The North Korean Plutonium Stock Mid-2006

By David Albright and Paul Brannan
Institute for Science and International Security (ISIS)
June 26, 2006

This report is the latest in a series by ISIS examining North Korea's plutonium production activity and providing our assessment of its current stocks of separated plutonium. This type of plutonium is weapons usable and provides an indication of the size of North Korea's nuclear arsenal.

North Korea has been accumulating plutonium since 1986. Between 1994 and 2003, North Korea "froze" its plutonium production program under the "Agreed Framework" with the United States. Under this agreement, North Korea shut down its main source of plutonium, the 5 megawatt-electric reactor at the Yongbyon nuclear site, and its nearby plutonium separation plant, the Radiochemical Laboratory (figures 1 and 2). Since the freeze ended, North Korea has been both producing and separating plutonium at Yongbyon.

In total through mid-2006, North Korea has produced an estimated 43 to 61 kilograms of plutonium, of which about 20 to 53 kilograms are in separated form and usable in nuclear weapons. About 80 to almost 100 percent of the separated plutonium were generated since the freeze ended in late 2002 (see table 1).

North Korea's stock of separated plutonium is enough for about 4 to 13 nuclear weapons. Little is known about its ability to make a nuclear weapon, although it is assessed as likely able to build a crude nuclear warhead for its Nodong missile. At this time, there is little evidence to suggest that North Korea is capable of making a nuclear warhead light enough for the Taepodong-2 missile.

Based on commercial satellite images, North Korea does not appear to be making significant progress in finishing its 50 megawatt-electric reactor at Yongbyon (see figure 3). If finished, this reactor could expand North Korea's plutonium production tenfold.

Absent an agreement limiting plutonium production, North Korea is projected by mid-2008 to have as much as 53 to 76 kilograms of plutonium, of which 40 to 68 kilograms could be usable in nuclear weapons (see table 2). The separated plutonium would be sufficient to build between 8 and 17 nuclear weapons.

Plutonium Production Prior to the End of the Freeze

Prior to 2003, North Korea had an estimated stock of roughly 28 to 39 kilograms of plutonium.[1] Almost all of this plutonium was produced in the 5 megawatt-electric reactor and discharged from the reactor in 1994 and perhaps in 1989. The reactor typically

---

[1] For background information on North Korean nuclear facilities and plutonium production, see David Albright and Kevin O'Neill (eds), *Solving the North Korean Nuclear Puzzle* (Washington, DC: ISIS, 2000).

operates on a core of nuclear fuel for a considerable period of time before the reactor is shut down and the irradiated fuel unloaded. International Atomic Energy Agency (IAEA) inspectors witnessed the core being discharged in 1994. However, the IAEA found evidence that another core could have been discharged earlier when inspectors were not permitted to inspect this reactor. North Korea insists that the 1994 discharge involved the reactor's first core and had been in the reactor since it started in 1986.

After the irradiated fuel cools for several months, it can be transported safely to the Radiochemical Laboratory for chemical processing to separate the plutonium. The US intelligence community estimates that North Korea separated up to 10 kilograms of plutonium prior to 1992, although this is a "worst-case" estimate subject to continuing scrutiny and controversy. The worst case estimate was that North Korea separated and did not declare to the IAEA about 8 to 9 kilograms of plutonium produced in the 5 megawatt-electric reactor and discharged in about 1989. Some US intelligence agencies believed that North Korea also separated and did not declare up to another 1 to 2 kilograms of plutonium produced in the Russian-supplied IRT research reactor at Yongbyon and separated in a nearby facility. Other US intelligence agencies believed the amount of plutonium produced in the IRT reactor was no more than a few hundred grams. The IAEA also independently arrived at this smaller estimate. In any case, a reasonable estimate is that no more than 10 kilograms of plutonium were separated prior to 1994, when the Agreed Framework froze all plutonium activities at the Yongbyon site.

In its assessments for this period, the CIA estimated that North Korea had separated 8-9 kilograms of plutonium. In interviews, CIA officials involved in these assessments have stated that there is a better than even chance that North Korea separated this plutonium, although the basis for this specific judgment can be debated.[2] Nonetheless, after taking account of estimated losses, the CIA concluded that this is enough separated plutonium for one or perhaps two nuclear weapons. However, assuming losses of 20 percent, which is reasonable for an initial effort and assumed in Energy Department intelligence assessments, the 8-9 kilograms of plutonium would likely not be enough plutonium for two nuclear weapons, if approximately 4-5 kilograms of plutonium are needed for each weapon.[3]

Until 2003, the bulk of the plutonium produced by North Korea remained in almost 8,000 irradiated fuel rods stored in a pond near the 5 megawatt-electric reactor and subject to monitoring by the IAEA. These rods contained an estimated 27-29 kilograms of plutonium.

Post-Freeze Period

[2] See for example, *Solving the North Korean Nuclear Puzzle*, op. cit.

[3] Two weapons would only be possible in the extreme case, namely a stock of 9 kilograms of plutonium, 4 kilograms per weapon, and 100 percent recycling of scrap from the first weapon. Ten percent losses could be achieved with difficulty, but this case requires a stock of 8.5 kilograms of plutonium, assuming again 100 percent recovery of the scrap produced during the production of the first weapon.

Since restarting the Radiochemical Laboratory in 2003, North Korea is believed to have reprocessed most of the 8,000 irradiated fuel rods discharged from the reactor in 1994. This conclusion is based on North Korean statements to the media and ISIS experts, commercial satellite images, and on information from government officials and experts in the United States, Japan, and South Korea.

North Korea has stated that it has reprocessed all the fuel rods, but this statement has not been independently verified. Nonetheless, a reasonable conclusion is that North Korea has separated a significant amount of plutonium from these rods—between 20 and 28 kilograms. The lower bound reflects confidence that at least most of rods have been reprocessed and the amount separated is highly unlikely to be lower than this value. The upper bound is the amount that would result if all the rods have been reprocessed with only small losses of plutonium during the entire process.

The 5 megawatt-electric reactor is estimated to produce about 5-7 kilograms of plutonium each year. Unclassified reports, confirmed by commercial satellite imagery, indicate that North Korea shut down the reactor in April 2005, likely to unload the fuel (see figure 4). At this time, the reactor's core was estimated to have contained 10-15 kilograms of plutonium.

North Korea is believed to have begun reprocessing the fuel that would have been unloaded from the 5 megawatt reactor in 2005. By mid-2006, it could have finished reprocessing all this fuel, although there is no confirmation of such an act. Our assessment, therefore, is that between 0 and 15 kilograms of this plutonium could have been separated by mid-2006.

In August 2005, Japanese media reported that US satellites had detected a plume at the 5 megawatt-electric reactor, indicating that operations had resumed. A September 2005 commercial satellite image shows a steam plume, confirming that the reactor was operating again. Subsequent satellite images confirm continued, although not continuous, operation of the reactor. From mid-2005 to mid-2006, the reactor could have produced another 5-7 kilograms of plutonium. This plutonium likely remains in the reactor core.

As of mid-2006, North Korea is estimated to have produced in total 43 to 61 kilograms of plutonium, of which 20 to 53 kilograms have been separated and are usable in nuclear weapons. The separated plutonium is sufficient to build between 4 and 13 nuclear weapons.

Absent an agreement to limit North Korea's nuclear weapons program, the 5 megawatt-electric reactor can be expected to continue to produce plutonium. Table 2 outlines a "high-side" projection of plutonium production and separation as of the summer of 2008, where the rate of plutonium production and separation is assumed to remain consistent with current estimated rates. As of mid-2008, North Korea is projected to produce in total 53 to 76 kilograms of plutonium, of which 40 to 68 kilograms are projected to be separated and usable in nuclear weapons. The separated plutonium is sufficient to build between 8 and 17 nuclear weapons.

Construction of the 50 Megawatt-Electric Reactor

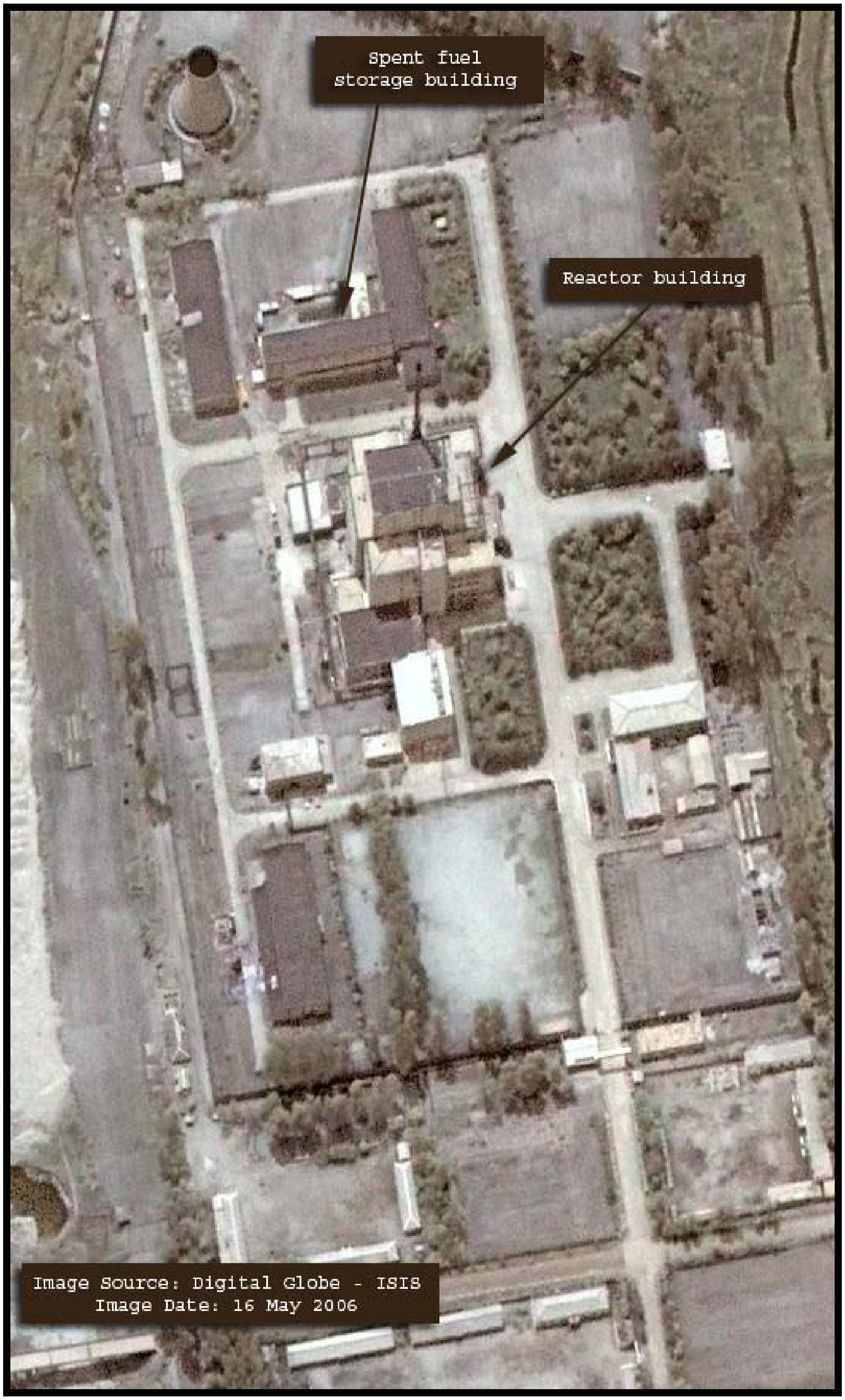
North Korean officials stated in the first half of 2005 that construction of the 50 megawatt-electric reactor had resumed. As of early June 2005, commercial satellite imagery did not show significant construction activity; in August 2005 media reports state that a mobile crane was moved to the site.[4] Additional reports stated that new gravel was seen along the road at the same site. Commercial satellite images from September 2005 confirmed these activities. A satellite image from May 2006 does not appear to show any substantial construction activity. In addition, the mobile crane, first identified in the September 2005 image, remains in the same location in the May 2006 image (see figure 5).

Because of the long period of inactivity at this reactor site, and the effect of the weather on the unfinished reactor, the completion of this reactor would likely take several years. If finished, the 50 megawatt-electric reactor could produce enough plutonium annually for roughly ten nuclear weapons.

---

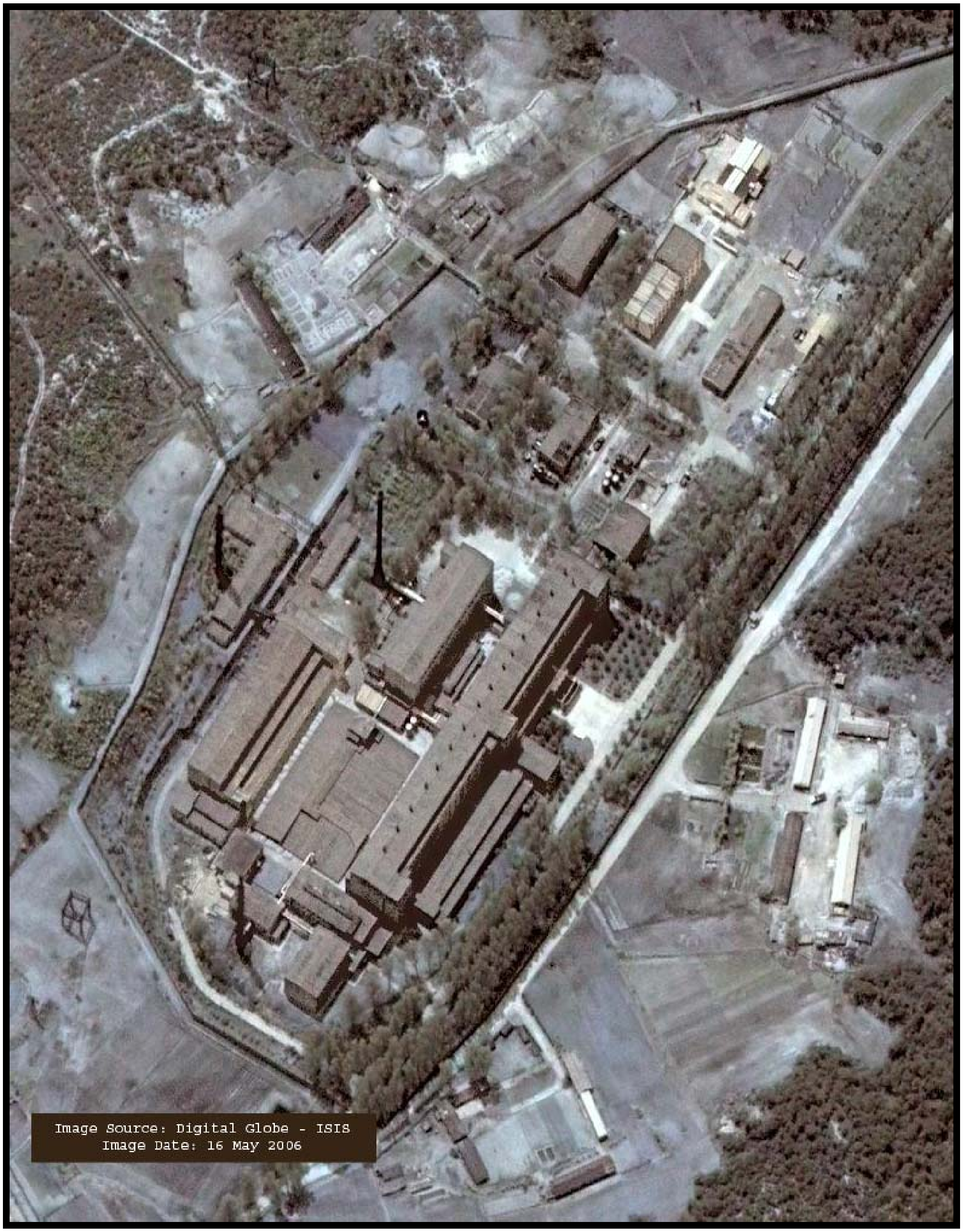
[4] Nobuyoshi Sakajire, "North Korea Brings in Crane Vehicle in Nuclear Construction Site Probably Six Party Talks in Mind," Asahi Shimbun, July 19, 2005, morning edition. Translation by FBIS.

Figure 1



5 MWe reactor at Yongbyon.

Figure 2



Radiochemical Laboratory at Yongbyon. Note the demolished corner near the bottom of the image in a facility whose purpose is unknown. The "canyon" where reprocessing occurs is a long, multistory building on the right

Figure 3

50 MWe reactor at Yongbyon.

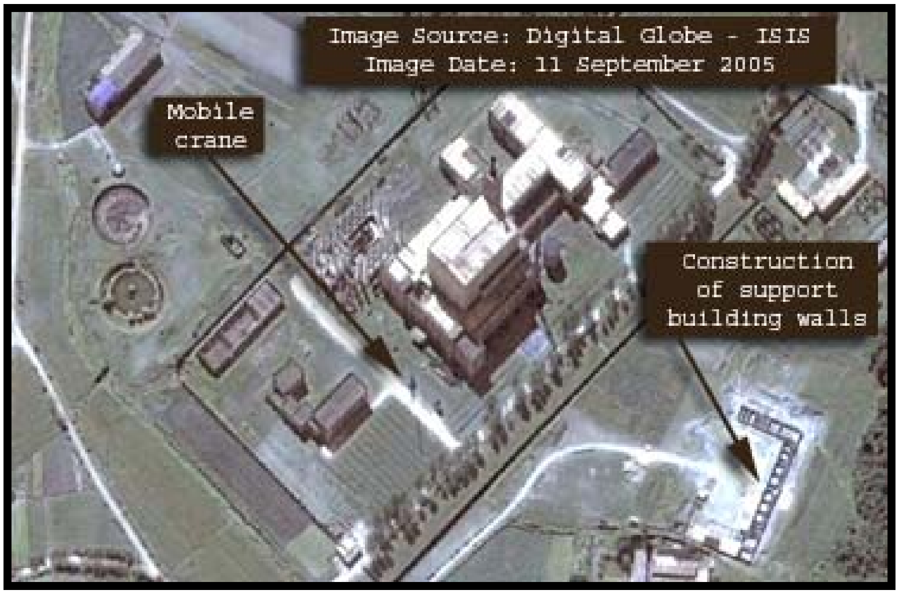
Figure 4

7 January 2005 **7 April 2005** **10 June 2005**

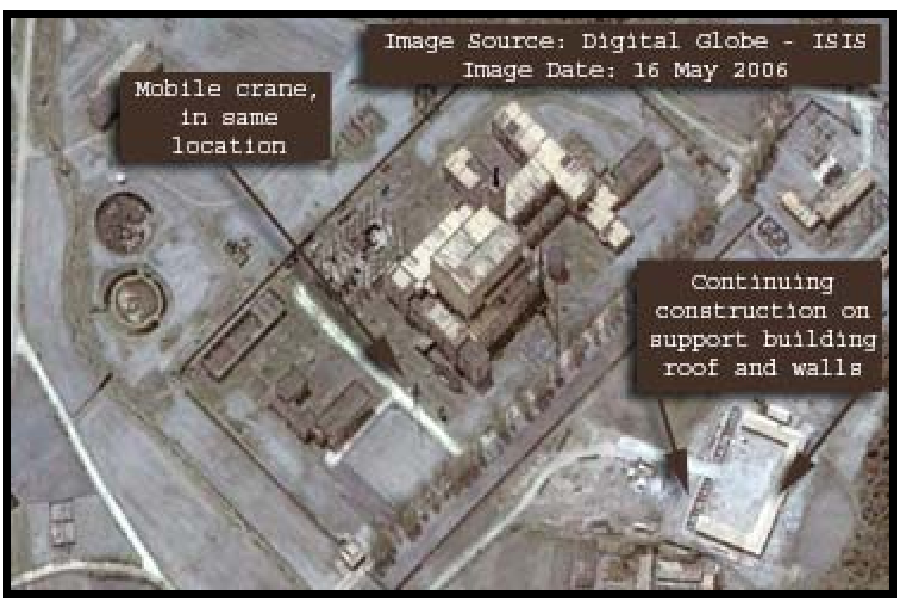
11 September 2005 **5 January 2006** **16 May 2006**

A composite series of images showing the cooling tower at the 5 MWe reactor. A plume is visible in January 2005 and is not visible in the images from April and June 2005. A plume is visible in September 2005 and January 2006. In the most recent image, from May 16, 2006, a plume is not visible above the cooling tower.

Figure 5



September 11, 2005



May 16, 2006

A comparison of September 2005 and May 2006 images of the 50 MWe reactor at Yongbyon. Continuing construction is evident at a support building adjacent to the 50 MWe reactor facility. Within the compound housing the industrial buildings, however, there does not appear to be any substantial construction activity. A mobile crane, first identified in the September 2005 image, remains in the same location in May 2006.

Table North Korean Plutonium Production and Separation, as of mid-2006

Plutonium Discharged From 5 MWe Reactor		Plutonium Separation		Weapon Equivalents*
Date	**Amount (kg)**	**Date**	**Amount (kg)**	**(number)**
Before 1990	1-10**	1989-1992	0-10	0-2
1994	27-29	2003-2004	20-28	4-7
Spring 2005?	0-15	2005-2006	0-15	0-3
In core of 5 MWe reactor	5-7	--	--	--
Total	**43-61**		**20-53**	**4-13*** **

Comments

* It is assumed that each nuclear weapon would require 4-5 kilograms of separated plutonium.

** This quantity includes up to 1-2 kilograms of plutonium produced in the IRT reactor prior to 1994, see text. Since then, this reactor has barely operated.

*** The upper bound of the number of weapons is higher than the sum of the individual upper bounds, because particular periods list more plutonium than needed to give the upper bound for that period.

Table 2 North Korean Plutonium Production and Separation, "High Side" Projection as of Mid-2008

Plutonium Discharged From 5MWe Reactor		Plutonium Separation		Weapon Equivalents*
Date	**Amount (kg)**	**Date**	**Amount (kg)**	**(number)**
Before 1990	1-10**	1989-1992	0-10	0-2
1994	27-29	2003-2004	20-28	4-7
Spring 2005	10-15	2005-2006	10-15	2-3
Summer 2007	10-15	2007-2008	10-15	2-3
In core summer 2008	5-7	--	--	--
Total	**53-76**		**40-68**	**8-17*** **

Comments

* It is assumed that each nuclear weapon would require 4-5 kilograms of separated plutonium.

** This quantity includes up to 1-2 kilograms of plutonium produced in the IRT reactor prior to 1994, see text. Since then, this reactor has barely operated.

*** The upper bound of the number of weapons is higher than the sum of the individual upper bounds, because particular periods list more plutonium than needed to give the upper bound for that period.