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The concept of connect Karczew to the railway network

Abstract: The article concerns railway network extension towards Karczew town in aspect of a railway connection to Warsaw. The first part presents how the public transport in Karczew has functioned over the years and current bus service is also described. Then functional variants of new railway line are described. In the article each proposed variant of the line is presented. The possibilities and threats related to the implementation of the concept are analyzed. In the summary the direction of further study works was indicated.

Keywords: Railway transport; Urban rapid rail; Karczew

Characteristics of Current Bus Services

Karczew, with a population of approximately 10,000 residents (9,670 as of December 31, 2021), is the southernmost town in the eastern, right-bank part of the Warsaw metropolitan area, belonging to the Otwock County. It borders the towns of Otwock and Józefów to the north, rural areas to the south, the Vistula River to the west, and the Mazovian Landscape Park to the east. The urban fabric of Karczew and Otwock is gradually merging, creating a residential area with a combined population of about 54,000. Including Józefów, this area totals around 75,000 residents.

The main transportation route passing through Karczew's outskirts is Provincial Road No. 801, connecting Warsaw and Puławy. Another important route is Mickiewicz Street (a municipal road), historically the main road leading from Karczew to Otwock and Warsaw. Despite its proximity to the Vistula River, Karczew lacks a direct river crossing to the left-bank part of the metropolitan area; the nearest bridges require a 10-15 km detour, depending on the route. There is no railway line running through Karczew; the nearest line (No. 7) is about 3.5 km from the town center. Consequently, Karczew is situated off the main transport routes, with public transportation connections limited mainly to Otwock and the southern parts of Otwock County.

Development and Decline of Karczew's Rail and Bus Connections to Warsaw

In 1914, a narrow-gauge railway line from Wawer Narrow-Gauge Station to Karczew was opened as an extension of the Jabłonna – Warsaw Most – Warsaw Wawer railway. Trains from Karczew initially operated to Warsaw Most Station, with 8 daily round trips in the winter 1919 schedule, growing to 16 by 1933/34. The journey to Warsaw Most took about 1.5 hours. The last schedule featuring direct narrow-gauge service to Warsaw was in 1952, with 13 round trips. After July 1952, service was limited to the Karczew-Otwock segment, providing connections to standard-gauge trains in Otwock. This short line (less than 4 km) had up to 24 daily round trips before being discontinued in 1963 and replaced by bus services.

At its peak, the state-owned PKS bus system offered up to 145 daily round trips between Karczew and Otwock. However, these buses did not provide direct service to Warsaw, terminating near Otwock Railway Station instead. In the 1990s, private operators emerged, offering frequent and direct bus routes from Karczew to Warsaw, as PKS services declined. The Karczew-based company Mini-Bus monopolized local transport, operating up to 140 daily connections on three routes, with buses running every 7.5 minutes during peak hours and every 15-20 minutes at other times. Mini-Bus effectively served as Karczew's and Otwock's municipal transport, rendering additional public bus services unnecessary.

The launch of the Warsaw Commuter Rail (SKM) line from Pruszków to Otwock in September 2010 significantly improved rail connections for Otwock and Józefów residents. The SKM's integration into the Warsaw Public Transport tariff attracted passengers from private bus lines, leading to a decline in profitability for private operators. By 2018, only 4 Mini-Bus trips operated during peak hours, dropping to 2-3 in 2019.

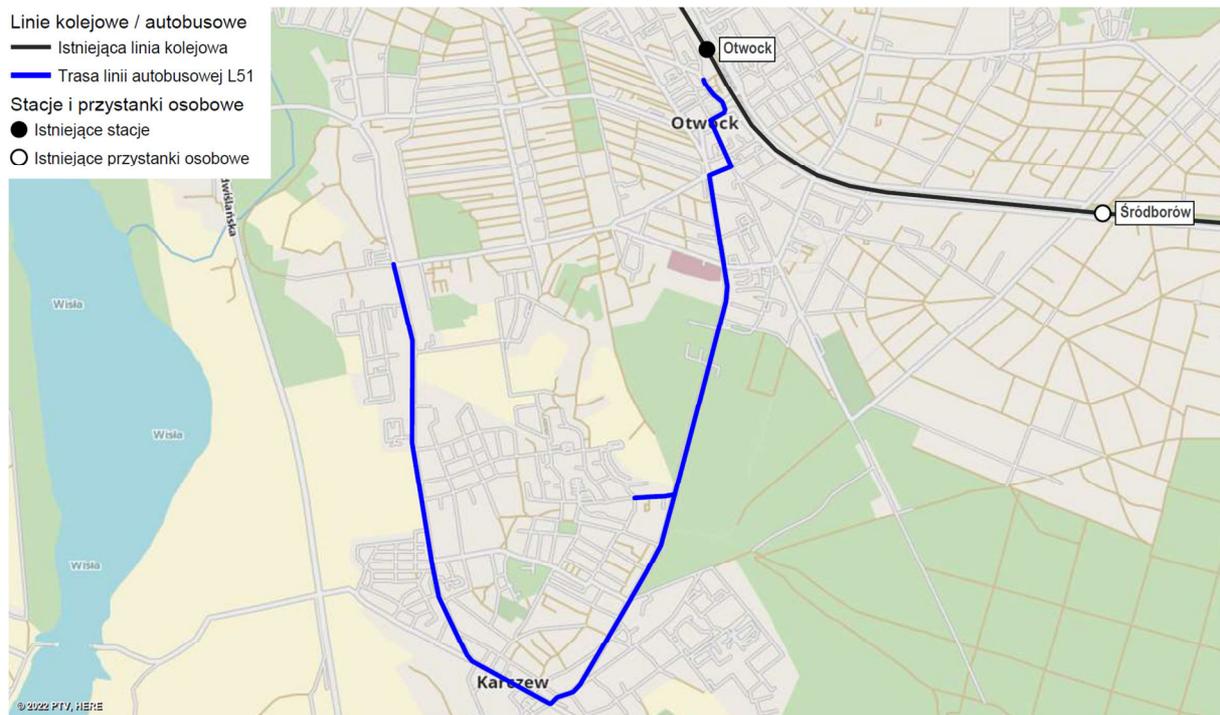
From September 2018 to March 2020, the Warsaw Public Transport Authority (ZTM) operated the L46 line, connecting the Ługi neighborhood in Otwock with the PKP station via Karczew. However, its infrequent schedule (hourly on weekdays) and limited appeal led to low ridership. The COVID-19 pandemic and resulting restrictions further disrupted passenger services. By July 1, 2022, all direct bus services from Karczew to Warsaw were suspended, leaving the town reliant on new transport solutions. In response, a shuttle line to Otwock was introduced on May 1, 2022.

Characteristics of Current Bus Services

As of November 2, 2022, there were no direct bus connections between Karczew and Warsaw. Transport from Karczew to Otwock is provided by:

1. **Line L51:** Operated by ZTM under an agreement with Karczew and Otwock municipalities. This line begins in southwest Otwock, loops around Karczew, and terminates near Otwock PKP Station. On weekdays, there are 30 daily trips (every 30 minutes during peak hours and hourly otherwise). On Saturdays, there are 17 trips (hourly service), and on Sundays/holidays, 12 trips (every 90 minutes). Partial integration with Warsaw Public Transport tariffs applies, but short-term tickets (e.g., 90-minute tickets) do not cover transfers from L51 to SKM trains in Otwock.
2. **Line O1:** A county-operated line (by UTJ Wołoszka) running 9 daily trips on weekdays. Its separate fare system and uncoordinated schedule with L51 limit its effectiveness as a complementary service for commuters traveling from Karczew to Otwock and onward to Warsaw.

In summary, Karczew's current public transport system is primarily oriented toward local connectivity, with limited options for direct or seamless travel to Warsaw.



1. L51 bus route

Origin of the Concept

Based on the information provided, the primary factor contributing to the gradual reduction of bus transportation's role between Otwock and Warsaw was the increased accessibility of commuter rail services, achieved through the introduction of sufficient train frequencies and expanded fare integration. Trains operated by SKM Warszawa and Koleje Mazowieckie provide a convenient and significantly faster alternative to buses for reaching the center of Warsaw. This creates opportunities for further system development, extending its reach to towns currently not served by rail.

Similar conclusions were drawn in 2019 by employees of the PKP PLK S.A. Strategy Office in the **Warsaw Rail Node Master Plan (WWK)** [3], which outlined development directions for the Warsaw Rail Node. The document identified the construction of railway lines between Otwock and Karczew, as well as between Konstancin-Jeziorna and Karczew, along with the modernization of line No. 937 (Warsaw Okęcie – Konstancin-Jeziorna), as potential investments. However, this idea was not detailed further, and if preliminary design work was conducted, its results have not yet been made public. This article can therefore be viewed as a continuation of the ideas developed by PKP PLK S.A. planners.

In the short term, the complete discontinuation of direct bus services between Warsaw and Karczew (as described earlier) underscored the need for reliable public transportation on this route. The current shuttle service is not without flaws—requiring transfers prolongs travel times and creates challenges during railway disruptions, reducing the attractiveness of public transportation. Establishing a direct bus line between Karczew and Warsaw that duplicates the railway route between Otwock and Warsaw would be economically inefficient due to the parallel funding of competing services. Therefore, in the long term, solutions must be sought to sustainably ensure efficient connections between Warsaw and Karczew.

Considering these factors, the authors of this article attempted to develop a concept for a new railway line between Otwock and Karczew and to define its functional variants.

Functional Concept for a Railway Connection to Karczew

The proposed railway line to Karczew would branch off from railway line No. 7 between Otwock Station and the Śródborów stop. The assumptions underlying the functional variants of the new line serving Karczew include the following key factors:

- Whether the Karczew station should be a terminal station or a through station allowing for further extension of the line westward.
- The categories of trains that could operate on the line.
- The anticipated traffic volume for each category of train.
- The basic parameters of the line (e.g., number of tracks, maximum speed).
- The required functionality of the station in Karczew.
- The method of branching the line in Otwock.

All variants assume the construction of an electrified line to maintain compatibility with the technical parameters and operational standards of railway services in the Warsaw metropolitan area.

The station in Karczew could be designed as either a terminal station or an intermediate through station. In the former case, the railway line would end in Karczew, while the latter option would allow for future extensions westward or southward. According to the **Warsaw Rail Node Master Plan** developed in 2019 by PKP Polskie Linie Kolejowe S.A., one of the proposed development directions includes the construction of a new railway connection Otwock – Karczew – Konstancin Jeziorna. The final location of the Karczew station within the railway network will determine how the town is served by the rail system.

The primary category of trains for the line would be commuter trains (SKM) and regional trains, operated by electric multiple units. The potential inclusion of long-distance trains (in the case of through station variants) remains an open question. Long-distance services could be handled by locomotive-hauled trains. Once train categories are determined, traffic volumes for each category and possible service patterns should be projected. These considerations will depend on the ultimate network layout planned for the area.

The above criteria will define the basic technical parameters of the railway line and the functional requirements of the Karczew station. An additional consideration is how the new line will connect to the existing line No. 7 in Otwock, including whether the connection should be grade-separated or at-grade, as well as the signaling and operational aspects. Based on these criteria, three functional variants for the railway line have been proposed, as outlined in **Table 1**.

Tab. 1. Functional Variants of the Railway Line to Karczew

(Note: The table content would list the details of the three proposed variants, such as their respective routing, technical specifications, and operational characteristics.)

Wariant		W1	W1+	W2
Stacja Karczew		Czołowa, koniec linii w Karczewie	Czołowa, koniec linii w Karczewie	Przechodnia, możliwość przedłużenia linii
Kategorie pociągów		Aglomeracyjny	Aglomeracyjny, regionalny	Aglomeracyjny, regionalny, międzyregionalny
Natężenie ruchu w dobie (w godzinie szczytu)	AGLO	40 (2) par poc.	40 (2) par poc.	40 (2) par poc.
	REG	brak	20 (2) par poc.	40 (2) par poc.
	MR	brak	brak	20 (1) par poc.
	TOW	brak	brak	sporadycznie

Maks. Długość pociągów	200m	200m	400m
Liczba torów	1	2	2
Kategoria linii (*)	P80	P80	M120
Wyprowadzenie z linii nr 7	kolizyjne	kolizyjne	Kolizyjne lub bezkolizyjne
(*) Wg standardów technicznych PKP PLK S.A. [7]			

Option 1 involves the construction of a single-track, dead-end railway line, operated by extended trains from Otwock along the Szybka Kolej Miejska (Fast Urban Railway) S1 line.

Option 1+ additionally anticipates the possibility of the line being served by some regional Koleje Mazowieckie (Mazovian Railways) trains that currently terminate in Otwock, likely necessitating the construction of two tracks.

Option 2 envisions the construction of a double-track line with a through station in Karczew, serviced not only by passenger trains but also by express trains, with the potential for extension, for instance, via a new bridge over the Vistula River toward Konstancin-Jeziorna.

As part of a preliminary technical feasibility assessment of the above options, draft routing was prepared in AutoCAD LT based on publicly available data. Additionally, a site inspection was conducted on September 2, 2022. As a result of these activities, five technical options for the line were ultimately proposed.

Technical Feasibility of the Otwock–Karczew Railway Line

Based on the site inspection and the assumptions adopted in the functional concept of the Otwock–Karczew railway connection, five routing options were developed. These include four options in the P80 standard (for urban or urban and regional passenger traffic) and one option in the M120 standard (for urban, regional, and interregional passenger traffic, with the possibility of light freight traffic). The options are described in the following paragraphs.

In **Option W1a**, the Otwock–Karczew railway line is designed as a single-track line in the P80 standard. The starting point is planned around kilometer 29.0 of railway line No. 7, just beyond the curve as the line exits Otwock station toward Pilawa. Integration with the existing track system is designed as a grade-separated solution, using three Rz-60E1-1:12-500 turnouts (for crossover and junction connections) allowing reverse travel at a speed of 60 km/h, and one Rz-49E1-1:9-190 turnout (for protective connection), which should be located within the signaling area of Otwock station.

From the branching point (see: Photograph 2), the planned line follows a curve with a 300-meter radius (see: Diagram 3), which allows it to safely bypass existing buildings (see: Photograph 4) and cross Poniatowskiego Street (see: Photograph 5) near Primary School No. 2 named after Irena Sendler in Otwock. In this area, there is a possibility of building the Otwock–Soplicowo passenger stop (200-meter platform).



2. The place of departure from railway line No. 7 and the intersection of Armii Krajowej Street in Otwock, view towards Otwock station.



3. Geometric layout of the railway line in the plan on the section to the Otwock – Sopicowo stop (variant W1a)



4. The building is located to the right of the proposed line, view towards Karczew



5. The intersection of Poniatowskiego Street in Otwock, view towards the Otwock station

The new line continues to the southwest, and after crossing Narutowicza Street, it runs parallel to it along the border of the Mazovian Landscape Park. Beyond the intersection with Andriollego Street, the line is designed to follow the Struga Pogorzelska canal (a forest clearing) and then proceeds toward the intersection of Mickiewicza and Piłsudskiego Streets in Karczew, near the Ługi housing estate. The proposed terminal station, **Karczew**, is designed as a double-track dead-end station with a two-edge 200-meter platform and an RZ-60E1-1:12-500 turnout (allowing reverse-direction speeds of up to 60 km/h). The station is planned along the alignment of the former narrow-gauge railway, with its front positioned at the intersection of Mickiewicza Street and Czerwona Droga.

In **Option W1a+**, the Otwock–Karczew railway line is designed as a double-track line in the P80 standard, following a route similar to that of Option W1a (the only difference being the section from Andriollego Street to Karczew station, due to the increased length of the station head in Karczew). Integration with the existing track system is designed as a grade-separated solution, using four Rz-60E1-1:12-500 turnouts (for crossover and junction connections). The **Otwock Sopicowo** passenger stop is designed with two single-edge platforms, each 200 meters long, in an alternating arrangement to minimize road crossing closure times.

The terminal **Karczew railway station** is designed as a three-track dead-end station (see Diagram 7) with one single-edge platform and one two-edge platform (both 200 meters long), positioned at the intersection of Mickiewicza Street and Czerwona Droga. The station head layout includes five Rz-60E1-1:12-500 turnouts and a St-60E1-1:4.444 track crossing. The alignments of the line in Options W1a and W1a+ are shown in Diagram 6.



6. Diagram of the proposed railway line to Karczew in variants W1a (single-track line) and W1a+ (double-track line)



7. The location and geometric layout of the Karczew station in variant W1a+

A second variant of the single-track line, **W1b**, was also proposed, along with its corresponding double-track variant, **W1b+** (see Diagram 8). In **Variant W1b**, the Otwock–Karczew railway line is designed as a single-track line in the P80 standard. Up to the area near the intersection of Narutowicza and Andriollego Streets, its alignment is identical to that of Variant W1a. From this point, the railway is routed slightly farther north compared to W1a, so that the track axis approaches Mickiewicz Street at the intersection with Bema Street. Near this intersection, the location of an additional passenger stop, **Otwock Ługi**, with a 200-meter platform, has been proposed. The locations and configurations of the **Otwock Sopicowo** passenger stop and the **Karczew terminal station** remain the same as in Variant W1a.

The alignment of **Variant W1b+** matches that of W1b. The differences lie in the configuration of the **Karczew station** and the **Otwock Ługi passenger stop**. The station is designed as a three-track terminal station in a dead-end layout, with one single-edge platform and one two-edge platform (both 200 meters long), located at the intersection of Mickiewicz Street and Czerwona Droga. The station head is configured using four Rz-60E1-1:12-500 turnouts, a St-60E1-1:4.444 track crossing, and one single-sided curved turnout derived from a standard Rz-60E1-1:12-500 turnout.

At the **Otwock Ługi** stop, two 200-meter platforms are planned, both single-edge. One of these platforms is located in the middle of the tracks of the main line.



8. Diagram of the proposed railway line to Karczew in variant W1b

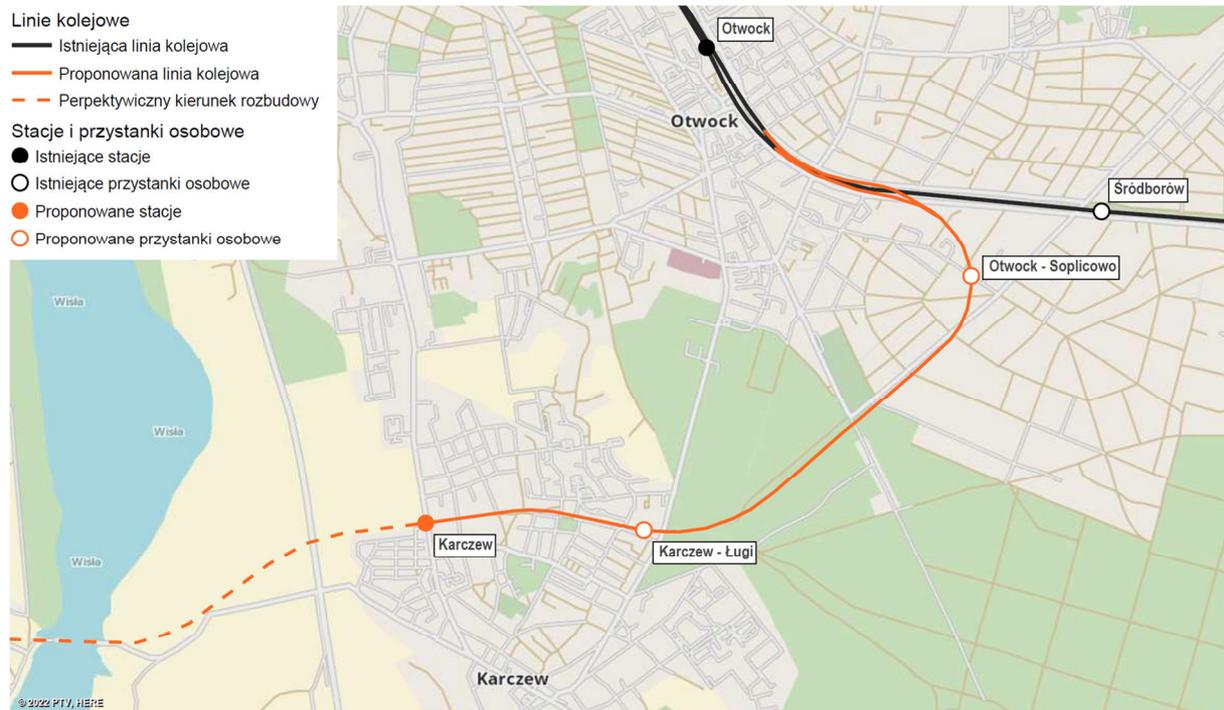
In **Variant W2** (Diagram 9), the Otwock–Karczew railway line is designed as a double-track line in the **M120 standard**. Its integration with the existing railway line No. 7 is planned as either a grade-separated or at-grade connection. A grade-separated connection would require more significant alterations to the existing track layout at Otwock station but would allow the new line to be routed with a more favorable geometric layout (a curve with a radius of approximately 500 m). If the economic viability of this solution is ruled out, an at-grade connection similar to those in Variants W1a+ and W1b+ is possible, assuming entry and exit to/from Otwock station occur at lower speeds than required for the M120 standard.

At the crossing of the proposed railway line with Poniatowskiego Street near Primary School No. 2 named after Irena Sendler in Otwock, the construction of the **Otwock Sopicowo** passenger stop for urban traffic is planned (with alternating platforms, each 200 meters long). The new line then continues southwestward and, after crossing Narutowicza Street, runs parallel to it along the border of the Mazovian Landscape Park. Beyond the intersection with Andriollego Street, the line is designed along the Struga Pogorzelska canal (a forest clearing) and then proceeds toward the strip of land between Piłsudskiego Street and the Ługi housing estate.

At the intersection with Mickiewicza Street, the construction of the **Karczew Ługi** passenger stop for urban traffic is proposed. This stop will feature alternating platforms, each 200 meters long, providing convenient transfers between buses traveling from Karczew's center and trains toward Otwock and vice versa. Further routing of the line utilizes the aforementioned strip of land south of the Ługi estate (see Photo 10), aligning the track axis near Piłsudskiego Street to minimize disruption to recreational spaces.

Near Popiełuszki Street, the eastern head of the **Karczew station** is proposed to begin (see Diagram 11). This station is designed to handle inter-urban, urban, and light freight traffic. It is planned as a through station with four tracks, each with a minimum usable length of 750 meters, and two double-edge platforms, each 400 meters long. Both station heads are designed with four Rz-60E1-1:12-500 turnouts, while the safety of the main tracks is ensured by four protective tracks connected via Rz-60E1-1:9-190 turnouts.

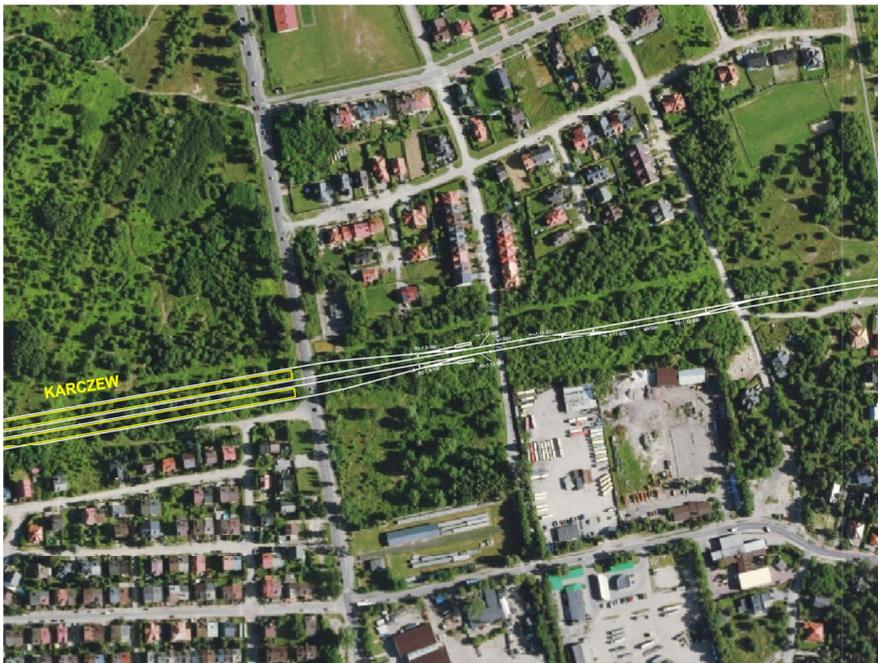
The location and track layout of the station were chosen to minimize the inconvenience of potential train stops, including freight trains, for nearby residents, with much of the station located outside densely built-up areas. Additionally, the availability of land to the north of the station and west of Wyszyńskiego Street allows for the possible placement of station infrastructure in that area.



9. Diagram of the proposed railway line to Karczew in variant W2



10. A strip of land in Karczew adjacent to the Ługi housing estate (at the height of Andersa Street), view towards the Karczew station



11. The location and geometric layout of the Karczew station in variant W2

The designed track layout takes into account the future extension of the railway line toward **Konstancin-Jeziorna** (including the construction of a rail-road bridge over the Vistula River in the area of the current ferry crossing), aligning with the concepts presented in the previously mentioned **Master Plan for the Warsaw Railway Node** [3]. Until the line is extended, it would terminate at **Karczew station**.

If the decision is made to abandon the construction of the connection toward Konstancin-Jeziorna, the line, as designed in Variant W2, would still be fully functional for ensuring the **Karczew–Otwock–Warsaw** connection.

Opportunities and Threats of Implementing the Concept

Like any investment in new linear transport infrastructure, the construction of the Otwock–Karczew railway line would involve significant intervention in the surrounding environment. Although the site inspection confirmed the possibility of routing the new line with minimal impact on existing buildings (not addressing the issue of land ownership at this stage), the main threat to the proposed design concept lies in routing the line through forested areas between Otwock and Karczew (requiring tree clearance), partly along the boundary of the Mazovian Landscape Park. Moreover, particularly in **Variant W2**, protests from residents of nearby neighborhoods are highly likely: multi-family housing to the north of the proposed alignment and single-family housing to the south. In contrast, **Variants W1** appear to be neutral in this regard.

An opportunity lies in significantly improving commuting conditions from Karczew to Warsaw, reducing road traffic as a result. Additionally, in **Variant W2**, the concept aligns with the design proposals found in existing planning documents.

Analyzing the proposed variants in terms of access to railway transport shows substantial differences. In **Variants W1a** and **W1a+**, the Karczew station, located on the outskirts of the town, would be 800–1600 meters away from the Ługi multi-family housing estate, the main traffic generator, and would not effectively serve the western part of the town. On the other hand, the terminal station would be adjacent to the industrial zone and about 1 km from the center of Karczew (measured from Zygmunt Stary Square). **Variant W1b** proposes bringing the Ługi estate about 500 meters closer to the railway via an additional **Otwock–Ługi** stop (essentially located on the border between Otwock and Karczew).

The most advantageous option for serving the Ługi estate (ignoring potential protests from some residents against having a railway "under their windows") is **Variant W2**, with the **Karczew–Ługi** stop providing direct service. Furthermore, in this variant, the Karczew station would directly serve the dense single-family housing in this part of the town, unlike **Variants W1a, W1a+, and W1b**. The distance from the town center (to both Karczew station and Karczew–Ługi stop) would be 1.2 km, only 200 meters longer than in the W1 variants. Assuming a forest path (used daily for recreational purposes) is used, access to the industrial zone would not worsen under **Variant W2**.

From a railway network functionality perspective, **Variants W1a, W1a+, and W1b** do not allow for extending the line westward or southward. In contrast, **Variant W2** enables further extension and connection to the railway network from the other side, such as through **Konstancin-Jeziorna, Nowa Iwiczna**, and onward to Warsaw. This extension could facilitate a bidirectional SKM circular line on the route **Warsaw–Otwock–Karczew–Konstancin-Jeziorna–Nowa Iwiczna–Warsaw**.

From an environmental perspective, all variants route the line along the boundary of the Mazovian Landscape Park (parallel to the existing Narutowicza Street) and, with slight alignment differences, cross forested areas between Otwock and Karczew. It is worth noting that not long ago, the construction of a road along a route similar to **Variant W2** was considered [9]. If the line is extended westward (Variant W2) with the construction of a bridge over the Vistula River, it would conflict with the southern edge of the Świderskie Islands Reserve. However, the proposed bridge site currently operates a vehicle-passenger ferry during spring and autumn. Furthermore, by shifting the route alignment slightly southward, it may be possible to entirely bypass the reserve.

The construction of a new line also presents an opportunity to enhance freight transport accessibility. The proposed track layouts can incorporate a siding to the industrial zone in Karczew. Local conditions, particularly in **Variant W2**, are favorable for such a solution.

Summary

This article presents an initial vision of the alignment and technical-operational parameters of the new Otwock–Karczew railway line in several variants. Of course, this is only the beginning of further analyses, and it is challenging at this stage to determine which solution is most advantageous. However, it can be stated that **Variant W2** offers the broadest functionality, providing direct railway transport service to the largest part of Karczew while leaving the possibility of extending the line in the future. Naturally, due to its extensive scope of work (the route is 1.0–1.5 km longer than in other variants, and it is a double-track line), it would also be the most expensive to implement. Therefore, if the possibility of extending the line westward seems very distant, costs could be reduced by scaling down the Karczew station and abandoning a grade-separated connection from railway line No. 7 in Otwock. Another way to lower costs would be to abandon the second main track, although this would be undesirable due to the flexible scheduling it allows for the Karczew–Otwock–Warsaw route.

The justification for the entire investment and its desired scope should be determined by more detailed studies, including traffic forecasts and cost-benefit analyses that consider various economic, financial, and environmental factors. Simultaneously, to verify the proposed track layout, appropriate railway traffic simulations should be performed using specialized software.

Implementing the concept would provide a direct and the fastest possible public transport connection between Karczew and Warsaw. Choosing **Variant W2** would also open new possibilities for shaping the SKM network within the Warsaw agglomeration, enabling travel along new routes, including in the southern part of the agglomeration, where the Vistula currently acts as a barrier due to the lack of a bridge crossing between the Southern Bridge (Anna Jagiellon Bridge on the S2 road) and the Nadwiślański Urzecze Bridge (on Route 50 near Góra Kalwaria).

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