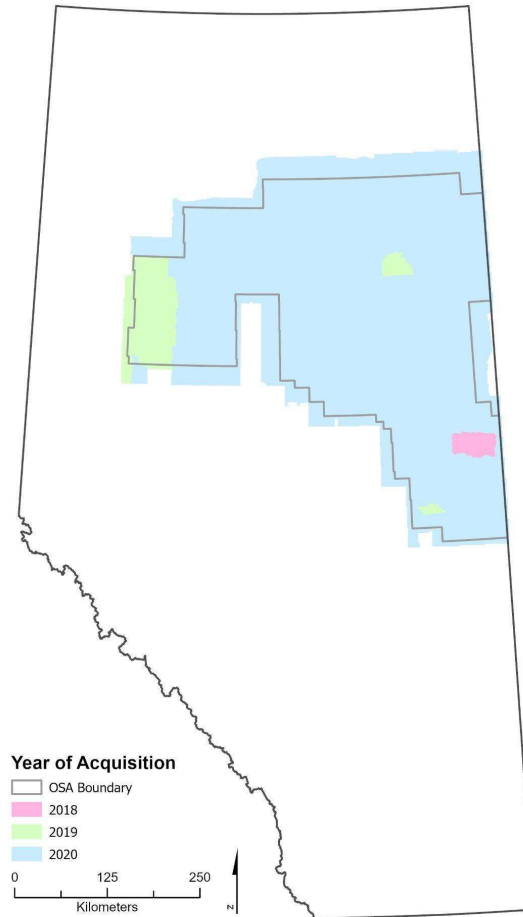
Figure 1: Spatial distribution of satellite imagery acquisition period, available for 2020 SPOT6 mosaic over the oil sands region of Alberta, Canada, showing the oil sands administrative boundary.

Representative human footprint polygons were delineated for 107 feature types, which were organized into 20 final sublayers.

1.3 Document History

Table 1. List of document versions and updates.

Update Date	Version	Section(s)	Description of Changes
2023-06-30	1.0	All	Initial full (final) version

2023-07-28	1.2	1.3 Document History	Added Document History section for capturing info on versioning and changes
		4 Enhanced Footprint Inventory 2020	Reorganized; placed later in document before description of enhancements
		9 Enhanced Attribution	Added section describing Noise attribution; added additional detail to methods in general
		10 Appendix	Added Noise to list of attributes
		Whole Document	Updated/revised heading names, table and figure numbers

1.4 Methods

The ABMI updates Human Footprint Inventory information annually. The OSM region was examined at a 1:30,000 scale to delineate all detectable human footprints. All of the features were created and/or verified using heads-up digitizing at a 1:5000 scale. All of the human footprint attributes were manually interpreted from satellite imagery. Government of Alberta Base Feature Datasets were used as a base layer.

This process was conducted for 2020 using SPOT6 satellite imagery. Dates were acquired from multiple imagery sources: 1950 using orthorectified aerial imagery, 1985 using orthorectified aerial imagery, 2000 using orthorectified aerial imagery, 2001 and 2004 using IRS satellite imagery for each year, 2005-2012 using SPOT 5 satellite imagery for each year, 2013 -2020 using SPOT6 satellite imagery (Table A.2).

Following updating to 2020 conditions, additional enhanced attribution was added to the various features and sublayers to produce the HFIeOSA2020 (v1.2). Theses additional attributes included:

- Age - 'year of origin' (for some features)
- Sector - the sector from which the feature originated (for all features)
- Vegetation - a spectrally-based estimate of vegetation 'greenness', from satellite (for all features)
- Light - nighttime light radiance, from satellite (for features in the Mine Sites, Industrial Sites, Well Sites (Active and Abandoned), and Residential sublayers)

- Noise - anthropogenic noise levels, modeled using human footprint, acoustic recording, and other inputs
- Exploration vs Production - the assignment of certain features to 'exploration'-related activities or 'production'-related activities (for features in the Mine Sites, Industrial Sites, Well Sites (Active and Abandoned), Pipelines and Seismic Lines and Trails sublayers)

These are further described in detail in Section 6.

IMPORTANT: this version of the ABMI HFIeOSA2020 (v1.2) does not account for succession (or reclamation) of human footprint, but treats all types of human footprint on the landscape equally. Put another way, "successional" HF (HF in which natural vegetation regenerates after the human disturbance has ceased) is treated the same as "alienating" HF (HF types which are maintained permanently with altered vegetation) despite the vegetation recovery that almost certainly will have occurred since the development. The current dataset does not present age of disturbance or the current habitat/vegetation cover within features such as harvested areas (previously referred to as cut blocks) or seismic lines.

This product is not error free. We continuously work to improve the accuracy and precision of this product.

This GIS polygon layer is updated annually, and new versions will be released accordingly.

The ABMI Human Footprint Inventory is stored in ESRI File Geodatabase (ArcGIS 10.7.1) format.

1.5 Credits

In addition to the human footprint features, data originating from open sources and created by the ABMI, this dataset includes human footprint data collected and created by the Alberta Human Footprint Monitoring Program and the Alberta Biodiversity Monitoring Institute, and support from members of the Oil Sands Monitoring program.

1.6 Acknowledgments

In 2014 the Alberta Biodiversity Monitoring Institute (ABMI) initiated work to create a group of organizations to collaborate in the development of human footprint information in a program called the Alberta Human Footprint Monitoring Program (AHFMP), a collaboration initiative between the Government of Alberta, the Alberta Biodiversity Monitoring Institute (ABMI), and non-governmental organizations. The intent was to bring the expertise and resources of various government and non-government organizations to create a common database of human footprint data. The AHFMP governance and organization structure are designed to promote relevancy, accessibility, and transparency of human footprint information. The AHFMP organization structure includes two Steering Committees (Operations and Technical). The Technical Committee is directly involved in the assembling of the enhanced sublayers (i.e., Roads, Railways, and Well Sites) and includes members from the GoA and the ABMI. Some of the sublayers used in the public version of the Human Footprint Inventory, e.g., the enhanced sublayers for Roads, Railways, Well Sites, and Pipelines sublayers were obtained from the Government of Alberta through the AHFMP.

In 2019 the ABMI, AHFMP members, and members of the Oil Sands Monitoring (OSM) program initiated a working group to create the enhanced Human Footprint Inventory for the Oil Sands Region. The current dataset represents an updated 2020 version of this original dataset.

1.7 Human Footprint Definition

The ABMI defines Human Footprint (HF) as:

the temporary or permanent transformation of native ecosystems to support residential, recreational or industrial land uses.

● Under this definition, HF includes the geographic extent of areas under human use that either have lost their natural cover for extended periods of time (**alienating HF**; e.g., cities, roads, agricultural land, and surface mines) or whose natural cover

is periodically reset to earlier successional conditions by industrial activities (**successional HF**; e.g., forest harvest areas and seismic lines).

IMPORTANT: This dataset does not account for succession or reclamation of human footprint. It is a cumulative record of human disturbances resulting from direct, mechanical activity. The disturbances are in various states of recovery (natural and human-influenced) and the interpretation of whether a disturbance is still considered a footprint is left to the discretion of the user and their specific requirements.

● Successional HF is treated the same as alienating HF despite the vegetation recovery that almost certainly will have occurred since the development. Any GIS analysis or subsequent interpretation that does not account for succession or reclamation of alienating/successional HF should be done with caution.

Physical Footprint

Definition adopted from AHFMP (Source: AHFMP_Footprint Data Manual.docx):

For the purposes of the AHFMP, this includes any direct physical modifications, temporary or permanent, that humans make to the surface of private, public, or specified (i.e., allocated through Legislation) lands. This includes the pressure (boundary), and state (attributes) of the modifications including what type of activity (well pad, road, etc.) caused the disturbance. The boundary represents the original extent of the disturbance even if the full extent is not visible.

In some situations, the extent of the disturbance was assumed based on operational requirements to construct the feature. For example, the full extent of a well pad in native grasslands is not always visible. The extent of the original disturbance is estimated with reference to disposition boundaries or buffering to allow for the potential disturbance resulting from the equipment used in the construction of the well pad.

1.8   Contact Information

If you have questions or concerns about the data, please contact:

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1.9   Keywords

Alberta, anthropogenic, human footprint, reservoirs, borrow pits, sumps, dugouts, lagoons, roads, rails, canals, mines, industrial, oil and gas well pads, landfills, recreation, wind generation facilities, transmission lines, confined feeding operations (CFO), residential, cultivation, harvested areas, pipelines, seismic lines, disturbed vegetation, sector, light, radiance, noise, Normalized Difference Vegetation Index (NDVI), exploration vs. production

1.10 Citation

Alberta Biodiversity Monitoring Institute and Alberta Human Footprint Monitoring Program. ABMI Enhanced Human Footprint Inventory (HFIe) for the Oil Sands Region of Alberta 2020 (version 1.2). Geodatabase. Last modified July 26, 2023.

1.11 Use Limitations

1.12 Proprietary Sourced Data

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IMPORTANT:

● SEISMIC LINES currently available in the ABMI's HFIeOSA2020 (v1.2) are not the complete representation of the seismic lines existing on the land surface. Low impact seismic lines might be missing from this dataset due to low detectability on SPOT imagery and due to the number of features that go beyond current capabilities of heads up digitization on the provincial scale HF dataset. The ABMI's sampling scale HF dataset (Temporal Human Footprint) within boundaries should be used for a more detailed representation of this sublayer within sampling sites (dimensions: 3 km by 7km; distributed in 20 km by 20 km spacing grid).

● New CULTIVATION features created by heads-up digitization ([SOURCE] attribute is either 'ABMI15', 'ABMI16', 'ABMI17', 'ABMI18', ABMI19', or 'ABMI20') were attributed based on visual interpretation of SPOT6 satellite natural color composite mosaics. HFI dataset has not included a reattribution of existing HFI_2014 cultivation Feature Types to status of circa 2020.

● HARVEST-AREAS might include areas that have been cleared for another purpose than timber harvesting (i.e., agricultural use, residential, mine or industrial areas expansion, or fire hazard reduction).

● HARVEST-AREAS [YEAR] attribute value is the best estimation of the year when the area was harvested. It has been determined by:
   o heads up digitization for years 2014 to 2020,
   o combination of source data values and remote sensing analysis for years 1985 to 2013,
   o and source data based for years prior to 1985.

● PIPELINES dataset is an ESTIMATE of the high-pressure pipelines in the province and is not suitable for locating pipelines on the ground! The data will also contain some low-pressure pipelines. A pipeline corridor is defined by the

AHFMP as any linear disturbance created for the purpose of constructing and maintaining pipelines. The pipeline verge estimates the extent of the direct physical disturbance of the pipeline corridor whether it is visible or not on available imagery.

● LINEAR FEATURES dataset should be used as a supporting dataset to polygonal representation of HF features available in HFIeOSA2020 (v1.2). There are areas where human footprint is captured in polygon layers (HFIeOSA2020 (v1.2) and Sublayers) but is still missing in the Linear Features (Polylines).

● Available attribute values of the LINEAR FEATURES dataset are limited. Polygon layers (HFIeOSA and Sublayers) should be used for geographic extent and more complete thematic information (i.e., available attribution, including source of the data).

2 Data Product Specification

2.1 Spatial Resolution

Dataset's scale denominator: 30,000

2.2 Processing Environment

Microsoft Windows 10; Esri ArcGIS 10.7.1

2.3 Extent

Geographical Extent

West: 317340.086000 m

East: 830715.521146 m

South: 5936381.299800 m

North: 6434025.305700 m

2.4 Resource Maintenance

Resource Maintenance updates frequency: as needed

2.5 Spatial Reference

NAD_1983_10TM_AEP_Forest

WKID: 3400 Authority: EPSG

Projection: Transverse Mercator

False Easting: 500000.0

False Northing: 0.0

Central Meridian: -115.0

Scale Factor: 0.9992

Latitude of Origin: 0.0

Linear Unit: Meter (1.0)

Geographic Coordinate System: GCS_North_American_1983

Angular Unit: Degree (0.0174532925199433)

Prime Meridian: Greenwich (0.0)

Datum: D_North_American_1983

Spheroid: GRS_1980

Semi-major Axis: 6378137.0

Semi-minor Axis: 6356752.314140356

Inverse Flattening: 298.257222101

2.6 Lineage

The ABMI's HFIeOSA2020 (v1.2) was built using open sourced, proprietary, historical, and remotely sensed data. Remotely sensed data were used for visual interpretation and heads-up digitization of human footprint features. Assessment analysis was conducted to identify new and missing features, which were then digitized and added to the dataset. This dataset comprises 20 unique Human Footprint categories, i.e., sublayers. This dataset is representative of the visual interpretation of anthropogenic disturbances on the Alberta landscape as seen from various satellite image sources dated to circa 2020 or earlier.

3   Human Footprint Inventory Integrated Dataset

The HFIeOSA2020 (v1.2) Feature Dataset, is a product of multiple sublayers that have been merged into a single layer. Each sublayer is listed in Section 5 (Sublayers), which includes a detailed description of the layer contents, the data source(s) used, and modifications made by the ABMI.

The order of precedence applied during creation of the final HFIe dataset, i.e., merging process of the sublayers is provided in Table 2.

Table 2. The order of precedence applied during creation of the final HFI dataset, i.e., merging process of the sublayers.

Order of Precedence	Sublayer
1	Reservoirs
2	Borrow Pits, Sumps, Dugouts and Lagoons
3	Roads
4	Railways
5	Canals
6	Verges
7	Mine Sites
8	Industrial Sites
9	Well Sites Active
10	Landfills
11	Other Vegetated Surfaces
12	Wind Generation Facilities
13	Transmission Lines

14	CFO and other High Density Livestock
15	Urban and Rural Residential
16	Well Sites Abandoned
17	Cultivation
18	Harvest Areas
19	Pipelines
20	Seismic Lines and Trails

4 Human Footprint Inventory Sublayers

4.1 01 RESERVOIRS

Feature type: RESERVOIR

Definition:

An artificial lake or storage pond resulting from a human made dam.

A body of water created by excavation or the man-made damming of a river or stream.

Interpretation Elements and Rules:

SIZE:

Different sizes: ranging from the small ones created by damming small streams for a purpose of watering livestock to large water bodies of hydro dams.

SHAPE:

Dam structure (straight or hyperbolic wall) must be visible on reservoirs created on streams and rivers. Sides of the water body are given by topology of the terrain.

Storage pond reservoir's shape is given by engineers to fulfill specific needs. There is no front wall but all sides of the storage pond are artificially created.

SHADOW: no shadow

COLOR: may depend on water depth, but usually in gradients of blue and brown

TEXTURE: fine

ASSOCIATED RELATIONSHIP or CONTEXT:

Dams must be in valleys of streams and rivers.

Storm water storage ponds are located nearby residential areas.

Irrigation storage ponds are located nearby agriculture along with irrigation structures – canals, pumps.

4.2   02 BORROW PITS, SUMPS, DUGOUTS and LAGOONS (BPSDL)

Feature type: LAGOON

Definition:

An artificial holding or treatment ponds for agricultural or municipal wastewater. Human made water and sewage lagoons used for municipal purposes.

Interpretation Elements and Rules:

SIZE:

Smaller to medium sized water bodies.

SHAPE:

Usually a rectangular- or square-shaped structure, occasionally might be triangular or other shape –following terrain topography and engineering design. Structural walls are usually elevated above surrounding terrain.

SHADOW: Shadow might be visible as lagoons are usually elevated above surrounding terrain.

COLOR: may depend on water depth, but usually in gradients of blue and brown

TEXTURE: fine

ASSOCIATED RELATIONSHIP or CONTEXT:

Lagoons are municipal structures built as part of water treatment facilities, so they are usually located nearby residential areas and within industrial zones.

Many times there are more than two lagoons built next to each other creating a cluster of water bodies.

Feature type: SUMP

Definition:

An artificial holding or treatment pond for industrial wastewater.

Drilling waste storage system – holding of drilling waste on well sites or remotely.

Either earthen excavation (in clayey soils) or sumps lined with a synthetic liner.

Interpretation Elements and Rules:

SIZE:

Smaller to medium size water bodies.

SHAPE:

Usually a rectangular- or square-shaped structure, occasionally might be triangular or other shape –following terrain topography and engineering design. Structural walls might be elevated above surrounding terrain for lined sump.

SHADOW: Shadow might be visible if sump walls are elevated above surrounding terrain.

COLOR: may depend on water depth, but usually in gradients of blue and brown

TEXTURE: fine

ASSOCIATED RELATIONSHIP or CONTEXT:

Sumps are industrial structures built as part of the water treatment process, so they are usually located nearby industrial sites and well pads.

There is usually a single drilling waste storage structure built for a single well pad/industrial site.

Feature types:

FEATURE_TY	Feature Description
BORROWPITS	Includes pits dug to build forestry and well-site roads. They are usually associated with a road or another structure.
BORROWPIT-DRY	Includes pits dug to build forestry and well-site roads. They are usually associated with a road or another structure. No presence of water.
BORROWPIT-WET	Includes pits dug to build forestry and well-site roads. They are usually associated with a road or another structure. Presence of water confirmed by visual interpretation.

RIS-BORROWPITS	Identifies any area disturbed for the purpose of extraction of aggregate materials including gravel pits in oil sand mines area only.

Definition:

Excavation outside of the road right-of-way, made solely for the purpose of removing or providing borrowed material for the construction of the sub-base for a specific roadway project. It includes any other associated infrastructure such as access roads. (*ALBERTA TRANSPORTATION; GUIDE TO RECLAIMING BORROW EXCAVATIONS – 2013 Edition*).

Interpretation Elements and Rules:

SIZE:

Usually a smaller excavation, quite often smaller than 1 ha.

SHAPE:

A rectangular- or square-shaped structure, occasionally might be triangular or other shape –following terrain topography and engineering design.

SHADOW: no shadows

COLOR: Depends whether they are dry or filled with water. Brown/Grey/Blue

TEXTURE: fine / coarser

ASSOCIATED RELATIONSHIP or CONTEXT:

Always located along roadways.

Feature type: DUGOUT

Definition:

Small water storage excavations that collect water from summer rains, a surplus of surface water that occurs during snowmelt in the spring, or from groundwater. *(Alberta Agriculture and Rural Development, QUALITY FARM DUGOUTS).*

Interpretation Elements and Rules:

SIZE:

Usually a smaller excavation, quite often smaller than 1 ha.

SHAPE:

A rectangular-, square- or elliptical-shaped structure.

SHADOW: no shadows

COLOR: Depends whether they are dry or filled with water. Brown/Grey/Blue

TEXTURE: fine / coarser

ASSOCIATED RELATIONSHIP or CONTEXT:

Usually located along pastures, farms and agriculture areas.

4.3   03 ROADS

Non-vegetated impermeable surfaces.

Feature types:

FEATURE_TY	Feature Description
AIRP-RUNWAY	An active landing facility for aircraft, usually associated with paved and lighted runways, an operating control tower, and services for aircraft and passengers.

INTERCHANGE-RAMP	A series of roadways (ramps) constructed to permit access to and from intersecting paved roads. These ramps are usually at different levels, and form an overpass / underpass.
RIS-AIRP-RUNWAY	Identifies operator owned landing facility for airplanes and related transportation in oil sand mines area only.
RIS-ROAD	Identifies roads that are not specifically part of other disturbed features in oil sand mines area only.
ROAD-GRAVEL-1L	A roadway surfaced with gravel constituting a main access route. The road surface is about 6 metres in width, and the road clearing is about 20 metres or greater in width. The surface, ditches, bridges and intersections are in good condition.
ROAD-GRAVEL-2L	A roadway surfaced with gravel constituting a main access route. The road surface is 7 metres or greater in width, and the road clearing is 30 metres or greater in width. The surface, ditches, bridges and intersections are in good condition.
ROAD-PAVED-1L	A roadway, paved with asphalt or concrete, consisting of one (1) lane.
ROAD-PAVED-2L	A major roadway, which is paved with asphalt or concrete, and consists of two (2) roadbeds separated by a median. Each road bed usually consists of two (2) or more lanes.
ROAD-PAVED-3L	A major roadway, which is paved with asphalt or concrete, and consists of 3 roadbeds separated by a median.
ROAD-PAVED-4L	A major roadway, which is paved with asphalt or concrete, and consists of 4 roadbeds separated by a median.
ROAD-PAVED-5L	A major roadway, which is paved with asphalt or concrete, and consists of 5 roadbeds separated by a median.
ROAD-PAVED-6L	A major roadway, which is paved with asphalt or concrete, and consists of 6 roadbeds separated by a median.
ROAD-PAVED-7L	A major roadway, which is paved with asphalt or concrete, and consists of 7 roadbeds separated by a median.
ROAD-PAVED-DIV	A major roadway, which is paved with asphalt or concrete, and consists of two (2) roadbeds separated by a median. Each road bed usually consists of two (2) or more lanes.
ROAD-PAVED-UNDIV-1L	A roadway, paved with asphalt or concrete, consisting of one (1) lane, and usually found servicing rural acreages that are close to large urban centres.
ROAD-PAVED-UNDIV-2L	A roadway, paved with asphalt or concrete, and consisting of two (2) adjacent lanes, with no median to separate them.

ROAD-PAVED-UNDIV-4L	A roadway, paved with asphalt or concrete, and consisting of four (4) adjacent lanes, with no median to separate them.
ROAD-UNCLASSIFIED	A temporary coding for an unknown class of road, which will be updated after a field check or verification. (Source: road_album_2.ppt)
ROAD-UNIMPROVED	A roadway surfaced with dirt constituting a minor access route. The road surface is up to 7 metres in width, and the road clearing is up to 20 metres in width. The surface and ditches are poorly maintained, and the bridges are narrow.
ROAD-UNPAVED-1L	A roadway surfaced with dirt constituting a minor access route.
ROAD-UNPAVED-2L	A roadway surfaced with dirt constituting a minor access route.
ROAD-WINTER	A clearing that is vehicular accessible in winter only.
TRUCK-TRAIL	A roadway surfaced with dirt or low vegetation constituting a minor access route.

Details of AHFMP processing steps and user guide are included in these documents:

AHFMP - Road Processing 2014 Footprint.pdf

AHFMP - Road User Guide 2014 Footprint.pdf

4.4 04 RAILWAYS

Rail lines, hard surface.

Feature types:

FEATURE_TY	Feature Description
RLWY-ABANDONED	An abandoned road or track for trains, consisting of parallel steel rails, supported on wooden crossbeams that is no longer in use.
RLWY-DBL-TRACK	A road or track for trains, consisting of parallel steel rails, supported on wooden crossbeams. The Double track consists of two parallel sets of tracks.

RLWY-MLT-TRACK	A road or track for trains, consisting of parallel steel rails, supported on wooden crossbeams. A multiple track railway consists of many parallel sets of tracks.
RLWY-SGL-TRACK	A road or track for trains, consisting of parallel steel rails, supported on wooden crossbeams. The single track consists of one parallel set of tracks.
RLWY-SPUR	A short length of railway leading off a main line, to a dead end. Spur lines usually lead to a commercial/industrial site, or may be used as a turnaround along a rail line.

4.5   05 CANALS

Feature type: CANAL

Definition:

A man-made watercourse built to convey water for irrigation. An irrigation canal is larger than a ditch, with reinforced banks that are usually well maintained.

A man-made drainage network channels built to prepare wetland areas for anthropogenic land use.

Interpretation Elements and Rules:

SIZE:

Linear feature, usually up to 40 meters in width with reinforced banks that are usually well maintained.

SHAPE: Linear.

SHADOW: no shadows

COLOR: Depends whether they are dry or filled with water. Brown/Grey/Blue

TEXTURE: fine / coarser

ASSOCIATED RELATIONSHIP or CONTEXT:

Located along irrigated cultivation fields.

4.6   06 VERGES

Vegetated surfaces of roads, trails, and railways.

Feature types:

FEATURE_TY	Feature Description
VEGETATED-EDGE-ROADS	Disturbed vegetation alongside road edges
VEGETATED-EDGE-RAILWAYS	Disturbed vegetation alongside railway edges.

Definition:

Disturbed vegetation alongside road edges and railway edges including ditches.

Details of AHFMP processing steps and User Guide are included in these documents:

AHFMP - Road Processing 2014 Footprint.pdf

AHFMP - Road User Guide 2014 Footprint.pdf

Interpretation Elements and Rules:

SIZE:

Linear feature - various widths.

SHAPE: Linear.

SHADOW: no shadows

COLOR: shades of green,

TEXTURE: fine / coarser

ASSOCIATED RELATIONSHIP or CONTEXT:

Usually located along roads and railways.

4.7   07 MINE SITES

Feature types:

FEATURE_TY	Feature Description
GRVL-SAND-PIT	An area of surface disturbance for the purpose of extracting sand and/or gravel consistently open and/or expanding over multiple years, usually close to lakes or rivers.
MINES-COAL	Heavy industry use with bare and/or vegetated ground and low human density for the purpose of coal mining.
MINES-OILSANDS	Heavy industry use with bare and/or vegetated ground and low human density for the purpose of oil sands mining.
MINES-PITLAKE	Areas of ground where surface water is collected into the existing mine pit usually after mining activity is finished.
OPEN-PIT-MINE	An area of surface disturbance for the purpose of mining (with the exception of sand and/or gravel), consistently open and/or expanding over multiple years, usually close to lakes or rivers.
PEAT	An area of surface disturbance for the purpose of mining peat, consistently open and/or expanding over multiple years, usually in bogs or fens.
RIS-DRAINAGE	Identifies surface disturbance for the purpose of managing surface water features.

RIS-MINES-OILSANDS	Identifies areas where overburden removal has commenced for the purposes of preparing an area for open pit mining and all mine pit features.
RIS-OILSANDS-RMS	Identifies reclamation material stockpiles (RMS). Each RMS may have several material types and corresponding volumes.
RIS-OVERBURDEN-DUMP	Includes all areas where overburden and interburden is placed out-of-pit or in-pit for disposal.
RIS-RECLAIM-READY	Identifies areas where landform construction has been completed and the site is ready for clean cap, subsoil and surface soil placement. This definition is consistent with that used for annual reporting which identifies land "no longer required for mine or plant purposes and available for reclamation but where reclamation activities have not yet commenced.
RIS-RECLAIMED-CERTIFIED	Identifies polygons of reclaimed areas which have received a reclamation certificate.
RIS-RECLAIMED-PERMANENT	Identifies polygons which meet the definition of permanent reclamation - land is considered permanently reclaimed when landform construction and contouring, clean material placement (as required), reclamation material placement and revegetation has taken place.
RIS-RECLAIMED-TEMP	Identifies polygons which meet the definition of temporary reclamation – areas being managed where vegetation has been seeded, planted, or ingressed, where there is an expectation that future disturbance may occur at that location. This does not include cleared areas (planned for future disturbance) that have naturally revegetated through ingress.
RIS-SOIL-REPLACED	Identifies areas which have had subsoil or topsoil placed and which have not been revegetated.
RIS-SOIL-SALVAGED	Identifies areas where soil salvage is occurring but where overburden removal has not commenced.
RIS-TAILING-POND	Identifies all areas associated with tailings including toe berms, dykes, beaches, ponds and drying areas.
RIS-WASTE	Identifies all areas associated with waste and by-product storage on-site.
RIS-WINDROW	Includes areas where a line of reclamation material (soil or vegetation) is heaped up by a machine.
TAILING-PILE	An area used to store waste materials produced in mining processes.

TAILING-POND	Body of water on/in close proximity to an oil sands mine composed of acids, benzene, hydrocarbons, residual bitumen, fine silts, and water.

Note: "RIS" features were imported from the Reclamation Information System (GoA) based on the cross-reference table (Table 3).

Table 3. Cross-reference table describing how information in the Reclamation Information System (Government of Alberta) was integrated into the ABMI HFI datasets.

RIS		ABMI HFI 2014	
LANDCOVER	FEATURE_TY	FEATURE_TY	Sublayer
CLEARED	Cleared other industry	RIS-CLEARING-UNKNOWN	08 Industrial Sites
	<null>	RIS-CLEARING-UNKNOWN	08 Industrial Sites
	Oil sands cleared	RIS-CLEARING-UNKNOWN	08 Industrial Sites
DISTURBED	Aerodrome	AIRP-RUNWAY-ACTIVE	03 Roads
	Borrow pit	RIS-BORROWPITS	02 Borrow Pits, Sumps, Dugouts and Lagoons
	Camp housing	RIS-CAMP-INDUSTRIAL	08 Industrial Sites
	Disturbed other industry	RIS-FACILITY-UNKNOWN	08 Industrial Sites
	Disturbed unclassified	RIS-FACILITY-UNKNOWN	08 Industrial Sites
	Drainage	RIS-DRAINAGE	07 Mine Sites
	<null>	RIS-FACILITY-UNKNOWN	08 Industrial Sites
	Mine pit	RIS-MINES-OILSANDS	07 Mine Sites
	Operations	RIS-FACILITY-OPERATIONS	08 Industrial Sites
	Other	RIS-FACILITY-UNKNOWN	08 Industrial Sites
	Overburden dump	RIS-OVERBURDEN-DUMP	07 Mine Sites
	Pipeline	RIS-PIPELINE	19 Pipelines
	Plant site	RIS-PLANT	08 Industrial Sites
	Powerline	RIS-TRANSMISSION-LINE	13 Transmission Lines
	Ready to reclaim	RIS-RECLAIM-READY	07 Mine Sites
	Reclamation material stockpile (RMS)	RIS-OILSANDS-RMS	07 Mine Sites

	River water intake structure	RIS-RESERVOIR	01 Reservoirs
	Road	RIS-ROAD	03 Roads
	Soil placed	RIS-SOIL-REPLACED	07 Mine Sites
	Soil salvaged	RIS-SOIL-SALVAGED	07 Mine Sites
	Tailings	RIS-TAILING-POND	07 Mine Sites
	Tank farm	RIS-TANK-FARM	08 Industrial Sites
	Utilities	RIS-UTILITIES	08 Industrial Sites
	Waste	RIS-WASTE	07 Mine Sites
	Wellsite	RIS-WELL	09 Well Sites Active
	Windrow	RIS-WINDROW	07 Mine Sites
RECLAIMED	Certified	RIS-RECLAIMED-CERTIFIED	07 Mine Sites
	<null>	RIS-RECLAIMED-UNKNOWN	07 Mine Sites
	Permanent	RIS-RECLAIMED-PERMANENT	07 Mine Sites
	Temporary	RIS-RECLAIMED-TEMP	07 Mine Sites
	Temporary (dam safety)	RIS-RECLAIMED-TEMP	07 Mine Sites

4.8 08 INDUSTRIAL SITES

Feature types:

FEATURE_TY	Feature Description
CAMP-INDUSTRIAL	Buildings used for temporary residence by employees on or in close proximity to an industrial activity such as mining, forestry, or oil and gas activities.
CLEARING-UNKNOWN	A human-made clearing with unknown purposes and contains no visible buildings, fences or equipment.
CLEARING-WELLPAD-UNCONFIRMED	Roughly square in shape clearing, roughly 90-120 meters wide (approximately 1 ha). Not confirmed as a well pad by available reference sources.

FACILITY-OTHER	Industrial facility(ies) characterized by large non-residential buildings most often surrounded by concrete for parking purposes. The purpose of the facility(ies) is not disclosed.
FACILITY-UNKNOWN	Industrial facility(ies) characterized by large non-residential buildings most often surrounded by concrete for parking purposes. The purpose of the facility(ies) is unknown.
MILL	Intense industrial and commercial development for the purpose of pulp or paper production.
MISC-OIL-GAS-FACILITY	Industrial facility used for the purpose of oil and gas. BATTERY SITE, COMPRESSOR SITE, FLARE STACK, METER STATION SITE, VALVE SITE
OIL-GAS-PLANT	Industrial facility used for oil production. REFINERIES, PLANTS, FACTORIES
RIS-CAMP-INDUSTRIAL	Identifies an area disturbed for the purposes of housing camp workers.
RIS-CLEARING-UNKNOWN	Identifies all areas where vegetation has been removed for the purposes of preparing the land for drainage, soil removal, overburden removal, mining, etc. but where soil has been left mostly intact and relatively undisturbed. May include any or all of: tree removal, shrub removal, and/or grubbing (stump removal). Identifies areas cleared for by other industries and not for the purposes of forest harvesting or for oil sands development.
RIS-FACILITY-OPERATIONS	Designated for areas which are not part of the plant site, e.g., may include laydown areas not integrated with the main plant site(s), tailings lines, water lines, compressor station, buildings away from the main plant site, flare stack, communications tower.
RIS-FACILITY-UNKNOWN	Identifies areas where the reclamation liability associated for the disturbance is currently held by another industry operator.
RIS-PLANT	Includes areas associated with extraction, processing, upgrader. Plant sites may have multiple non-contiguous polygons.
RIS-TANK-FARM	Identifies areas where products of extraction or upgrading are stored. Products stored for on-site use can be identified under plant site or operations.
RIS-UTILITIES	Identifies areas specifically disturbed for the purposes of utilities (power generation).
URBAN-INDUSTRIAL	An industrial facility within the boundary of an urban residence.

Note: "RIS" features were imported from the Reclamation Information System (GoA) based on the cross-reference table (Table 3.)

4.9   09 WELL SITES ACTIVE

Feature types:

FEATURE_TY	Feature Description
RIS-WELL	Identifies areas disturbed for the purpose of establishing exploration, production or disposal wells.
WELL-BITUMEN	Well site - ground cleared for a bitumen well pad.
WELL-CASED	Well site - ground cleared and well cased.
WELL-CLEARED-DRILLED	Well site - confirmation of drilling and the boundary outline are provided by reference sources.
WELL-CLEARED-NOT-CONFIRMED	Well site - confirmation of the boundary outline is not provided by reference sources.
WELL-CLEARED-NOT-DRILLED	Well site - confirmation of the boundary outline is provided by reference sources.
WELL-DRILLED-OTHER	Well site - confirmation of drilling is provided by reference sources.
WELL-GAS	Well site - ground cleared for a gas well pad.
WELL-OIL	Well site - ground cleared for an oil well pad.
WELL-OTHER	Well site - clearing, purpose is unknown.
WELL-UNKNOWN	Well site - ground cleared, well status unknown or license location

Note: "RIS" features were imported from the Reclamation Information System (GoA) based on the cross-reference table (Table 3.)

Details of AHFMP processing steps and User Guide are included in these documents:

AHFMP - Well Pad Procedures for 2014 Footprint.pdf

AHFMP - Well Pad User Guide 2014 Footprint.pdf

4.10 10 LANDFILLS

Feature types:

FEATURE_TY	Feature Description
LANDFILL	Larger area of raised land, indicating buried garbage. Some landfills have evidence of surface revegetation and garbage dispersed throughout designated extent. They may also have large perimeter berms or fences.
TRANSFER_STATION	Smaller area of land, less than one hectare, usually fenced with a U-shaped road and two entry ways. Used primarily for garbage drop-off and located close to municipalities or present in rural areas.

Interpretation Elements and Rules:

SIZE:

Various sizes, often larger polygons of landfills than transfer stations.

SHAPE:

Often a rectangular- or square-shaped structure.

SHADOW: no shadows

COLOR: various colours

TEXTURE: fine / coarser

ASSOCIATED RELATIONSHIP or CONTEXT:

Usually located in the proximity of residential areas.

4.11 11 OTHER VEGETATED SURFACES

Human footprint related to vegetated facilities and recreation.

Feature types:

FEATURE_TY	Feature Description
CAMPGROUND	Disturbed vegetation with frequently changing facilities of RVs and tents used for overnight stay. Most often consists of several individual clearings surrounded by vegetation and gravel or asphalt roads connecting clearings.
GOLFCOURSE	Large recreational area comprising a series of grass patches surrounded by trees.
GREENSPACE	Greenspace used for recreation within a residential area including parks, schools, school yards and sport fields.
RECREATION	Urban/rural greenspace and recreation that does not fit into other categories (e.g. graveyards, baseball diamonds, parks, shelterbelts, ski hills, clearings from old industrial activity that is now vegetated). This layer was also used to identify green-space features that do not fit into other categories such as storage areas and parking lots.
RUNWAY	Vegetated runway.
SURROUNDING-VEG	Disturbed vegetation surrounding airport runways, highway ramps and other industrial features.

Interpretation Elements and Rules:

SIZE:

Various sizes, often larger polygons of landfills than transfer stations.

SHAPE:

Often a rectangular- or square- shaped structure. .

SHADOW: no shadows

COLOR: various colours

TEXTURE: fine / coarser

ASSOCIATED RELATIONSHIP or CONTEXT:

Usually located in the proximity to residential areas.

4.12 13 TRANSMISSION LINES

Feature types:

FEATURE_TY	Feature Description
TRANSMISSION-LINE	A utility corridor >10 m wide with poles, towers and lines for transmitting high voltage electricity (voltage greater than 69 kV).
RIS-TRANSMISSION-LINE	Include the right of way area designated for the power line.

Interpretation Elements and Rules:

SHAPE: Linear shape – corridor in landscape. Tower structure visible.

WIDTH:

Buffered to 19 m - each side from the centerline (38 m in total width of the corridor) for AHFMP and the BASEFE dataset (see Table A.1).

Buffered to measured width for ABMI14, ABMI15, ABMI16, ABMI17 features.

SHADOW: tower shadows

COLOR: shades of green or brown/grey depending on vegetation cover of the corridor

TEXTURE: usually finer texture as a result even vegetation on the corridor

ASSOCIATED RELATIONSHIP or CONTEXT:

Corridor connects energy users with energy providers.

4.13 14 CFO

Confined feeding operations and other high density livestock features.

Feature type: CFO

Interpretation Elements and Rules:

SIZE: Various sizes.

SHAPE: Often regular shape.

SHADOW: shadows of building and facilities associated with CFO features

COLOR: various colours

TEXTURE: usually coarser texture

ASSOCIATED RELATIONSHIP or CONTEXT:

Usually in proximity of farm fields, residential or industrial features.

4.14 15 URBAN and RURAL RESIDENTIAL

Feature type: COUNTRY-RESIDENCE

Definition:

Country-residential developments with density of 10 - 100 buildings per quarter section.

Interpretation Elements and Rules:

SIZE:

Minimum size of the polygon should be 0.4 Ha (1 Acre) in case one country-residential property creates an acreage polygon. More often – multiple country-residential developments are captured into one polygon therefore maximum size of polygon is not limited.

SHAPE:

Multi-vertices polygons, where boundaries follow property lines, fences, clearings of country-residential development.

SHADOW: no shadow

COLOR: no unique color

TEXTURE: no unique texture

ASSOCIATED RELATIONSHIP or CONTEXT:

Country residential areas are often grouped together with a road system as a backbone of such residential development.

Feature type: RURAL-RESIDENCE

Definition:

Rural-residential developments with density of less than 10 buildings per quarter section.

Interpretation Elements and Rules:

SIZE:

Various sizes. Usually one polygon per rural residence.

SHAPE:

Multi-vertices polygons, where boundaries follow property lines, fences, clearings of rural-residential development.

SHADOW: no shadow

COLOR: no unique color

TEXTURE: no unique texture

ASSOCIATED RELATIONSHIP or CONTEXT:

Rural residences are often isolated by other human footprint types (cultivation) or native landscape (lodges). They are connected to the other areas by access road.

Feature type: URBAN-RESIDENCE

Definition:

Residential areas in cities, towns, villages, hamlets and ribbon developments. Areas that are dominated by dwellings.

Interpretation Elements and Rules:

SIZE:

Various sizes. Usually one polygon per many urban residences.

SHAPE:

Multi-vertices polygons, where boundaries follow property lines, fences, clearings of urban -residential development.

SHADOW: no shadow

COLOR: no unique color

TEXTURE: no unique texture

ASSOCIATED RELATIONSHIP or CONTEXT:

Urban residences are often surrounded by other human footprint types (recreational – GREENSPACE, industrial – URBAN-INDUSTRIAL).

Feature type: RESIDENCE_CLEARING

Definition:

Areas cleared for building developments that do not yet have any buildings.

Interpretation Elements and Rules:

SIZE:

Various sizes. Usually one polygon per one residence clearing.

SHAPE:

Multi-vertices polygons, where boundaries follow property lines, fences, clearings of residential development.

SHADOW: no shadow

COLOR: no unique color

TEXTURE: no unique texture

ASSOCIATED RELATIONSHIP or CONTEXT:

Residence clearings are often in the vicinity of existing urban residences.

4.15 16 WELL SITES ABANDONED

Feature type: WELL- ABAND

Definition: Ground cleared for an oil/gas well pad where the well is currently abandoned.

Details of AHFMP processing steps and User Guide are included in these documents:

AHFMP - Well Pad Procedures for 2014 Footprint.pdf

AHFMP - Well Pad User Guide 2014 Footprint.pdf

4.16 17 CULTIVATION

Feature type: CROP

Definition:

Cultivated cropland or cropland planted with annual crop species, including farmlands that are in cultivation rotation.

Cropland includes: **small grains** (wheat, barley, oats and mixed grains), **oilseeds** (canola, flax), **specialty crops** (peas, lentils), **row crops** (potatoes, sugar beets, corn, vegetables).

Fallow describes areas used for the production of the crops that do not exhibit visible vegetation as the result of being cultivated.

Interpretation Elements and Rules:

SIZE: Variable size from smaller fields, usually next to a rural residential area, up to very large polygons covering multiple townships.

SHAPE: Often a rectangular, square or multi-vertex shape with distinct round corners as a result of active cultivation by agricultural equipment and machinery.

Circular shape for irrigated crop fields.

SHADOW: no shadows

COLOR: Variable - depending on type of the cropland and imagery acquisition date.

TEXTURE: Consistent smooth, fine texture for cropland / coarser texture for fallow.

STRUCTURE: Often visible tillage lines as a result of active cultivation by agricultural equipment (field cultivator, disk and plow).

ASSOCIATED RELATIONSHIP or CONTEXT: No evidence of grazing as livestock are restricted from these fields during the growing season.

Feature type: TAME_PASTURE

Definition:

Lands where the soil has been disturbed and planted to perennial grass species used primarily for grazing livestock.

Tame pasture represents areas of grasses, legumes or grass-legume mixtures planted for livestock grazing or hay collection.

Interpretation Elements and Rules:

SIZE: Variable size from smaller fields, usually next to a rural residential area, up to very large polygons covering multiple townships.

SHAPE: Often a rectangular, square or multi-vertex shape with distinct round corners as a result of active cultivation by agricultural equipment and machinery.

Circular shape for irrigated hay fields.

SHADOW: no shadows

COLOR: Variable - depending on the type of the pasture (grazing/hay) and imagery acquisition date.

TEXTURE: Coarser texture compared to crops.

STRUCTURE: Often visible hay collection lines or hay bales.

ASSOCIATED RELATIONSHIP or CONTEXT: Evidence of grazing by livestock – trails, dugouts.

Feature type: ROUGH_PASTURE

Definition:

Lands where the forest and/or shrubs have been removed so that native or introduced grasses can flourish for the grazing of livestock.

This pastureland has not been irrigated or fertilized and the soil has not been disturbed to improve productivity.

Interpretation Elements and Rules:

SIZE: Variable.

SHAPE: Variable

SHADOW: no shadows

COLOR: Usually shades of green - depending on imagery acquisition date.

TEXTURE: Coarser texture for new clearings, smoother for old ones.

STRUCTURE: There might be remains of cleared wood/shrub lands on new clearings– wood piles, timber.

ASSOCIATED RELATIONSHIP or CONTEXT: Usually still surrounded by forest or wooded/shrubby remains. Quite often nearby existing farmland and crop/tame pasture fields.

Feature type: CULTIVATION_ABANDONED

Definition:

Agricultural land that has been formally seeded and tilled, but no evidence of present day production use. Landscape appears to have a heterogeneous mix of vegetation and closely resembles natural cover.

Feature type: FRUIT-VEGETABLES

Definition:

AAFC 2014 Crop Types: Vegetables, Tomatoes, Potatoes, Sugar beets, Other Vegetables, Fruits, Berries, Blueberry, Cranberry, Other Berry, Orchards, Other Fruits, Herbs.

HFI_2014 dataset cultivation Feature Types were based on AAFC 2014 classification (*ISO 19131 AAFC Annual Crop Inventory, Agriculture and Agri-food Canada, 2014).* AAFC 2014 classification crop types were overlaid onto HFI_2014 polygons and area coverage of individual AAFC crop types within HFI polygon was computed. Cross-referencing all cultivation polygons to Crop Type values based on AAFC 2014 classification is displayed in Table 4.

Details of AHFMP processing steps and User Guide are included in these documents:

AHFMP_Cultivation_User_Guide_Footprint_HFI_2014FTv2.pdf

AHFMP_Cultivation_User_Guide_HFI_2014.pdf

Details about AAFC 2014 processes are available in document:

ISO 19131_AAFC_Annual_Crop_Inventory_Data_Product_Specifications.pdf

IMPORTANT:

New cultivation features created by heads-up digitization ([SOURCE] either ABMI15, ABMI16, ABMI17, ABMI18, ABMI19, or ABMI20) were attributed based on visual interpretation of SPOT6 satellite natural color composite mosaics. Current HFIeOSA2020 (v1.2) dataset has not included a reattribution of existing HFI_2014 cultivation Feature Types to status of circa 2020.

Table 4. Cross-reference table used to convert the AAFC2014 labels into ten ABMI human footprint feature types for the HFI2014 product.

AAFC	ABMI [proposed]

Code	Label	Feature_Ty
10	Cloud	NA
20	Water	HYDRO
30	Exposed Land and Barren	NATIVE-NATURAL
34	Urban and Developed	URBAN-INDUSTRIAL
35	Greenhouses	NA
50	Shrubland	NATIVE-NATURAL
80	Wetland	WETLAND
110	Grassland	NATIVE-NATURAL
120	Agriculture	CROP
122	Pasture and Forages	TAME-PASTURE
130	Too Wet to be Seeded	CROP-WETLAND
131	Fallow	CROP
132	Cereals	CROP
133	Barley	CROP
134	Other Grains	CROP
135	Millet	CROP
136	Oats	CROP
137	Rye	CROP
138	Spelt	CROP
139	Triticale	CROP
140	Wheat	CROP
141	Switchgrass	TAME-PASTURE
145	Winter Wheat	CROP
146	Spring Wheat	CROP
147	Corn	CROP
148	Tobacco	CROP
149	Ginseng	AGRICULTURE-OTHER
150	Oilseeds	CROP
151	Borage	CROP
152	Camelina	CROP
153	Canola and Rapeseed	CROP

154	Flaxseed	CROP
155	Mustard	CROP
156	Safflower	CROP
157	Sunflower	CROP
158	Soybeans	CROP
160	Pulses	CROP
AAFC		**ABMI [proposed]**
Code	Label	Feature_Ty
162	Peas	CROP
167	Beans	CROP
174	Lentils	CROP
175	Vegetables	FRUIT-VEGETABLES
176	Tomatoes	FRUIT-VEGETABLES
177	Potatoes	FRUIT-VEGETABLES
178	Sugarbeets	FRUIT-VEGETABLES
179	Other Vegetables	FRUIT-VEGETABLES
180	Fruits	FRUIT-VEGETABLES
181	Berries	FRUIT-VEGETABLES
182	Blueberry	FRUIT-VEGETABLES
183	Cranberry	FRUIT-VEGETABLES
185	Other Berry	FRUIT-VEGETABLES
188	Orchards	FRUIT-VEGETABLES
189	Other Fruits	FRUIT-VEGETABLES
190	Vineyards	AGRICULTURE-OTHER
191	Hops	AGRICULTURE-OTHER
192	Sod	AGRICULTURE-OTHER
193	Herbs	FRUIT-VEGETABLES
194	Nursery	AGRICULTURE-OTHER
195	Buckwheat	CROP
196	Canaryseed	CROP
197	Hemp	CROP
198	Vetch	TAME-PASTURE

199	Other Crops	AGRICULTURE-OTHER
200	Forest	NATIVE-NATURAL
210	Coniferous	NATIVE-NATURAL
220	Broadleaf	NATIVE-NATURAL
230	Mixedwood	NATIVE-NATURAL

4.17 18 FOREST HARVEST AREAS

Feature type: HARVEST-AREA

Definition:

Areas where forestry operations have occurred (clear-cut, selective harvest, salvage logging, etc.).

IMPORTANT:

- HARVEST-AREAS might include areas that have been cleared for another purpose then timber harvesting (i.e. agricultural use, residential, mine and industrial areas expansion.)

- HARVEST-AREAS [YEAR] value is the best estimation of the year when the area was harvested. It has been determined by:
  - heads up digitization for years 2014 to 2020,
  - combination of source data values and remote sensing analysis for years 1985 to 2013,
  - source data based for years prior to 1985.

Interpretation Elements and Rules:

SIZE: Variable.

SHAPE: Variable

SHADOW: no shadows

COLOR: Usually shades of green - depending on imagery acquisition date.

TEXTURE: Coarser texture for new clearings, smoother for old ones.

STRUCTURE: There might be remains of cleared wood/shrub lands on new clearings– wood piles, timber.

ASSOCIATED RELATIONSHIP or CONTEXT: Usually still surrounded by forest or wooded/shrubby remains.

Feature type: HARVEST-AREA-WHITE-ZONE

Definition:

Areas in Alberta's unforested White Zone where woody vegetation (i.e. shrub, trees, etc.) have been removed and the purpose of the clearing has not yet been determined.

4.18 19 PIPELINES

Feature type: PIPELINE

Definition:

A line of underground and overground pipes, of substantial length and capacity, used for the conveyance of petrochemicals.

The physical clearing that contains underground and above-ground high pressure pipelines.

These clearings may contain one or multiple pipelines.

Data Source: The Pipeline Verge feature class was created by the Geographic Science Team (GScT) of Alberta Environment and Protected Areas for the Alberta Human Footprint Monitoring Program (AHFMP). The data is used to monitor the total area of pipeline corridors in the province of Alberta. The data is an ESTIMATE of the high-pressure pipelines in the province and is not suitable for locating pipelines on the ground. The data will also contain some low-pressure pipelines. A pipeline corridor is defined by the AHFMP as any linear disturbance created for the purpose of constructing and maintaining pipelines. The pipeline verge estimates the extent of the direct physical disturbance of the pipeline corridor whether it is visible or not on imagery. The verges were derived from the Digitally Integrated Dispositions (DIDs), Rural Cadastral pipeline right of ways and from manual digitizing using SPOT imagery. Some verges were also buffered using the estimated pipeline centre lines within the pipeline centre line feature class. The Alberta Energy Regulator (AER) pipeline dataset was used as reference to locate the pipeline corridors. The data was designed specifically for monitoring human footprint and may not be suitable for some cartographic purposes.

Data created by Alberta Human Footprint Monitoring Program (AHFMP) was consequently modified by ABMI. Digitized pipelines interpreted from satellite imagery (year 2017) were added to the source dataset to create a final HFI sublayer that represents estimated status of pipelines up to year 2017.

Details of AHFMP processing steps and user guide are included in these documents:

AHFMP - Pipeline Procedures Manual for 2016 Footprint - Ver 3.pdf

AHFMP - Pipeline User Guide for 2016 Footprint - Ver 2.pdf

Interpretation Elements and Rules:

SIZE: Variable.

SHAPE: Variable

SHADOW: no shadows

COLOR: shades of green or brown/grey depending on vegetation cover of the corridor

TEXTURE: usually finer texture as a result even vegetation on the corridor

ASSOCIATED RELATIONSHIP or CONTEXT:

Corridor connects energy users with energy providers.

IMPORTANT:

● PIPELINES might include corridors that contain pipelines built for another purpose than the conveyance of petrochemicals, e.g. municipal water.

4.19 20 SEISMIC LINES and TRAILS

Feature types:

FEATURE_TY	Feature Description
LOW-IMPACT-SEISMIC	A polygon feature class derived from a 1.5-meter buffer (3 meter total width) of a pre-low-impact-seismic centerline.
CONVENTIONAL-SEISMIC	A polygon feature class derived from a 3-meter buffer (6 meter total width) of a pre-low-impact-seismic centerline.
TRAIL	A polygon feature class derived from a 2-meter buffer (4 meter total width) of a pre-low-impact-seismic centerline.

Buffered to:

TRAIL = 2m half width (**4m full width**)

CONVENTIONAL-SEISMIC = 3m half width (**6m full width**)

LOW-IMPACT-SEISMIC = 1.5m half width (**3m full width**)

Details of AHFMP processing steps and User Guide are included in these documents:

AHFMP - Seismic User Guide 2014 Footprint Ver3.docx

Disclaimer:

● Seismic lines currently available in the ABMI's HFIeOSA2020 (v1.2) are not complete representation of the seismic lines existing on the land surface. The ABMI's sampling scale Temporal Human Footprint dataset (THF) should be used for a more detailed representation of this sublayer.

● [YEAR] value is the best estimation of the year when the seismic line was created. It has been determined by visual interpretation based on available aerial/satellite imagery, and through comparisons to existing digital data provided by Pulse Seismic (www.pulseseismic.com). It is less accurate for the years prior to 2005 (the first year with higher spatial resolution mosaic available for the entire province of Alberta).

5 Human Footprint Inventory Linear Features

This dataset consists of digital representations of linear features, centerlines (Geometry Type: Polylines) within the HFIeOSA2020 (v1.2) dataset, including:

1. pipelines,
2. roads,
3. railways,
4. transmission lines,
5. seismic lines.

Disclaimer:

● The Linear Features dataset should be used as a supporting dataset to polygonal representation of HF features available in HFIeOSA2020 (v1.2). There are areas where human footprint is captured in polygon layers (HFIeOSA2020 (v1.2) and Sublayers) but is still missing in the Linear Features (polylines).

● Available attribute values of the Linear Features dataset are limited. Polygon layers (HFIeOSA2020 (v1.2) and Sublayers) should be used for geographic extent and more complete thematic information (i.e., available attribution, including source of the data).

5.1 ROADS

Feature class: o03_RoadsCenterlines_HFIeOSA2020 (v1.2)

Feature types: 'AIRP-RUNWAY' 'FORD-WINTER-XING' 'INTERCHANGE-RAMP' 'RIS-ROAD' 'ROAD' 'ROAD-GRAVEL-1L' 'ROAD-GRAVEL-2L' 'ROAD-PAVED-1L' 'ROAD-PAVED-2L' 'ROAD-PAVED-3L' 'ROAD-PAVED-4L' 'ROAD-PAVED-5L' 'ROAD-PAVED-6L' 'ROAD-PAVED-7L' 'ROAD-PAVED-DIV' 'ROAD- PAVED-UNDIV-1L' 'ROAD-PAVED-UNDIV-2L' 'ROAD-PAVED-UNDIV-4L' 'ROAD-UNCLASSIFIED' 'ROAD-UNIMPROVED' 'ROAD-UNPAVED-1L' 'ROAD-UNPAVED-2L' 'ROAD-WINTER-ACCESS' 'ROAD-WINTER-ROAD' 'TRAIL-ATV' 'TRUCK-TRAIL'

Details of AHFMP processing steps and user guide are included in these documents:

AHFMP - Road Processing 2014 Footprint.pdf

AHFMP - Road User Guide 2014 Footprint.pdf

5.2 RAILWAYS

Feature class: o04_RailwaysCenterlines_HFIeOSA2020 (v1.2)

Feature types: 'RLWY' 'RLWY-ABANDONED' 'RLWY-DBL-TRACK' 'RLWY-MLT-TRACK' 'RLWY-SGL-TRACK' 'RLWY-SPUR'

5.3   TRANSMISSION LINES

Feature class: o13_TransmissionLineCenterlines_HFIeOSA2020

Feature types: 'TRANSMISSION-LINE'

5.4   PIPELINES

Feature class: o19_PipelineCenterlines_HFIeOSA2020

Feature types: 'PIPELINE'

The Pipeline Centre Line feature class was created by the Geographic Science Team (GScT) of Alberta Environment and Protected Areas for the Alberta Human Footprint Monitoring Program (AHFMP). The data is used to monitor the linear density of pipeline corridors in the province of Alberta. The data is an estimate of the high-pressure pipelines in the province and is not suitable for locating pipelines on the ground. The data will also contain some low-pressure pipelines. A pipeline corridor is defined by the AHFMP as any linear disturbance created for the purpose of constructing and maintaining pipelines. The center line represents the linear distance of the corridor and a single center line is placed in the corridor regardless of the number of pipelines in that corridor. The data was derived from the Digitally Integrated Dispositions (DIDs), Rural Cadastral pipeline right of ways and SPOT imagery using a combination of raster processing and manual digitizing. The Alberta Energy Regulator (AER) pipeline dataset was used as reference to locate the pipeline corridors. The data was designed specifically for monitoring human footprint and may not be suitable for some cartographic purposes.

Data created by Alberta Human Footprint Monitoring Program (AHFMP) was consequently modified by ABMI. Digitized pipelines interpreted from satellite imagery (year 2017) were added to the source dataset to create a final HFI sublayer that represents estimated status of pipelines up to year 2020.

Details of AHFMP processing steps and user guide are included in these documents:

AHFMP - Pipeline Procedures Manual for 2016 Footprint - Ver 3.pdf

AHFMP - Pipeline User Guide for 2016 Footprint - Ver 2.pdf

5.5   SEISMIC LINES

Feature class: o20_SeismicCenterlines_HFIeOSA2020

Feature types: 'LOW-IMPACT-SEISMIC', 'CONVENTIONAL-SEISMIC', 'TRAIL'

Details of AHFMP processing steps and user guide are included in these documents:

AHFMP - Seismic User Guide 2014 Footprint Ver3.docx

6   Enhanced Human Footprint Inventory

The HFIeOSA2020 (v1.2) is an enhanced version of the ABMI's original HFI dataset in that it contains additional information about the following for particular sublayers and features:

- the origin of each human footprint:
  - industry that created human footprint - [SECTOR_HFIe],
  - year of the origin - [YEAR],

- vegetation on the human footprint:
  - normalized difference vegetation index – [NDVI_mean]
  - day/night band radiance [VIIRS_DNB]
  - anthropogenic noise - [Noise]

- exploration- vs production-related activities:
  - exploration vs. production - [EXPL_V_PROD]

More details about these and other dataset attribute fields can be found in Section 9 below, and in the Appendix.

7 Enhanced Attribution

7.1 Sector Attribution

Table 5 lists definitions for each of the sector attribute values. These were determined using a combination of HF feature type and local landscape context in relation to other nearby HF features.

Table 5. Sector definitions used in the HFIeOSA2020 (v1.2) dataset.

Sector	Definition
AGRICULTURE	Land disturbed for agricultural purposes such as crop and tame pasture.
ANTHROPOGENIC_WATER	Human-made water features.
BITUMEN_INSITU	Bitumen is a low-grade of crude oil which is composed of complex, heavy hydrocarbons with a high viscosity and will not flow to a well. In-situ (in the original place) requires enhanced recovery methods such as SAGD (steam assisted gravity drainage) to recover the resource. The AER designated three areas in the province Cold Lake, Peace River and Athabasca as oil sands areas where this recovery method is employed. These designated oil sands areas do not include the AER designated surface mining area.
BITUMEN_MINING_SURFACE	Bitumen is a low-grade of crude oil which is composed of complex, heavy hydrocarbons with a high viscosity. Mining Surface is an area defined by the AER (Alberta Energy Regulator) where the recovery of this resource is accomplished by removing overburden to physically access the resource.
ENERGY/INDUSTRIAL_OTHER	Industrial or energy disturbances unrelated to oil and gas.
ENERGY_TRANSMISSION	Disturbances related to the transportation of oil and gas products through pipelines to and from facilities and the transmission of electrical energy through power lines from power generating sources such as power plants, windmills, etc. to the consumers.
FORESTRY	Disturbances related to the harvesting of timber.
FORESTRY-UNCONFIRMED	A potential timber-harvest area or other forestry-related activity such as a log storage yard that has not been verified. This classification is applied mainly (but not exclusively) to older timber harvest areas that predate the Phase 3 Forest Inventory, where there are very few reference data available for confirmation. (Source: AHFMP)
MINING_SURFACE_OTHER	Mining sites unrelated to oil and gas. i.e. coal, peat, gravel, etc.
MUNICIPAL_INDUSTRIAL	Industry related to municipal services or within the municipal boundary.

MUNICIPAL_RECREATIONAL	Recreational areas within a municipal boundary.
MUNICIPAL_RESIDENTIAL	All residential areas.
OIL_GAS_BITUMEN_UNKNOWN	Infrastructure in close proximity to and maybe related to Bitumen/oil and gas that is not obvious.
OIL_GAS_CONVENTIONAL	Conventional oil and gas refers to petroleum, or crude oil, and raw natural gas extracted from the ground by the natural pressure from the wells and pumping operations and do not require enhanced recovery methods.
RECREATIONAL/OTHER	Recreational facilities located outside a municipal boundary.
TRANSPORTATION_MAJOR	A roadway, which is paved with asphalt or concrete or surfaced with gravel and constituted as a main access route.
TRANSPORTATION_MINOR	A roadway surfaced with dirt or low vegetation constituting a minor access route.
UNKNOWN	Any feature too ambiguous to assign a specific sector.

7.2 Nighttime Light Attribution

Data source and description:

Nighttime light values were attributed to HFIeOSA2020 (v1.2) features using information from the Visible Infrared Imaging Radiometer Suite's (VIIRS's) Stray Light Corrected Nighttime Day/Night Band (DNB) Composites Version 1. These data are provided by the Earth Observation Group, Payne Institute for Public Policy, Colorado School of Mines (https://payneinstitute.mines.edu/eog/), and were accessed and processed using Google's online Earth Engine (GEE) platform (GEE product "NOAA/VIIRS/DNB/MONTHLY_V1/VCMSLCFG").

The above data product offers monthly average radiance composite images from the VIIRS DNB. Data are cloud-masked, and have been corrected for stray light. However, Version 1 data has not been filtered to remove light from aurora phenomena, fires, boats, or other temporal lights. The product covers the globe from latitudes 75^0N to 65^0S, and are produced in 15 arc-second geographic grids. The products available through the GEE Data Catalog are provided at a spatial resolution of 463.8 m, and in units of nanoWatts/cm^2/sr. More information about the data can be found here:

https://developers.google.com/earth-engine/datasets/catalog/NOAA_VIIRS_DNB_MONTHLY_V1_VCMSLCFG#description.

Processing steps:

A JavaScript custom script was used in the online GEE platform to access and process the VIIRS DNB monthly composite data. This script:

1) combines monthly average Day/Night Band composites for the months of January through March, and October through December,

2) creates a mean DNB radiance value composite from the selected images,

3) exports the result from GEE using the Alberta NAD83 10TM Forest coordinate system.

Once exported, the mean DNB composite raster (see Figure 2) is used in a zonal statistics geostatistical process (run in ArcGIS software) to extract per-feature mean DNB radiance values. These are assigned to the [DNB_VIIRS_mean] attribute of the relevant human footprint features. Where feature polygons cannot be attributed with DNB values in this way (i.e., they are too small, or are oddly shaped), a point placed within the boundary of the polygon is used to extract a DNB value for that point; this value is then assigned to the polygon. The approach used to attribute various features is captured in the [MethodLight] attribute, whereby a '1' indicates the use of zonal statistics, and a '2' indicates the use of a point-based value.
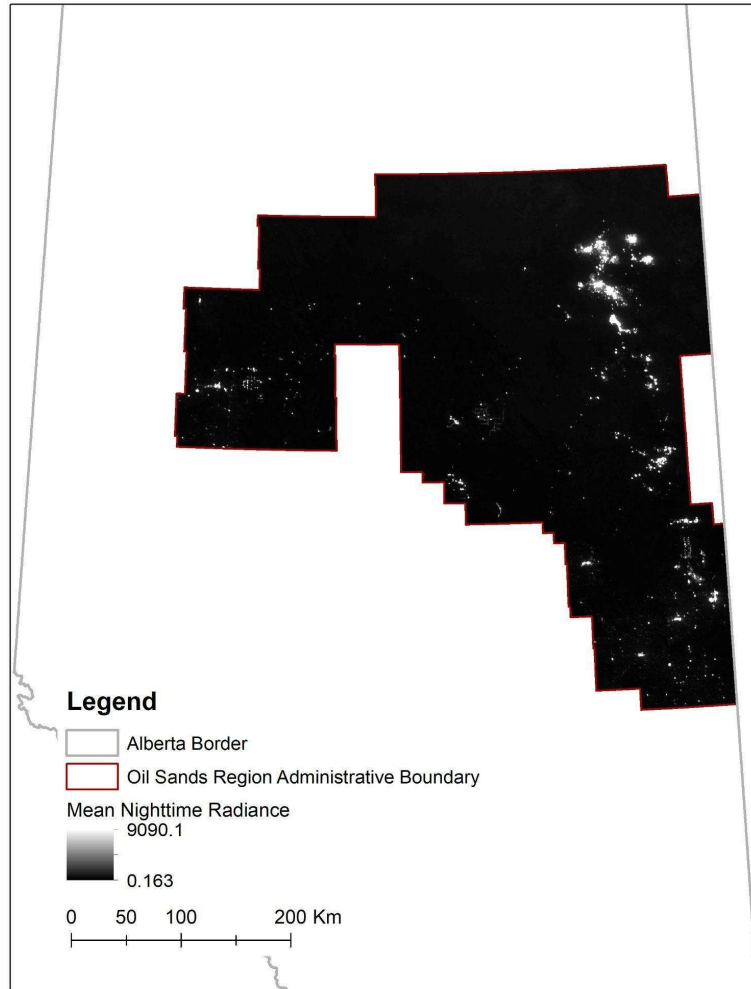
Figure 2. Average 2020 composite of VIIRS Day/Night Band radiance for the Oil Sands Region boundary in Alberta, Canada, showing the oil sands administrative boundary.

Features within the following sublayers are attributed with a nighttime light ([VIIRS_DNB]) attribute (Table A.1):

- Mine Sites
- Industrial Sites
- Well Sites (Active and Abandoned)
- Urban and Rural Residential

7.3 Vegetation Attribution

Data source and description:

Vegetation is represented by spectral Normalized Difference Vegetation Index (NDVI) values, which are extracted from the European Space Agency's (ESA'S) Harmonized Sentinel-2A and Sentinel-2B MultiSpectral Instrument optical satellite sensor surface reflectance data. These data are provided by the ESA's Copernicus Mission (https://sentinels.copernicus.eu/web/sentinel/home), and were accessed and processed using Googles online Earth Engine (GEE) platform (GEE product "COPERNICUS/S2_SR_HARMONIZED").

The data above offer 13 band, multi-spectral surface reflectance image scenes at a global scale, on an equatorial frequency of every 5 days. They have been atmospherically- and geometrically-corrected, and are accompanied by cloud and other quality flags for further processing. NDVI calculations with these data used surface reflectance in bands 4 (red visible) and 8 (near-infrared), both provided at a 10 m spatial resolution. More information about the data can be found here: https://developers.google.com/earth-engine/datasets/catalog/COPERNICUS_S2_SR_HARMONIZED#description.

Processing steps:

A JavaScript custom script was used in the online GEE platform to access and process the Sentinel-2A and -2B imagery into an annual NDVI composite. This script:

1) combines individual Sentinel-2A and -2B surface reflectance scenes covering the area of interest, from the months of June through September,

2) uses quality assurance flags to identify and remove cloud and cirrus effects from the imagery,

3) calculates per-scene NDVI using the equation [Band 8 – Band 4]/[Band 8 + Band 4],

4) creates a mean NDVI annual composite for 2020 from the stack of NDVI images,

5) exports the result from GEE using the Alberta NAD83 10TM Forest coordinate system.

Once exported, the mean NDVI composite raster (see Figure3) is used in a zonal statistics geostatistical process (run in ArcGIS software) to extract per-feature mean NDVI values from each composite. These are assigned to the [NDVI_mean] attribute of the relevant human footprint features. Where feature polygons cannot be attributed with NDVI values in this way (i.e., they are too small, or are oddly shaped), a point placed within the boundary of the polygon is used to extract an NDVI values for that point; this value is then assigned to the polygon. The approach used to attribute various features is captured in the [MethodMean] attribute, whereby a '1' indicates the use of zonal statistics, and a '2' indicates the use of a point-based value.

Values description:

Values of NDVI range from -1 to +1, and represent the scattering of near-infrared wavelengths by healthy green leaves, and the absorption of red wavelengths by plant chlorophyll. Negative NDVI values (i.e., those approaching -1) correspond to water surfaces, while values close to zero (-0.1 to 0.2) generally indicate areas of barren rock, soil, or snow. Low, positive values generally represent shrub and grassland (~0.2 to 0.4), and higher positive values often reflect treed vegetation such as temperate or tropical forests (see https://custom-scripts.sentinel-hub.com/sentinel-2/ndvi/ for more information).
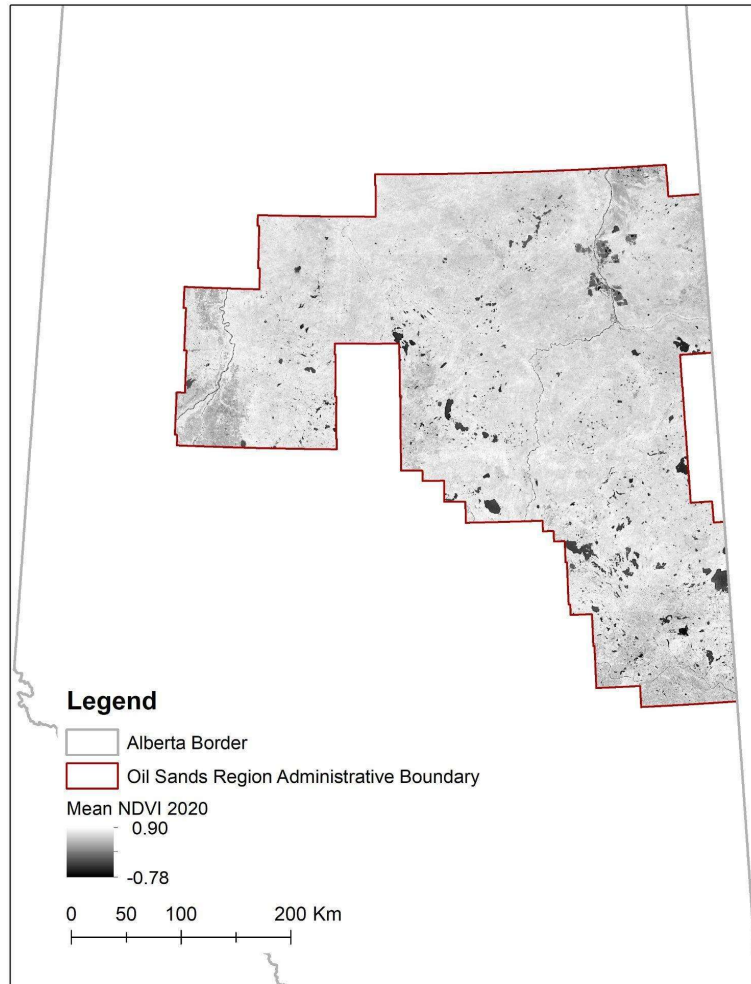
Figure 3. Mean 2020 composite of mean normalized difference vegetation index (NDVI) for the Oil Sands Region boundary in Alberta, Canada, showing the oil sands administrative boundary.

7.4 Noise Attribution

Data source and description:

Anthropogenic noise was modeled over the Oil Sands Region of Alberta following the methods outlined in the following:

Hedley, R.W. 2021. Chapter 3: Mapping Anthropogenic Noise in Alberta' Oil Sands Region Using Passive Acoustic Monitoring. In ABMI Geospatial Report

2020-2021: Oil Sands Monitoring - Geospatial Program Development Report (2020-2021 Work Plan CC-2-1920), March 2021, pp. 32 - 48.

Modeling involved the application of boosted regression tree machine learning, and involved inputs from 3,400 acoustic sound recording locations distributed across the region, alongside information on the presence and distribution of various human footprint features over the same area. The latter was derived from the ABMI's HFI 2020 dataset. The approach predicts both the probability of anthropogenic noise under a given condition (i.e., during a recording window), and the amount or level of this noise under this condition. Combining these two predictions together produced an overall prediction of expected average noise levels for any location across the area of interest. Only human footprint features identified as producing anthropogenic noise were used in analysis.

Processing steps:

Once modeled, the anthropogenic noise raster (Figure 4) is used in a zonal statistics geostatistical process (run in ArcGIS software) to extract per-feature mean noise values. These are assigned to the [Noise] attribute of the relevant human footprint features. Where feature polygons cannot be attributed with Noise values in this way (i.e., they are too small, or are oddly shaped), a point placed within the boundary of the polygon is used to extract a Noise value for that point; this value is then assigned to the polygon. The approach used to attribute various features is captured in the [MethodNoise] attribute, whereby a '1' indicates the use of zonal statistics, and a '2' indicates the use of a point-based value.

Table 6 lists the HFIe sublayers and specific feature types that were used in anthropogenic noise modeling and attributed with the [Noise] attribute in the HFIeOSA2020 (v1.2).

Table 6: HFIeOSA2020 (v1.2) sublayers and features types to which [Noise] is attributed.

Sublayer	Feature Type(s)
02 - Borrow Pits, Sumps, Dugouts and Lagoons	BORROWPIT-DRY; BORROWPITS; BORROWPIT-WET
03 - Roads	All
04 - Railways	RLWY-MLT-TRACK RLWY-SPUR
07 - Mine Sites	GRVL-SAND-PIT MINES-OILSANDS OPEN-PIT-MINE RIS-OILSANDS-RMS RIS-TAILING-POND TAILING-POND
08 - Industrial Sites	FACILITY-OTHER FACILITY-UNKNOWN MILL MISC-OIL-GAS-FACILITY OIL-GAS-PLANT RIS-CAMP-INDUSTRIAL RIS-FACILITY-OPERATIONS RIS-FACILITY-UNKNOWN RIS-PLANT RIS-TANK-FARM RIS-UTILITIES URBAN-INDUSTRIAL
09 - Well Sites (Active)	RIS-WELL WELL-BIT WELL-CASED WELL-CLEARED-DRILLED WELL-CLEARED-NOT-CONFIRMED WELL-CLEARED-NOT-DRILLED WELL-DRILLED-OTHER WELL-GAS WELL-OIL WELL-OTHER
10 - Landfills	All
11 - Other Veg Surfaces	CAMPGROUND RECREATION RUNWAY
12 - Win Gen Facility	All
13 - Transmission Lines	All

14 - CFO/High Density Livestock	All
15 - Urban/Rural Residential	COUNTRY-RESIDENCE RURAL-RESIDENCE URBAN-RESIDENCE
19 - Pipelines	All
20 - Seismic Lines	PRE-LOW-IMPACT-SEISMIC TRAIL

Values description:

Modeled anthropogenic noise is provided in decibels (dB), and the 2020 model produced values ranging from 0 dB to 21.5 dB. It is important to note that the output of this model was constrained to positive values (i.e. greater than zero).
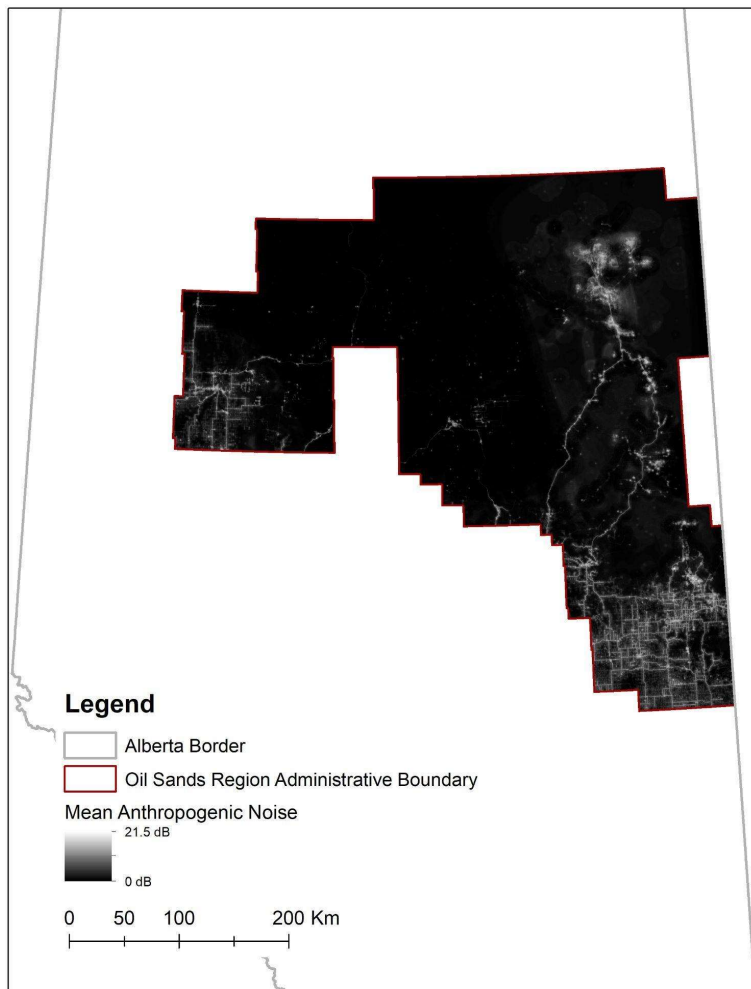
Figure 4. Mean 2020 anthropogenic noise (decibels; dB) for the Oil Sands Region in Alberta, Canada, showing the oil sands administrative boundary.

7.5 Exploration vs. Production Attribution

The attribution of whether a human footprint feature is exploration- or production-related is captured using the [EXPL_v_PROD] field. Valid values include:

- 'Expoloration',

- 'Produciton',

- 'NA' (for *not applicable*), and

- 'Unknown' (where the feature's designation is unknown or as of yet undetermined).

Features designated as "exploration" are defined as those associated with the search for reservoirs of oil and gas, including geophysical surveys (e.g., seismic lines), and drilling of exploration wells (i.e., those that never reported production). For the purposes of this dataset, it is assumed that 4D seismic lines are "exploration", as data to determine otherwise is not currently available.

Features designated as "production" in the current attribution comprise everything that is downstream of exploration-related features and activities. This includes all oil and gas reclamation features, as designated by the Alberta Reclamation Information System (RIS). "Production" attribution is given to features such as: well pads that have reported bringing well fluids to the surface, or are injection or disposal wells; open pit oil sands mines; facilities (e.g., for crushing, separating, storing, waste processing, upgrading, refining etc.); and, transport via pipeline (note: batteries and trucking are not currently included in the latter type of feature). Features that are not within the scope of this current exploration vs production attribution work include: coal and peat mines, and energy transmission lines, though it is recognized that the latter do form a component of the energy footprint on the Alberta landscape.

The feature sublayers to which this attribute is added for the HFIeOSA2020 (v1.2) dataset include:

- 07 Mine Sites

- 08 Industrial Sites

- 09 Well Sites Active

- 16 Well Sites Abandoned

- 19 Pipelines

- 20 Seismic Lines and Trails

Steps and rules for assigning an 'EXPL_v_PROD' attribute value to the features in these sublayers are outlined in the Table 7 below.

Assignation of this attribute is not applicable to features within the following HFIeOSA2020 (v1.2) sublayers (i.e. features in these sublayers will have an 'NA' value in them):

- 01 Reservoirs

- 05 Canals

- 12 Wind Generation Facilities

- 14 CFO and other High Density Livestock

- 17 Cultivation

- 18 Harvest Areas

Finally, the below sublayers are not attributed with 'Exploration' vs 'Production' values for HFIeOSA2020 (v1.2) dataset. Future versions of the product may include this attribution for some or all of the following sublayers. They require further efforts to develop appropriate approaches and decision rules for determining such attribution, as many are multi-use features

● 02 Borrow Pits, Sumps, Dugouts and Lagoons

● 03 Roads

● 04 Railways

● 06 Verges

● 10 Landfills

● 11 Other Vegetated Surfaces

● 13 Transmission Lines

● 15 Urban and Rural Residential

The decision rules developed for attributing the selection of OSR HFIe 2020 features with "Exploration", "Production", "NA", or "Unknown" are provided in Table e below. These rules largely rely on a feature's type and its designated sector (see Section 3.2 Sector attribution). However, for well site sublayers, existing attribution provided by collaborators in the Alberta Human Footprint Monitoring Program (AHFMP) in the form of a provided well bore PROD_EX_P attribute, is used to designate these features as exploration, production or unknown, as appropriate.

Table 7. Instructions and decision rules for assigning values to the EXPL_v_PROD attribute for OSMHFIe2020 feature sublayers, based on existing FEATURE_TY and SECTOR attributes. Valid values include: 'Exploration', 'Production', 'NA' (for not applicable), and 'Unknown'.

HFI Sublayer	EXPL_v_PROD Attribution
07 Mine Sites	Mine features that meet one of the following criteria are attributed as "Production": ● Their FEATURE_TY o is "MINES-OILSANDS" ● Their FEATURE_TY

	o begins with "RIS-" Mine features that do not meet these criteria are attributed as "NA" (this includes gravel and coal mines, peat, etc.).

08 Industrial Sites	Industrial features that meet one of the following criteria are attributed as "Production":
	
	● Their FEATURE_TY
	    o begins with "RIS-" **or**
	    o is "MISC-OIL-GAS-FACILITY" or "OIL-GAS-PLANT"
	
	● Their FEATURE_TY
	    o is "CAMP-INDUSTRIAL" **and**
	  their SECTOR
	    o is "BITUMEN_MINING_SURFACE", "BITUMEN_INSITU", or "OIL_GAS_CONVENTIONAL"
	
	Industrial features that meet one of the following criteria are attributed as "Unknown":
	
	● Their FEATURE_TY
	    o is "FACILITY-OTHER", "FACILITY-UNKNOWN", or "CLEARING-UNKNOWN" **and**
	  their SECTOR
	    o is "BITUMEN_MINING_SURFACE", "BITUMEN_INSITU", "OIL_GAS_CONVENTIONAL", "INDUSTRIAL_OTHER", "MINING_SURFACE_OTHER", or "MUNICIPAL_INDUSTRIAL"
	
	Industrial features that meet one of the following criteria are attributed as "NA":
	
	● Their FEATURE_TY
	    o is "MILL" or "URBAN-INDUSTRIAL"
	
	● Their FEATURE_TY
	    o is "FACILITY-OTHER", "FACILITY-UNKNOWN", "CLEARING-WELLPDAD-UNCONFIRMED", or "CLEARING-UNKNOWN" **and**
	  their SECTOR
	    o is "ENERGY_TRANSMISSION", "AGRICULTURE", "FORESTRY", "MUNICIPAL_RESIDENTIAL", "MUNICIPAL_RECREATION", "RECREATIONAL_OTHER", "TRANSPORTATION_MAJOR", or "TRANSPORTATION_MAJOR"

09 Well Sites Active	All wells that meet <u>one or more</u> of the following criteria are to be attributed as "Production": ● They have a 'PROD_X_P_value" value of **2** (the ABMI numerical value equivalent to the AHFMP value of 'PRODUCTION AND RELATED') ● The have been drilled ● They possess a production-related information (i.e., a SPUD date) All wells that meet the following criteria are to be attributed as "Exploration": ● They have a 'PROD_X_P_value" value of **1** (the ABMI numerical value equivalent to the AHFMP value of 'EXPLORATION AND RELATED') Any remaining wells are to be attributed as "Unknown"
16 Well Sites Abandoned	All wells that meet <u>one or more</u> of the following criteria are to be attributed as "Production": ● They have a 'PROD_X_P_value" value of **2** (the ABMI numerical value equivalent to the AHFMP value of 'PRODUCTION AND RELATED') ● The have been drilled ● They possess a production-related information (i.e., a SPUD date) All wells that meet the following criteria are to be attributed as "Exploration": ● They have a 'PROD_X_P_value" value of **1** (the ABMI numerical value equivalent to the AHFMP value of 'EXPLORATION AND RELATED') Any remaining wells are to be attributed as "Unknown"
19 Pipelines	"Production"
20 Seismic Lines	"Exploration"

8 Appendix

8.1 Attribute List

Table A.1: List of mandatory and enhanced attributes per sublayer in the OSMHFIe2020 dataset. Note that 1) Wind Generation Facilities do not occur within the OSR and the following is not applicable (N/A) to this sublayer; and 2) not all features in a given sublayer are attributed with Noise - see Section 9.4 (Noise Attribution) for details.

Sublayer	Attributes								
	HFI_ID	FEATURE_TY	SOURCE	YEAR	SECTOR	VIIRS_DNB	NDVI	Noise	EXPLR_V_PROD
01 - Reservoirs	✔	✔	✔	1950 - 2020	✔		✔		
02 - Borrow Pits, Sumps, Dugouts, and Lagoons	✔	✔	✔	NULL 1950 - 2020	✔		✔	✔	
03 - Roads	✔	✔	✔	NULL 1884 - 2020	✔		✔	✔	
04 - Railways	✔	✔	✔	1905 - 2020	✔		✔	✔	
05 - Canals	✔	✔	✔	1950 - 2020	✔		✔		
06 - Verges	✔	✔	✔	NULL	✔		✔		
07 - Mine SItes	✔	✔	✔	1950 - 2020	✔	✔	✔	✔	✔
08 - Industrial Sites	✔	✔	✔	1890 - 2020	✔	✔	✔	✔	✔
09 - Well Sites Active	✔	✔	✔	NULL 1897 - 2020	✔	✔	✔	✔	✔
10 - Landfills	✔	✔	✔	1984 - 2020	✔		✔	✔	
11 - Other Vegetated Surfaces	✔	✔	✔	1950 - 2020	✔		✔	✔	
12 - Win Generation Facilities	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13 - Transmission Lines	✔	✔	✔	NULL	✔		✔	✔	
14 - CFO	✔	✔	✔	1950 - 2020	✔		✔	✔	
15 - Urban and Rural Residential	✔	✔	✔	NULL	✔	✔	✔	✔	
16 - Well Sites Abandoned	✔	✔	✔	1894 - 2020	✔	✔	✔		✔
17 - Cultivation	✔	✔	✔	NULL 1950 - 2020	✔		✔		
18 - Harvest Areas	✔	✔	✔	1940 - 2020	✔		✔		
19 - Pipelines	✔	✔	✔	1894 - 2020	✔		✔	✔	✔
20 - Seismic Lines and Trails	✔	✔	✔	NULL 1950 - 2020	✔		✔	✔	✔

8.1.1 Mandatory Fields:

"FEATURE_TY"

The category of human footprint.

"SOURCE"

The source of the feature in the dataset.

Values:

'ABMI' – data updated by ABMI prior to HFI_2014 update,

'ABMI00' – data updated by ABMI during HFI_2000 update,

'ABMI07' – data updated by ABMI during HFI_2007 update,

'ABMI10' – data updated by ABMI during HFI_2010 update,

'ABMI12' – data updated by ABMI during the HFI_2012 update,

'ABMI14' – data updated by ABMI during HFI_2014 update,

'ABMI15' – data updated by ABMI during HFI_2015 update,

'ABMI16' – data updated by ABMI during HFI_2016 update,

'ABMI17' – data updated by ABMI during HFI_2017 update,

'ABMI18' – data updated by ABMI during HFI_2018 update,

'ABMI19' – data updated by ABMI during HFI_2019 update,

'ABMI20' – data updated by ABMI during HFI_2020 update,

'ABMI37' – data updated by ABMI during temporal human footprint on sample scale update,

'AHFMP'– data updated by Alberta Human Footprint Mapping Program

'AVIE' – data derived from the Alberta Vegetation Inventory obtained from the Government of Alberta

'AVI' – data derived from the Alberta Vegetation Inventory obtained from the Government of Alberta

'BASEFE' – data obtained from the Government of Alberta under the Open Data License. Data source: http://www.altalis.com/products/base/20k_base_features.html

'BUFF10' – data updated by ABMI during HFI_2010 update by the buffering of residential centroid points

'GVI' – data derived from the Grassland Vegetation Inventory obtained from the Government of Alberta

'GVIed' – data derived from the Grassland Vegetation Inventory obtained from the Government of Alberta updated by ABMI

'NA' – data source not available

'PLVI' – data derived from the Primary Land and Vegetation Inventory obtained from the Government of Alberta

'PLVIed' – data derived from the Primary Land and Vegetation Inventory obtained from the Government of Alberta updated by ABMI,

'RIS' – Reclamation Information System (RIS) data obtained from the Government of Alberta, Alberta Environment and Parks

'SRDSPT' – Special Areas data obtained from the Government of Alberta, Alberta Environment and Parks

'SPAREA' – Special Areas data obtained from the Government of Alberta, Alberta Environment and Parks

"YEAR"

[YEAR] attribute contains a value of "year of origin". This value is either introduced to HFI dataset from other sources (along with original features) or it is being attributed by ABMI processes. When a feature is updated by ABMI, [YEAR] value is updated based on available imagery in ABMI mosaic catalogue – years of 1949-1951, 1999-2003, and 2004 to 2020.

Google Earth Timelapse was used as a reference tool for year of origin determination of some features.

Year value has not been determined for all polygons. The ABMI is constantly updating human footprint inventory dataset including filling in year values. It is expected that the next release of HFI dataset will contain more human footprint features with known year of origin than the current version.

"HFI_ID"

Unique identifier used for additional analysis

8.1.2 Optional attributes:

"NAME"

The name of the particular location.

"BNDRY_SOURCE"

The source of the feature boundary.

8.2 Data References

Table A.2: Data source references used in OSA HFIe 2020 creation.

Title	Association Type	Location/Reference
Alberta Vegetation Inventory (AVI)	Source	Government of Alberta, 2016. Data provided by Alberta Human Footprint Mapping Project (AHFMP), https://open.alberta.ca/opendata/ahfmp
Grassland Vegetation Inventory (GVI)	Source	Government of Alberta, 2016. Data provided by Alberta Human Footprint Mapping Project (AHFMP), https://open.alberta.ca/opendata/ahfmp
Primary Land and Vegetation Inventory (PLVI)	Source	Government of Alberta, 2016. Data provided by Alberta Human Footprint Mapping Project (AHFMP), https://open.alberta.ca/opendata/ahfmp
Alberta Human Footprint Mapping Project (AHFMP)	Source	Government of Alberta, 2016. Data provided by Alberta Human Footprint Mapping Project (AHFMP), https://open.alberta.ca/opendata/ahfmp
Reclamation Information System (RIS)	Source	Government of Alberta, 2016. Data provided by Alberta Human Footprint Mapping Project (AHFMP), https://open.alberta.ca/opendata/ahfmp
Government of Alberta (SRDSPT)	Source	Government of Alberta, 2016. Data provided by Alberta Human Footprint Mapping Project (AHFMP), https://open.alberta.ca/opendata/ahfmp
Digitally Integrated Dispositions (DIDs)	Source	Government of Alberta, 2016. Data provided by Alberta Human Footprint Mapping Project (AHFMP), https://open.alberta.ca/opendata/ahfmp
Alberta Vegetation Inventory Enhanced (AVIE)	Source	Government of Alberta, 2016. Data provided by Alberta Human Footprint Mapping Project (AHFMP), https://open.alberta.ca/opendata/ahfmp
Special Areas (SPAREA)	Source	The Special Areas; specialareas.ab.ca
Land Use Classification in the Special Areas of Alberta	Source	Publication No. 731; technical Bulletin No.39; Issued: February. 1942
SPOT6, 2014	Source	Alberta Environment and Parks, 2019. Air, Biodiversity and Policy Integration Branch, Policy and Planning Division, Provincial coverage of pan sharpened and multispectral SPOT6, years 2010 to 2017. [Edmonton, AB: Alberta Environment and Parks, 2019].
SPOT6, 2017	Source	Alberta Environment and Parks, 2019. Air, Biodiversity and Policy Integration Branch, Policy and Planning Division, Provincial coverage of pan sharpened and multispectral SPOT6, years 2010 to 2017. [Edmonton, AB: Alberta Environment and Parks, 2019].
SPOT6, 2019	Source	Alberta Environment and Parks, 2020. Air, Biodiversity and Policy Integration Branch, Policy

		and Planning Division, Provincial coverage of pan sharpened and multispectral SPOT6, years 2017 to 2019. [Edmonton, AB: Alberta Environment and Parks, 2020]
SPOT6, 2020	Source	Alberta Environment and Protected Areas, 2021. Lands Planning Branch, Lands Division, Provincial coverage of pan sharpened and multispectral SPOT6, years 2018 to 2020. [Edmonton, AB: Alberta Environment and Protected Areas, 2021]
Valtus Orthophoto Mosaic cca 2000	Reference	Alberta Environment and Parks, 2016. Informatics Branch
IRS Satellite	Reference	Alberta Environment and Parks, 2016. Informatics Branch
Base Features (BASEFE)	Source	Government of Alberta, 2016. Open Data License, Retrieved from http://www.altalis.com/products/base/20k_base_features.html
Google Maps	Reference	https://maps.google.ca
Google Earth Timelapse	Reference	https://earthengine.google.com/timelapse/
Alberta Recycling Management Authority	Reference	http://www.albertarecycling.ca/collection-site-search-results
City of Calgary	Source	https://data.calgary.ca/Base-Maps/Land-Use-Polygons/gbpb-ymc5/about https://maps.calgary.ca/CalgaryImagery/
Alberta Environment and Sustainable Resource Development	Reference	Alberta Environment and Sustainable Resource Development, 2016. Informatics Branch, 1.5 m Colour SPOT 6 Mosaic. Retrieved from http://environment.alberta.ca/
Valtus Imagery Services	Reference	Valtus Imagery Services, 2010. Valtus Imagery. Retrieved from http://www.valtus.com/
Valtus Imagery Services	Reference	Valtus Imagery Services, 2011. Valtus Imagery. Retrieved from http://www.valtus.com/
Valtus Imagery Services	Reference	Valtus Imagery Services, 2012. Valtus Imagery. Retrieved from http://www.valtus.com/
Valtus Imagery Services	Reference	Valtus Imagery Services, 2013. Valtus Imagery. Retrieved from http://www.valtus.com/
Valtus Imagery Services	Reference	Valtus Imagery Services, n.d. Valtus Imagery. Retrieved from http://www.valtus.com/
Quality Farm Dugouts (3rd Edition)	Reference	http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex15866

Alberta Vegetation Inventory Standards and Data Model Documents	Reference	https://www.agriculture.alberta.ca/app21/forestrypage?cat1=Vegetation%20Inventory%20Standards
Grassland Vegetation Inventory Standards	Reference	https://geodiscover.alberta.ca/geoportal/catalog/search/resource/details.page?uuid=%7BD3AB9031-8EC0-4589-9335-C1E50AE05992%7D
Primary Land and Vegetation Inventory Standards	Reference	https://geodiscover.alberta.ca/geoportal/catalog/search/resource/details.page?uuid=%7BF640CD9D-C232-481D-9CFF-7A7B66E51E49%7D
road_album_2.ppt	Reference	Government of Alberta document, provided by Alberta Human Footprint Mapping Project (AHFMP)
Alberta Transportation Guide to Reclaiming Borrow Excavations – 2013 Edition	Reference	www.transportation.alberta.ca/Content/docType245/Production/borrowguide.pdf
AHFMP_Footprint Data Manual.docx	Reference	Government of Alberta document, provided by Alberta Human Footprint Mapping Project (AHFMP),
AHFMP - Road Processing 2014 Footprint.pdf	Reference	Government of Alberta document, provided by Alberta Human Footprint Mapping Project (AHFMP),
AHFMP - Well Pad User Guide 2014 Footprint.pdf	Reference	Government of Alberta document, provided by Alberta Human Footprint Mapping Project (AHFMP)
AHFMP - Well Pad Procedures for 2014 Footprint.pdf	Reference	Government of Alberta document, provided by Alberta Human Footprint Mapping Project (AHFMP)
AHFMP - Well Pad User Guide 2014 Footprint.pdf	Reference	Government of Alberta document, provided by Alberta Human Footprint Mapping Project (AHFMP)
AHFMP_Cultivation_User_Guide_Footprint_HFI_2014FTv2.pdf	Reference	Government of Alberta document, provided by Alberta Human Footprint Mapping Project (AHFMP)
AHFMP_Cultivation_User_Guide_HFI_2014.pdf	Reference	Government of Alberta document, provided by Alberta Human Footprint Mapping Project (AHFMP)
ISO 19131_AAFC_Annual_Crop_Inventory_Data_Product_Specifications.pdf	Reference	Agriculture and Agri-Food Canada (AAFC); AAFC Crop Inventory, 2014
AHFMP - Seismic User Guide 2014 Footprint Ver3.docx	Reference	Government of Alberta document, provided by Alberta Human Footprint Mapping Project (AHFMP)
AAFC Annual Crop Inventory Data	Source	http://www.agr.gc.ca/atlas/data_donnees/agr/annualCropInventory/tif/
SENTINEL - 2	Reference	European Space Agency (ESA); The Copernicus Sentinel-2 mission; https://sentinel.esa.int/web/sentinel/missions/sentinel-2
Visible Infrared Imaging Radiometer Suite (VIIRS)	Reference	Image and Data processing by NOAA's National Geophysical Data Center.

			DMSP data collected by the US Air Force Weather Agency.
Pulse Seismic Inc.	Reference	Pulse Seismic Inc., pulseseismic.com
Historical Orthophotos ca 1980s	Reference	Alberta Environment and Parks, 2019. Provided by the Government of Alberta's Air Photo Library, through the Alberta Human Footprint Mapping Program (AHFMP)

8.3 Thematic and Spatial Accuracy

Table A.3: Known thematic accuracy of source data used in OSA HFIe 2020 creation.

SOURCE	Collection	Source Category	Accuracy [%]
External	Inventories	AVI - Photo Interpretation Audit	≥ 90%
		GVI	≥ 65%
		PLVI	≥ 90%

Table A.4: Known spatial (horizontal) accuracy of source data used in OSA HFIe 2020 creation.

SOURCE	Collection	Source Category	Accuracy [+-m]
External	Base features	1:20 000 Provincial Digital Mapping Program	5
		Alberta 1:50 000 Access Mapping	50
		GPS field data	25
		IRS-1C/1D imagery	25
		NTDB data	100
		Federal hydrography	100
		Orthophoto imagery	10
		Aerial photography	10
		SRD regional investigation	25
		Ikonos imagery	10
		Derived from supplementary data	25
		SPOT imagery	2.5
	Inventories	Alberta Vegetation Inventory	20
		GVI upland	5
		GVI wetland	2

		PLVI	5
	Cadastral	Cadastral urban	0.15
		Cadastral rural	3
ABMI	ABMI	Heads-up digitization SPOT "green zone"	10 – 20
Buffer	Buffer	Calculated RMSE per feature type	