

# Landsat Collection 1 Level-1 Quality Assessment Band

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The Landsat Collection 1 Level-1 Quality Assessment (QA) band allows users to apply per pixel filters to the Landsat 4-5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 8 Operational Land Imager (OLI)-only and Landsat 8 OLI/Thermal Infrared Sensor (OLI/TIRS)- combined Collection 1 Level-1 data products. The Landsat 8 TIRS-only QA band only contains fill information.

The [Pre-Collection Landsat 8 QA band page](#) provides information on Pre-Collection Landsat 8 data.

Each pixel in the QA band contains unsigned integers that represent bit-packed combinations of surface, atmospheric, and sensor conditions that can affect the overall usefulness of a given pixel.

The tables below display the Landsat 4-5 TM, Landsat 7 ETM+, Landsat 8 OLI-only, and Landsat 8 OLI/TIRS combined Collection 1 Level-1 Quality Band attributes.

Landsat 4-5 TM, Landsat 7 ETM+ Collection 1 Quality Band Attributes				Landsat 8 OLI, OLI/TIRS Collection 1 Quality Band Attributes			
Bit	Value	Cumulative Sum	Description	Bit	Value	Cumulative Sum	Description
0	1	1	Designated Fill	0	1	1	Designated Fill
1	2	3	Dropped Pixel	1	2	3	Terrain Occlusion
2	4	7	Radiometric Saturation	2	4	7	Radiometric Saturation
3	8	15		3	8	15	
4	16	31	Cloud	4	16	31	Cloud
5	32	63	Cloud Confidence	5	32	63	Cloud Confidence
6	64	127		6	64	127	
7	128	255	Cloud Shadow Confidence	7	128	255	Cloud Shadow Confidence
8	256	511		8	256	511	
9	512	1023	Snow/Ice Confidence	9	512	1023	Snow/Ice Confidence
10	1024	2047		10	1024	2047	
11	2048	4095		11	2048	4095	Cirrus Confidence
12	4096	8191		12	4096	8191	
13	8192	16383		13	8192	16383	
14	16384	32767		14	16384	32767	
15	32768	65535		15	32768	65535	

## What are QA Bits?

The bit-packed information in the QA bands is a translation of binary strings. As a simple example, the integer value “1” translates to the binary value “0001.” The binary value “0001” has 4 bits, written right to left as bits 0 (“1”), 1 (“0”), 2 (“0”), and 3 (“0”). Each of the bits 0-3 represents a condition that can affect the calculation of a physical value. Bit 0 may be used to identify fill values, Bit 1 may be used to identify a dropped pixel (Landsat 4-5 TM, 7 ETM+) or terrain occlusion (Landsat 8 OLI, OLI/TIRS), Bits 2 and 3 together may be used to indicate the level of radiometric saturation present. If the condition is true, the bit is set to “1,” and “0” if false.

Used effectively, QA bits improve the integrity of science investigations by indicating which pixels might be affected by instrument artifacts or subject

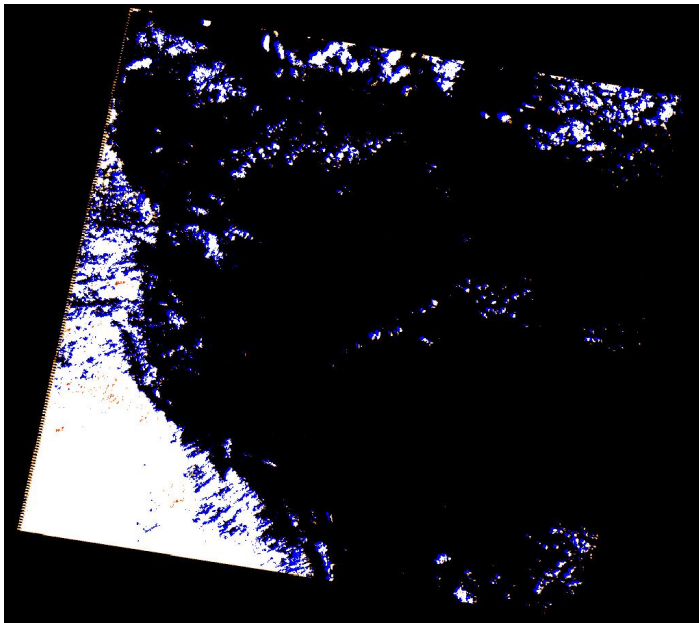
to [cloud contamination](#). For example, NDVI calculated over pixels containing clouds will show anomalous values. If such pixels were included in a phenology study, the results might not show the true characteristics of seasonal vegetation growth. Cloud contaminated pixels will lower NDVI values, and measures like the timing of 'green up' or peak maturity would appear later than they actually occurred. A worse consequence would be that the reported reduction of vegetation growth would be taken as an indicator of environmental change, potentially prompting unnecessary land management policies or practices.

### Extracting QA Band bits

The [Landsat QA Tools](#) can be used to extract bits from Landsat QA bands and the [Landsat QA ArcGIS Toolbox](#) can be used to classify, visualize, and interpret QA bit values.

### Landsat Collection 1 Level-1 QA Band File (BQA.TIF)

The Landsat Collection 1 Level-1 QA band is included in the "Level-1 GeoTIFF Data Product" download option for each result on EarthExplorer. Rigorous science applications seeking to optimize the value of pixels used in a study will find QA bits useful as a first level indicator of certain conditions. The Collection 1 Level-1 QA image can be stretched to emphasize the light and dark pixels for a quick look at general quality conditions. In the image below, the lighter pixels are likely to be affected by a quality condition, in this case, clouds and cloud shadows. The dark areas indicate clear conditions. Although this enables a quick "qualitative" assessment, users are encouraged to use the common pixel values (table below) to interpret the values, or use the [Landsat QA Tools](#) to extract specific QA bits that may impact quantitative image analyses for their particular studies, or use the [Landsat QA ArcGIS Toolbox](#) for visualization and interpretation of QA bit values.



Landsat Collection 1 Level-1 Quality Assessment Band (BQA.TIF) displayed as .jpg for reference only.  
Landsat 5 Thematic Mapper (TM) Path 39 Row 37, acquired April 26, 2012.

The pixel values in the QA file must be translated to 16-bit binary form to be used effectively.

The tables below show the bits currently populated in the Landsat 4-5 TM, Landsat 7 ETM+, and Landsat 8 OLI and OLI/TIRS Collection 1 Level-1 QA bands.

Landsat 4-5 TM, Landsat 7 ETM+ Collection 1 QA band bits: Read from RIGHT to LEFT, starting with Bit 0																
BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Description						Snow/Ice Confidence		Cloud Shadow Confidence		Cloud Confidence		Cloud	Radiometric Saturation		Dropped Pixel	Designated Fill

Landsat 8 OLI, OLI/TIRS Collection 1 QA band bits: Read from RIGHT to LEFT, starting with Bit 0																
BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Description				Cirrus Confidence		Snow/Ice Confidence		Cloud Shadow Confidence		Cloud Confidence		Cloud	Radiometric Saturation		Terrain Occlusion	Designated Fill

For the single bits (0, 1, and 4):

- 0 = "No" = This condition does not exist
- 1 = "Yes" = This condition exists

For radiometric saturation bits (2-3), read from left to right, represent how many bands contain saturation:

- 00 - No bands contain saturation
- 01 - 1-2 bands contain saturation
- 10 - 3-4 bands contain saturation
- 11 - 5 or more bands contain saturation

For the remaining double bits (5-6, 7-8, 9-10, 11-12), read from left to right, represent levels of confidence that a condition exists:

- 00 = "Not Determined" = Algorithm did not determine the status of this condition / "No" = This condition does not exist
- 01 = "Low" = Algorithm has low to no confidence that this condition exists (0-33 percent confidence)
- 10 = "Medium" = Algorithm has medium confidence that this condition exists (34-66 percent confidence)
- 11 = "High" = Algorithm has high confidence that this condition exists (67-100 percent confidence)

All possible pixel values and their meanings are included in the tables below.

### Landsat 4-7 Collection 1 QA Values

Attribute	Pixel Value
Fill	1
Dropped Pixel	2, 674
Clear	672, 676, 680, 684
Radiometric Saturation - 1-2 bands	676, 708, 756, 932, 964, 1700, 1732
Radiometric Saturation - 3-4 bands	680, 712, 760, 936, 968, 1704, 1736
Radiometric Saturation - 5+ bands	684, 716, 764, 940, 972, 1708, 1740
Cloud	752, 756, 760, 764
Cloud Confidence - Low	672, 674, 676, 680, 684, 928, 932, 936, 940, 1696, 1700, 1704, 1708
Cloud Confidence - Medium	704, 708, 712, 716, 960, 964, 968, 972, 1728, 1732, 1736, 1740
Cloud Confidence - High	752, 756, 760, 764
Cloud Shadow - High	928, 932, 936, 940, 960, 964, 968, 972
Snow/Ice - High	1696, 1700, 1704, 1708, 1728, 1732, 1736, 1740

## Landsat 4-7 Collection 1 QA Value Interpretation

This table shows examples from the full list of possible QA values.

This .xls file contains all possible Landsat 4-7 QA values and their descriptions.

Pixel Value	Snow/Ice Confidence	Cloud Shadow Confidence	Cloud Confidence	Cloud	Radiometric Saturation	Dropped Pixel	Fill	Pixel Description
0	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined
1	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Yes	Fill
2	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Yes	No	Dropped pixel
672	Low	Low	Low	No	No	No	No	Clear terrain
674	Low	Low	Low	No	No	Yes	No	Dropped pixel
676	Low	Low	Low	No	1-2 bands	No	No	Clear terrain w/ some saturation
680	Low	Low	Low	No	3-4 bands	No	No	Clear terrain w/ moderate saturation
684	Low	Low	Low	No	5+ bands	No	No	Clear terrain w/ frequent saturation
704	Low	Low	Medium	No	No	No	No	Medium confidence cloud
1696	High	Low	Low	No	No	No	No	Snow/Ice
1700	High	Low	Low	No	1-2 bands	No	No	Snow/Ice w/ some saturation

## Landsat 8 Collection 1 QA Values

Attribute	Pixel Value
Fill	1
Terrain Occlusion	2, 2722
Clear	2720, 2724, 2728, 2732
Radiometric Saturation - 1-2 bands	2724, 2756, 2804, 2980, 3012, 3748, 3780, 6820, 6852, 6900, 7076, 7108, 7844, 7876
Radiometric Saturation - 3-4 bands	2728, 2760, 2808, 2984, 3016, 3752, 3784, 6824, 6856, 6904, 7080, 7112, 7848, 7880
Radiometric Saturation - 5+ bands	2732, 2764, 2812, 2988, 3020, 3756, 3788, 6828, 6860, 6908, 7084, 7116, 7852, 7884
Cloud	2800, 2804, 2808, 2812, 6896, 6900, 6904, 6908
Cloud Confidence - Low	2720, 2722, 2724, 2728, 2732, 2976, 2980, 2984, 2988, 3744, 3748, 3752, 3756, 6816, 6820, 6824, 6828, 7072, 7076, 7080, 7084, 7840, 7844, 7848, 7852
Cloud Confidence - Medium	2752, 2756, 2760, 2764, 3008, 3012, 3016, 3020, 3776, 3780, 3784, 3788, 6848, 6852, 6856, 6860, 7104, 7108, 7112, 7116, 7872, 7876, 7880, 7884
Cloud Confidence - High	2800, 2804, 2808, 2812, 6896, 6900, 6904, 6908
Cloud Shadow - High	2976, 2980, 2984, 2988, 3008, 3012, 3016, 3020, 7072, 7076, 7080, 7084, 7104, 7108, 7112, 7116
Snow/Ice - High	3744, 3748, 3752, 3756, 3776, 3780, 3784, 3788, 7840, 7844, 7848, 7852, 7872, 7876, 7880, 7884
Cirrus Confidence - Low	2720, 2722, 2724, 2728, 2732, 2752, 2756, 2760, 2764, 2800, 2804, 2808, 2812, 2976, 2980, 2984, 2988, 3008, 3012, 3016, 3020, 3744, 3748, 3752, 3756, 3780, 3784, 3788
Cirrus Confidence - High	6816, 6820, 6824, 6828, 6848, 6852, 6856, 6860, 6896, 6900, 6904, 6908, 7072, 7076, 7080, 7084, 7104, 7108, 7112, 7116, 7840, 7844, 7848, 7852, 7872, 7876, 7880, 7884

## Landsat 8 Collection 1 QA Value Interpretation

This table shows examples from the full list of possible QA values.

This [.xls](#) file contains all possible Landsat 8 QA values and their descriptions.

Pixel Value	Cirrus Confidence	Snow/Ice Confidence	Cloud Shadow Confidence	Cloud Confidence	Cloud	Radiometric Saturation	Terrain Occlusion	Fill	Pixel Description
0	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Not determined
1	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Yes	Fill
2	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined	Yes	No	Terrain occlusion
2720	Low	Low	Low	Low	No	No	No	No	Clear terrain
2804	Low	Low	Low	High	Yes	1-2 bands	No	No	High confidence cloud with some saturation
2988	Low	Low	High	Low	No	5+ bands	No	No	Cloud shadow with frequent saturation
3744	Low	High	Low	Low	No	No	No	No	Snow/ice
3748	Low	High	Low	Low	No	1-2 bands	No	No	Snow/ice with some saturation
7072	High	Low	High	Low	No	No	No	No	Cirrus cloud, cloud shadow
7076	High	Low	High	Low	No	1-2 bands	No	No	Cirrus cloud, cloud shadow with some saturation
7116	High	Low	High	Medium	No	5+ bands	No	No	Cirrus cloud, cloud shadow, medium cloud confidence with frequent saturation

For assistance with unpacking the Quality Assessment band, check out the [Landsat QA Tools](#) or the [Landsat QA ArcGIS Toolbox](#).

### Collection 1 LandsatLook 8-bit Quality Image

The Collection 1 [LandsatLook](#) 8-bit Quality Image (.jpg) provides a quick view of the quality of the pixels within the scene to determine if a particular scene would work best for the user's application. LandsatLook Collection 1 Quality images can be downloaded individually from the Download Options for each Landsat Level-1 result using [EarthExplorer \(EE\)](#).

The tables below display the values and colors associated with the Collection 1 LandsatLook 8-bit Quality Images.

Landsat 4-5 TM, Landsat 7 ETM+ Collection 1 LandsatLook 8-bit Quality Image Values								
Description	0	1	2	3	4	5	6	7
	Designated Fill	Dropped Pixel	Radiometric Saturation	Cloud	Cloud Shadow	Snow/Ice	Reserved	Reserved

Landsat 8 OLI, OLI/TIRS Collection 1 LandsatLook 8-bit Quality Image Values								
Description	0	1	2	3	4	5	6	7
	Designated Fill	Terrain Occlusion	Radiometric Saturation	Cloud	Cloud Shadow	Snow/Ice	Cirrus	Reserved