Technical Analysis of Frequency, Receiver Sensitivity and Site Suitability for Amateur Radio VHF Repeater Deployment

Syamsul Bahri Mohamad[1*], Shahidzwan A. Rahim[1], Azmi Ali[2], and Mohd Nor Zamani Abdul Afri[3]

[1]Department of Electrical Engineering, Politeknik Merlimau Melaka, KM 2.5, Jalan Merlimau-Jasin, 77300 Merlimau, Melaka, Malaysia.

[2]Muar Amateur Radio Society, Jalan Sulaiman, 84000 Muar, Johor, Malaysia.

[3]CTS Energy Resources (M) Sdn Bhd, No. 122-1, Jalan TU 2, Taman Tasik Utama, 75450 Ayer Keroh, Melaka, Malaysia.

[*]Corresponding Author's Email: syamsulbahri@pmm.edu.my

Article History: Received 12 April 2026; Revised 23 June 2026; Accepted 24 June 2026; Published 30 June 2026

Abstract

Reliable local radio communication requires compatible frequency allocation, sufficient receiver sensitivity, and a suitable repeater installation site. However, the deployment of a VHF amateur radio repeater requires systematic evaluation of spectral compatibility and link feasibility to minimise interference and ensure satisfactory communication coverage. This study evaluates the technical feasibility of a proposed stand-alone local VHF amateur radio repeater at Wisma Daim, Bandar Maharani, Muar, Johor, Malaysia. The deployment is intended to improve local communication reliability, but its proposed channel, predicted coverage, receiver performance and rooftop configuration require an integrated assessment before regulatory application and installation. The system uses MCMC channel RV87, comprising 146.900 MHz downlink and 146.300 MHz uplink, a −0.600 MHz offset, and a 203.5 Hz continuous tone-coded squelch system (CTCSS). A five-phase assessment covering system baseline definition, spectral-clearance and QRM screening, FSPL and P.1546-referenced suburban coverage estimation, receiver-sensitivity benchmarking, and a weighted site-suitability evaluation was conducted. The proposed channel had a minimum separation of 75 kHz from the closest identified VHF channel with no channel conflict in the study dataset. The author-defined 52 dBμV/m planning threshold was reached at approximately 29.1 km by the suburban planning curve. At 146.900 MHz, this field strength corresponds to approximately −68.5 dBm for a 0 dBi receiving antenna, producing a 52.5 dB reference-threshold-to-sensitivity headroom relative to the Baofeng UV-5RE specification of approximately −121 dBm at 12 dB SINAD. The site achieved a suitability score of 8/10 (80%), which indicates that the Wisma Daim site is suitable for the preliminary planning stage. These findings support proceeding to formal frequency coordination and controlled installation, subject to spectrum monitoring, TX/RX isolation testing, SINAD measurements and a post-installation drive test.

Keywords: Amateur Radio Repeater, Frequency Suitability, Propagation Modelling, Receiver Sensitivity, VHF Communication

1.0 Introduction

Amateur radio remains a resilient communication platform for community coordination, public-service activities and emergency response when conventional networks are disrupted, congested or unavailable. ITU-R recognises the role of amateur and amateur-satellite services in disaster mitigation and relief [1], while Malaysian research has similarly described amateur radio as a contingency communication technology during emergencies [2]. In Bandar Maharani, Muar, a local VHF repeater can support flood-response coordination, volunteer operations, cycling events and other community activities by retransmitting user signals from an elevated site.

The proposed deployment is a stand-alone local repeater rather than a linking repeater. Its intended service area is Bandar Maharani, Muar town and nearby mukim, not long-range regional coverage. The system must nevertheless be screened against both nearby local and linking repeaters because co-channel or adjacent-channel energy can affect the receiver even when the proposed repeater is not linked to them. Continuous Tone-Coded Squelch System (CTCSS) can reduce unwanted audio activation, but it does not remove RF interference, receiver blocking or desensitisation.

The Malaysian Communications and Multimedia Commission (MCMC) Standard Radio System Plan allocates 144-148 MHz to the Amateur Radio Service and defines paired repeater channels, a 0.6 MHz separation and a 12.5 kHz channel bandwidth [3]. Under that plan, 146.300/146.900 MHz is channel RV87. Regulatory conformity alone does not demonstrate operational suitability: the active status, shift, tone, location and coverage of nearby repeaters must be coordinated, and spectrum monitoring remains necessary before commissioning. Coverage prediction is also required because VHF performance depends on antenna height, terrain, clutter, receiving-antenna height and local obstruction. Recommendation ITU-R P.1546 provides a recognised point-to-area framework over 30 MHz to 4000 MHz [4]. For analogue FM reception, the 12 dB SINAD criterion is commonly used to express minimum usable receiver input [5]. Antenna-height analyses and amateur-radio planning guidance show that elevation can extend line-of-sight opportunity, although buildings, vegetation and terrain can still create shadowing and multipath [6], [7]. Technical treatments of receiver sensitivity further emphasise the relationship between signal level, noise bandwidth and intelligible FM audio [8], [9].

A further practical issue is repeater self-interference. The proposed architecture uses one Motorola GM338 for the transmit path and another for the receive path, with separate antennas. This arrangement may improve isolation, but separation alone does not guarantee adequate protection; transmitter noise, antenna coupling and nearby RF sources can still desensitise the receiver [10]. Rooftop access, installation permission, power availability and maintainability must therefore be evaluated with the frequency and propagation results. Previous work and technical guidance commonly address emergency use, channel planning, propagation, receiver sensitivity or antenna isolation as separate issues. The research gap is the absence of an integrated, locally grounded assessment for the proposed Wisma Daim deployment. The novelty of this study is a single decision framework that combines regulatory channel fit, nearby-channel screening, an explicitly bounded radial coverage model, receiver-sensitivity benchmarking and installation practicality. The objectives are: (i) to evaluate the preliminary frequency suitability of RV87 through spectral-clearance and QRM screening; and (ii) to assess predicted local coverage, receiver-sensitivity headroom and rooftop site suitability. The study contributes a reproducible pre-installation workflow and a cautious technical basis for formal MCMC coordination and field validation.

2.0 Technical Background and Related Works

2.1 VHF Repeater Operation and Frequency Coordination

A conventional analogue VHF repeater receives a low-power user transmission on an uplink channel and simultaneously retransmits the recovered audio on a paired downlink channel. The proposed system follows the Malaysian 0.600 MHz negative-offset arrangement, with users transmitting at 146.300 MHz and receiving the repeater at 146.900 MHz. In engineering terms, usable repeater performance depends on more than nominal channel assignment: transmitter spectral purity, receiver selectivity, antenna isolation, feed-line loss and the strength of other signals at the receiver input all affect system reliability. The proposed use of two Motorola GM338 radios, one for each RF path, is consistent with the required transmit and receive functions, while the product platform supports the relevant VHF channel spacing [11].

Frequency coordination must consider co-channel operation, adjacent-channel energy and strong-signal effects from both local and linking repeaters. A linking repeater is not part of the proposed service architecture, but it remains relevant when its transmitter or receiver assignment falls near RV87. QRM terminology generally describes man-made radio interference and coordination concerns [12], [13]. CTCSS 203.5 Hz can prevent the audio path from opening for signals without the matching tone; however, it cannot reject RF energy already entering the front end, correct overload, or guarantee freedom from desensitisation. Consequently, directory comparison is only an initial screening stage and must be followed by current-status confirmation and an on-site spectrum survey.

2.2 Propagation and Receiver-Performance Foundations

Free-space path loss provides a deterministic reference for the reduction of power density with distance, and Recommendation ITU-R P.525 gives the standard expression used as the ideal baseline [14]. Real terrestrial VHF paths are not free space. ITU-R P.1546 incorporates frequency, distance, effective transmitting-antenna height, receiving-antenna height, time percentage, location percentage and path environment, while ITU-R P.2108 provides complementary treatment of clutter loss [4], [15]. For the Wisma Daim assessment, these principles justify comparing an ideal FSPL baseline with a conservative suburban curve defined for a 25 m AGL rooftop transmitter, a 1.5 m receiving antenna, 10% time and 50% locations.

Receiver performance is commonly benchmarked at a specified SINAD rather than by sensitivity in dBm alone. The Baofeng UV-5RE specification of 0.2

microvolt at 12 dB SINAD is approximately -121 dBm in a 50-ohm system and provides a conservative handheld reference [16]. Field strength can be converted to the power available from an idealised receiving antenna, but the result depends on frequency and receiving-antenna gain. Therefore, the difference between the author-defined 52 dBuV/m planning threshold and nominal receiver sensitivity is treated in this study as threshold-to-sensitivity headroom. It is not a complete installed-system link margin because it does not include every transmitter, feeder, antenna, penetration, body-loss, noise and co-site isolation term.

2.3 Related Works and Research Gap

Existing literature establishes the public-service value of amateur radio and the importance of technical planning, but the evidence is distributed across different problem domains. ITU-R M.2085-1 and the Malaysian study by Johar et al. support amateur radio as a resilient contingency medium [1], [2]. Abdul Kareem and Abbas quantified the coverage effect of antenna height in VHF/UHF line-of-sight communication, while Straw and Hall translated antenna-height considerations into practical guidance for amateur-radio installations [6], [7]. These works support elevated deployment but do not determine whether a particular Muar rooftop, frequency pair and two-radio arrangement are jointly suitable.

Operational directories such as MARTS and RepeaterBook help identify nearby assignments [17], [18], although their records must be treated as time-sensitive planning inputs rather than regulatory proof. At the modelling level, Wang et al. reviewed ideal, empirical and deterministic terrestrial path-loss methods and showed that model selection depends on frequency, range and environment [19]. Wu et al. subsequently compared three prediction models against VHF FM measurements around Beijing and reported strong relative performance by ITU-R P.1546, while also showing that prediction accuracy varied with terrain, frequency and distance [20]. The combined evidence supports P.1546 as a planning reference, not as a substitute for local measurement. The unresolved research gap is therefore methodological and site-specific: prior sources do not provide an integrated pre-installation decision for RV87 at Wisma Daim that simultaneously tests nearby-channel separation, bounded radial coverage, receiver-sensitivity headroom, TX/RX isolation readiness and rooftop practicality. This study addresses that gap through a traceable five-phase workflow. Its contribution is not a claim of measured operational coverage; rather, it is a reproducible analytical screen that identifies whether the proposal is sufficiently credible to proceed to formal coordination, controlled installation and field validation.

3.0 Methodology

3.1 Study Area, Repeater Configuration and Workflow

The proposed site is the flat rooftop above the fourth floor of Wisma Daim, Bandar Maharani, Muar. The Muar District Amateur Radio Association operates from the building and has access for installation, monitoring and maintenance. The rooftop provides greater antenna elevation than a groundlevel installation while remaining practical for technical adjustment. Table 1 consolidates the hardware, regulatory and modelling parameters used in the assessment.

Table 1: Proposed local repeater and planning parameters

Parameter	Value/planning assumption
Deployment purpose	Stand-alone local VHF analogue FM voice repeater; no linking
Proposed site	Wisma Daim flat rooftop, Bandar Maharani, Muar, Johor
MCMC channel	RV87; 146.300 MHz user uplink / 146.900 MHz repeater downlink
Offset/channel bandwidth	-0.600 MHz / 12.5 kHz
CTCSS tone	203.5 Hz
Repeater radio arrangement	2 Motorola GM338 VHF units [11]
Antenna arrangement	Separate Gazten VHF TX and RX antennas; isolation to be verified
Planning antenna heights	TX approximately 25 m AGL; handheld/mobile RX 1.5 m AGL
Propagation interpretation	Land path; mixed urban/suburban clutter; 10% time; 50% locations
Radial analysis range	1-50 km; planning curve rather than a geographic coverage map
Target service area	Bandar Maharani, Muar town and nearby mukim

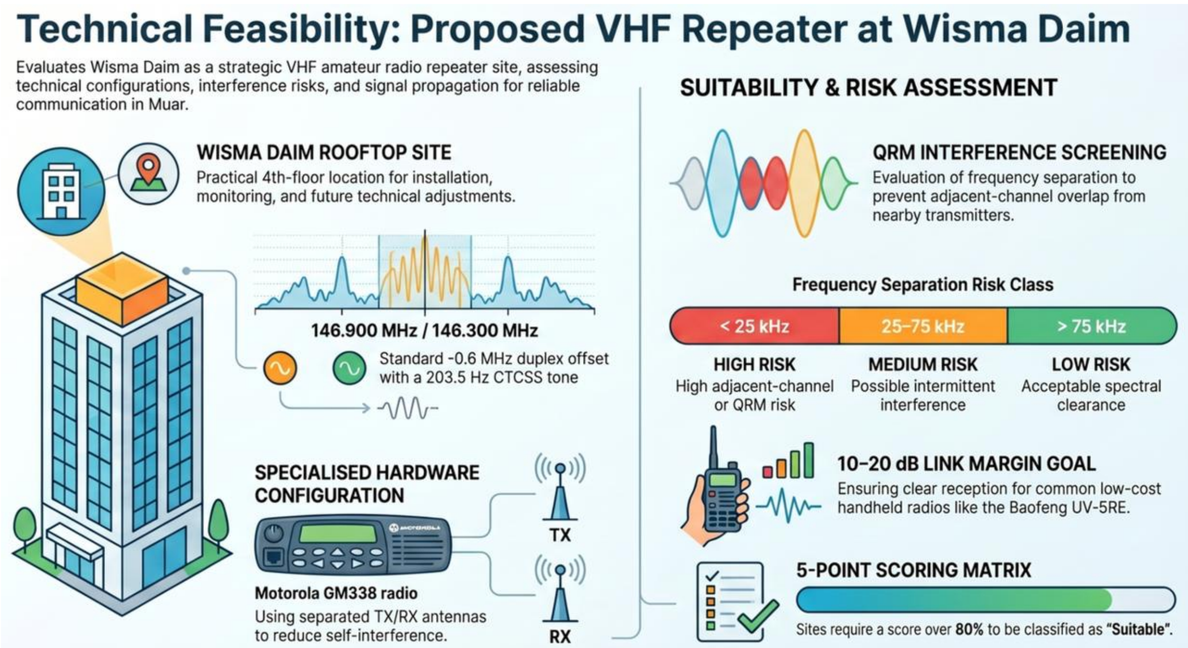

Figure 1: Technical feasibility framework for proposed repeater

Figure 1 provides an integrated visual overview of the proposed site, frequency pair, separated transmit and receive paths, preliminary interference screening and site-decision logic. Figure 2 organises these elements into five analytical phases and Figure 3 expresses the executable technical sequence using standard process, input and decision symbols, including the channel-revision feedback loop and the Suitability Index decision. Post-installation tests remain outside the planning-stage score and are shown as the mandatory next validation stage.

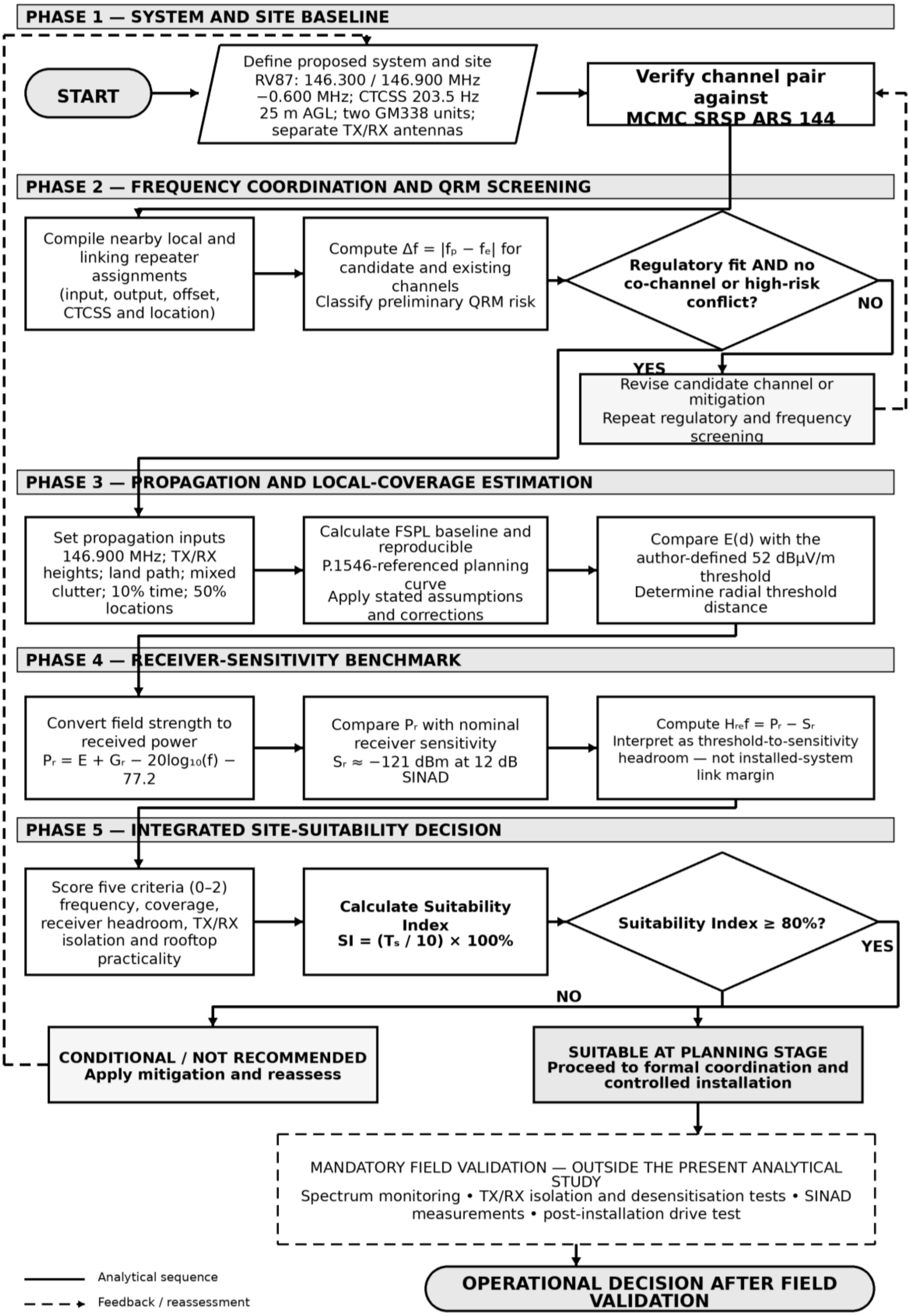

Figure 2: Technical decision flowchart for the five-phase feasibility assessment

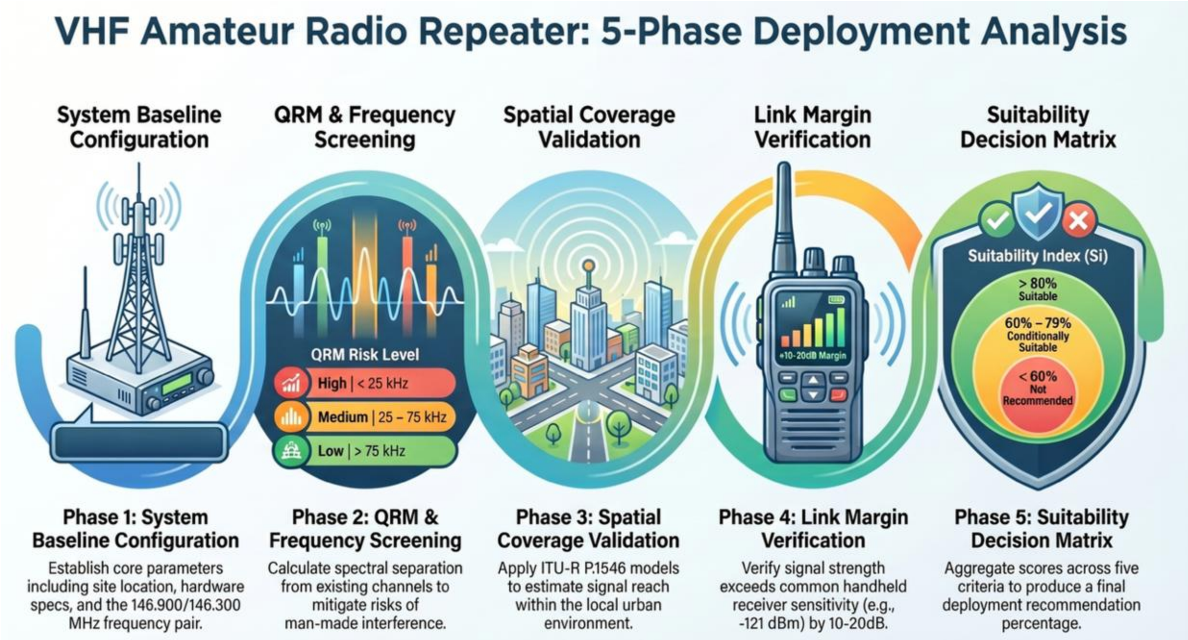

Figure 3: Five-phase deployment analysis framework

Figures 1 and 2 use concise planning labels, whereas Figure 3 gives the technical sequence and post-decision validation. The controlling definitions are low preliminary QRM risk is an absolute separation of at least 75 kHz as shown in Table 2; coverage is a radial prediction rather than field validation; link margin is interpreted as threshold-to-sensitivity headroom; five criteria are scored from 0 to 2; and a Suitability Index of at least 80% is suitable at the planning stage.

Table 2: Frequency-separation and preliminary QRM-risk classes

Absolute separation	Risk class	Planning interpretation
≤ 25 kHz	High	Co-channel/adjacent-channel concern; do not proceed without mitigation
>25 kHz to <75 kHz	Medium	Possible intermittent interference; monitoring and review required
≥ 75 kHz	Low	Acceptable preliminary spectral clearance; field confirmation still required

3.2 Frequency Compatibility and QRM Screening

Frequency screening first verified the RV87 pair against the MCMC channel plan [3]. The proposed 146.900 MHz downlink was then compared with the nearby VHF channels identified in the study dataset, including local repeaters and the Gunung Ledang linking entry. QRM was treated as man-made interference arising from co-channel use, adjacent-channel energy or strong nearby transmissions [12], [13]. Absolute frequency separation was calculated as:

$$\Delta f = |f_p - f_e| \tag{1}$$

where f_p is the proposed downlink and f_e is an identified nearby channel. Table 2 defines the author-adopted conservative screening classes. These classes are a preliminary planning rubric, not an MCMC assignment decision and not a substitute for spectrum monitoring.

3.3 Propagation Prediction and Local Coverage Estimation

The propagation assessment used two deliberately different curves. Free-space path loss (FSPL) provided an ideal upper-bound baseline using the current ITU-R free-space recommendation [14]:

$$FSPL\ (\text{dB}) = 32.44 + 20\log_{10} f_c(\text{MHz}) + 20\log_{10} d_c(\text{km}) \quad (2)$$

A conservative suburban planning curve was then referenced to the P.1546 concepts of land path, antenna height, time percentage, location percentage and clutter [4], [15]. To make the plotted curve reproducible, the study represents it as a log-distance fit to the planning dataset:

$$E\_plan(d_c) = 92.4 - 27.6\log_{10} d_c(\text{km}),\ 1 \le d_c \le 50\ \text{km} \quad (3)$$

where $E\_plan(d_c)$ is in dBμV/m and d is in kilometres. The corresponding FSPL field-strength baseline uses the same 1 km reference, $E\_FSPL(d_c)$ = 92.4 − $20\log_{10} d_c(\text{km})$. The value 52 dBμV/m is an author-defined conservative planning threshold, not an ITU-R protection criterion or receiver-sensitivity specification. Because precise site coordinates, a digital elevation profile, final effective radiated power and route-specific clutter measurements were not available, the adjusted curve is described as P.1546-referenced rather than a full terrain-profile implementation of Recommendation P.1546-6. It is a radial pre-installation comparison and cannot establish guaranteed coverage in a named mukim or along a specific road.

3.4 Receiver-Sensitivity Benchmarking and Planning Headroom

The Baofeng UV-5RE was retained as a common low-cost handheld reference. Its published receiver sensitivity is 0.2 μV at 12 dB SINAD, approximately 121 dBm in a 50 ohm system [16]. The study converts the reference field strength to received power for a 0 dBi receiving antenna using:

$$P_{ref} = E_{ref} + G_r - 20\log_{10} f_c(\text{MHz}) - 77.2 \quad (4)$$

Table 3: Reference-threshold-to-sensitivity headroom interpretation

Headroom, H_{ref}	Interpretation
≥ 20 dB	Strong analytical planning headroom; field validation still required
10-19 dB	Acceptable analytical planning headroom
0-9 dB	Marginal planning headroom
< 0 dB	Reference level is below nominal receiver sensitivity

The resulting planning headroom is $H_{ref} = P_{ref} - S_r$, where S_r is the nominal receiver sensitivity. This quantity is not labelled an actual link margin because it excludes final transmitter power, feeder loss, TX antenna gain, handheld-antenna efficiency, body shielding, penetration loss, receiver noise environment and co-site desensitisation. Table 3 therefore interprets only reference-threshold-to-sensitivity headroom.

3.5 Site-Suitability Scoring

Five criteria were scored from 0 to 2. The rubric in Table 4 explicitly distinguishes predicted performance from verified performance, resolving the risk of assigning full credit to untested receiver headroom or antenna isolation.

Table 4: Site-suitability scoring rubric

Criterion	2 - Acceptable	1 - Mitigation/verification	0 - Not acceptable
Frequency compatibility	Low-risk separation; no co-channel identified	Medium risk or incomplete status data	Co-channel/high-risk conflict
Predicted local coverage	Planning threshold supports intended local radius	Marginal/partial predicted coverage	Threshold not achieved
Receiver headroom	≥20 dB and field-verified	≥10 dB predicted but unverified	<10 dB or negative
TX/RX antenna arrangement	Isolation verified	Separate antennas planned; isolation untested	No practicable isolation
Rooftop practicality	Permission, access and maintenance feasible	Conditional access or remedial work	No permission/access

The Suitability Index (*SI*) was calculated from the total score T_s out of a maximum of 10 and the decision is conveyed in Table 5:

$$SI = \left[{}^{T_s}\!/_{10} \right] \times 100\% \tag{5}$$

Table 5: Suitability decision bands

Suitability Index	Decision
≥ 80	Suitable at the planning stage
60% - 79%	Conditionally suitable
< 60%	Not recommended

4.0 Results and Discussion

4.1 Frequency Compatibility

Channel RV87 is a valid 12.5 kHz repeater pair in the MCMC SRSP [3]. Table 6 shows downlink screening against the nearby channels compiled for the study. The closest identified entry was 146.975 MHz at Segamat, separated by 75 kHz; the remaining separations were 100-200 kHz. All were therefore classed as low risk under Table 2, and no direct co-channel match was identified in the dataset. The change from the earlier 146.925 MHz candidate to 146.900 MHz increased separation from the nearest listed channel from 50 to 75 kHz.

Table 6: Preliminary nearby-channel compatibility result

Station/site	Role in screening	Listed channel	Separation	Risk
9M4RSG / Segamat	Nearby local entry	146.975 MHz	75 kHz	Low
9M4RBP / Batu Pahat	Nearby local entry	146.800 MHz	100 kHz	Low
9M4RGL / Gunung Ledang	Linking entry; interference source only	147.100 MHz	200 kHz	Low
9M4RML / Bukit Beruang	Nearby local entry	147.025 MHz	125 kHz	Low
9M4RMN / Bukit Nyalas	Nearby local entry	146.775 MHz	125 kHz	Low

The directory information was compiled from the MARTS and RepeaterBook listings available to the study [17], [18]. Because online directories can be incomplete or stale, Table 6 is evidence of preliminary clearance only. Formal coordination must verify every nearby station's current status, downlink, uplink, shift, CTCSS and location. In addition, 203.5 Hz CTCSS should not be interpreted as protection against RF overlap; a strong adjacent signal can still degrade the GM338 receiver.

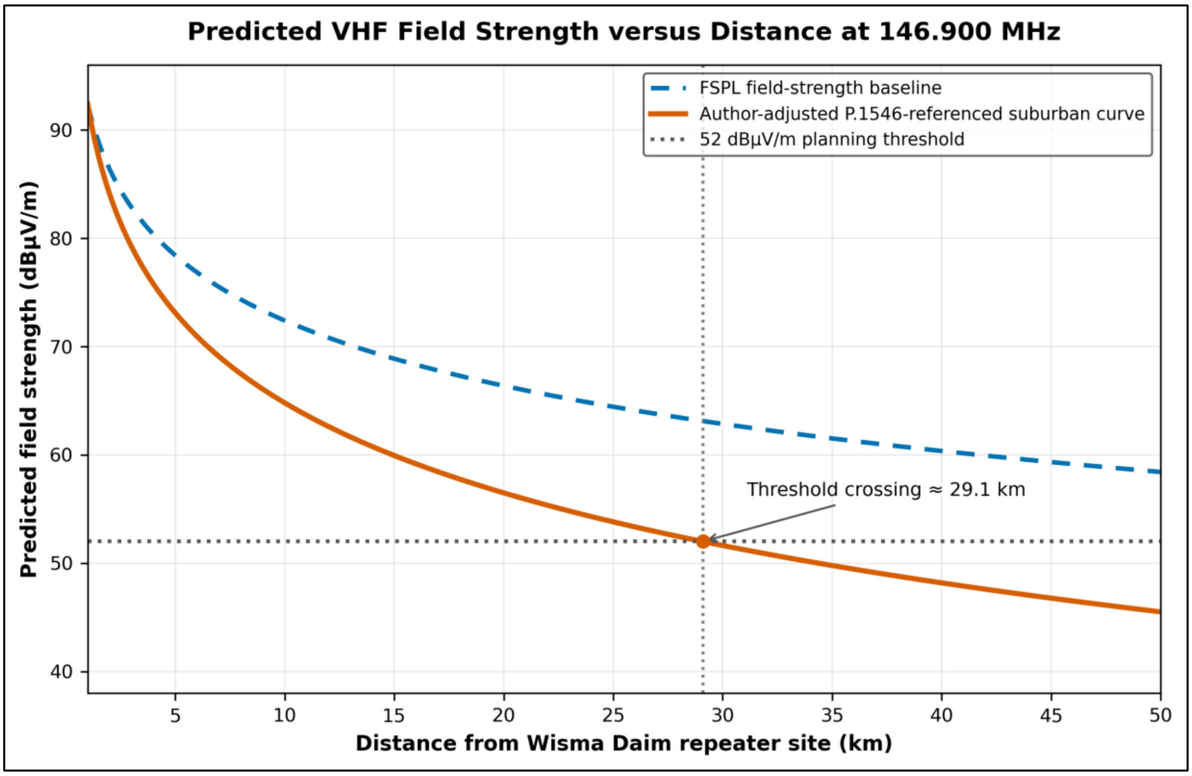

Figure 4: FSPL and P.1546-referenced suburban planning curves at 146.900 MHz

4.2 Propagation and Predicted Local Coverage

Figure 4 compares the ideal FSPL field-strength baseline with the author-adjusted P.1546-referenced suburban curve. The adjusted curve reaches the 52 dBμV/m planning threshold at approximately 29.1 km, whereas the FSPL baseline remains above the threshold throughout the plotted range. The difference illustrates why an ideal free-space curve is an upper bound and why clutter and environment must be represented in pre-installation planning.

The result is consistent with recent propagation literature in two ways. A 2023 review distinguishes ideal, empirical and deterministic models and stresses that model suitability depends on frequency, distance and environment [19]. More recently, measurement-based VHF FM work over Beijing found that ITU-R P.1546 performed best among three evaluated models, but also showed that performance varied with terrain, distance and frequency [20]. These findings support P.1546 as a planning reference while reinforcing the need for local calibration. Consequently, the 29.1 km crossing indicates a radial planning boundary, not confirmed coverage of Pagoh or any other specific locality. A route-based terrain model and drive-test measurements are required for geographic claims.

4.3 Receiver-Sensitivity Headroom

At 146.900 MHz, 52 dBμV/m corresponds to approximately -68.5 dBm for a 0 dBi receiving antenna. Compared with the UV-5RE nominal sensitivity of about -121 dBm at 12 dB SINAD [16], the reference-threshold-to-sensitivity headroom is 52.5 dB, as summarised in Table 7. The calculation demonstrates that the selected planning threshold is far above the receiver's nominal sensitivity limit; it does not demonstrate a 52.5 dB installed-system link margin.

Table 7: Receiver-sensitivity benchmarking result

Assessment item	Value/interpretation
Reference frequency	146.900 MHz
Author-defined field-strength threshold	52 dBμV/m
Receiving-antenna reference	0 dBi
Equivalent received power	Approximately -68.5 dBm
UV-5RE sensitivity	Approximately -121 dBm at 12 dB SINAD
Threshold-to-sensitivity headroom	Approximately 52.5 dB; analytical and not field-verified

Practical reception can be lower because a handheld rubber-duck antenna may have negative effective gain and may be used near the body, indoors or inside a vehicle. Receiver blocking, feeder loss, polarisation mismatch and local shadowing are also excluded from the conversion. For this reason, the headroom criterion received a conservative site score of 1 rather than 2 until

SINAD and received-signal measurements are completed.

4.4 Integrated Site-Suitability Decision

The integrated site-suitability assessment for the proposed local VHF is presented in Table 8. The assessment considers frequency compatibility, predicted local coverage, receiver headroom, TX/RX antenna arrangement, and rooftop practicality. Each criterion is scored according to the strength of the available technical evidence with a maximum score of 2. The proposed Wisma Daim site achieved a total score of 8 out of 10, corresponding to an 80% Suitability Index.

Table 8: Site-suitability assessment for the proposed local VHF repeater

Criterion	Score	Evidence/limitation
Frequency compatibility	2	RV87 compliance; 75-200 kHz preliminary separation
Predicted local coverage	2	Threshold crossing at about 29.1 km; radial model only
Receiver headroom	1	52.5 dB analytical headroom; no field verification
TX/RX antenna arrangement	1	Separate antennas planned; isolation/desense untested
Rooftop practicality	2	Permission, access and maintenance feasible
Total / Suitability Index	8/10	80% - Suitable at the planning stage

The 80% Suitability Index indicates that the Wisma Daim site is technically suitable for further planning and field validation. The assessment is supported by RV87 compliance, preliminary channel separation, predicted local coverage and feasible rooftop access. The predicted coverage is consistent with proven VHF propagation-planning approaches [21], [22]. However, field validation remains necessary because local propagation and environmental conditions can affect actual signal strength [22]. The lower scores for receiver headroom and TX/RX antenna arrangement reflect the absence of field verification rather than demonstrated technical deficiencies. Final suitability should therefore be confirmed through spectrum monitoring, antenna-isolation measurements, drive testing and receiver-performance verification.

5.0 Conclusion

This study presented a comprehensive technical evaluation of frequency suitability, coverage performance, and site feasibility for the proposed 146.900 / 146.300 MHz local VHF amateur radio repeater deployment at Wisma Daim, Bandar Maharani, Muar, Johor, with clear evidence demonstrating that the objectives were successfully achieved. The spectral clearance analysis verified that the selected frequency pair maintained acceptable separation (75–200 kHz) from nearby VHF amateur channels, thereby satisfying the objective of minimising interference risk, while the propagation modelling results confirmed that the Wisma Daim rooftop provided adequate and practical localised coverage within Bandar Maharani and its surrounding mukim, meeting the objective of reliable service delivery. Furthermore, the downlink receiver sensitivity assessment indicated that the predicted signal levels remained significantly above the minimum threshold of a typical handheld receiver, supporting practical usability under planning assumptions despite expected real-world losses. These findings established that the proposed configuration was technically suitable at the planning stage, with additional strengths in site accessibility, installation feasibility, and maintenance practicality; however, the analytical nature of the study necessitates further validation, and future work should therefore focus on comprehensive post-installation field verification, including spectrum monitoring, drive testing, SINAD-based receiver measurements, antenna optimisation, and on-air performance evaluation to confirm real-world operational reliability and refine system performance.

Acknowledgement
The authors gratefully acknowledge the institutional, logistical, and technical support provided by Politeknik Merlimau Melaka, Muar Amateur Radio Society, and CTS Energy Resources (M) Sdn. Bhd. in support of this study.

Author Contributions
Syamsul Bahri Mohamad: Conceptualisation, Methodology, Investigation, Formal Analysis, Data Curation, Visualisation, Writing – Original Draft, Project Administration; **Shahidzwan A. Rahim**: Methodology, Investigation, Validation, Resources, Writing – Review & Editing; **Azmi Ali**: Investigation, Validation, Resources; **Mohd Nor Zamani Abdul Afri**: Validation, Resources, Formal Analysis, Writing – Review & Editing.

Conflicts of Interest
The authors declare that they have no conflicts of interest.

References
[1] International Telecommunication Union, *Role of the Amateur and Amateur-Satellite Services in Support of Disaster Mitigation and Relief*, Rep. ITU-R M.2085-1, Geneva, Switzerland: ITU, 2011.
[2] A. Johar, W. R. S. Osman, and A. A. Aziz, "Amateur radio communication technology contingency communication in emergency situation," in *SHS Web of Conferences*, vol. 33, 2017, Art. no. 00023, doi: 10.1051/shsconf/20173300023.
[3] Malaysian Communications and Multimedia Commission, *Standard Radio System Plan: Requirements for Amateur Radio Service Operating in the Frequency Band of 144 MHz to 148 MHz*, MCMC SRSP ARS 144, Cyberjaya, Malaysia, Nov. 2022.

[4] International Telecommunication Union, *Method for Point-to-Area Predictions for Terrestrial Services in the Frequency Range 30 MHz to 4000 MHz*, Recommendation ITU-R P.1546-6, Geneva, Switzerland: ITU, Aug. 2019.

[5] National Institute of Justice, *Fixed and Base Station FM Receivers*, NIJ Standard-0206.01, Washington, DC, USA: U.S. Department of Justice, Jul. 1988.

[6] F. A. E. Abdul Kareem and R. H. Abbas, "An analytic study for the effect of antenna height on line-of-sight VHF/UHF communications coverage distance applied to Baghdad city," Periodicals of Engineering and Natural Sciences, vol. 7, no. 4, pp. 1965−1976, 2019, doi: 10.21533/pen.v7.i4.1799.

[7] R. D. Straw and G. L. Hall, *Antenna Height and Communications Effectiveness: A Guide for City Planners and Amateur Radio Operators*, 2nd ed. Newington, CT, USA: American Radio Relay League, 1999.

[8] D. Layne, "Receiver sensitivity and equivalent noise bandwidth," *High Frequency Electronics Magazine*, vol. 22, 2014. [Online]. Available: https://highfrequencyelectronics.com

[9] J. DePolo, "Measuring FM receiver sensitivity," *Repeater Builder Technical Information Page*, 2001. [Online]. Available: https://www.repeater-builder.com

[10] M. Morris, "Isolation between the repeater receiver and RF sources," Repeater Builder Technical Information Page. [Online]. Available: https://www.repeater-builder.com

[11] Motorola, *GM338/GM398 Conventional MDC Mobile Radio*, Product Brochure, 2009.

[12] Radio Amateurs of Canada, "VHF, UHF and repeater definitions." [Online]. Available: https://www.rac.ca

[13] Upstate New York Repeater Council, "Repeater coordination terminology." [Online]. Available: https://www.unyrepco.org

[14] International Telecommunication Union, *Calculation of Free-Space Attenuation*, Recommendation ITU-R P.525-5, Geneva, Switzerland: ITU, Nov. 2024.

[15] International Telecommunication Union, *Prediction of Clutter Loss*, Recommendation ITU-R P.2108-1, Geneva, Switzerland: ITU, Sep. 2021.

[16] Baofeng, "UV-5RE dual-band VHF/UHF radio." [Online]. Available: https://www.baofengradio.com/products/uv-5re/1000

[17] Malaysian Amateur Radio Transmitters' Society, "List of repeaters." [Online]. Available: https://marts.org.my/ver2/repeaters/west-malaysia/

[18] RepeaterBook, "Malaysia amateur radio repeaters." [Online]. Available: https://www.repeaterbook.com/row_repeaters/Display_SS.php?state_id=MY

[19] J. Wang, Y. Hao, and C. Yang, "The current progress and future prospects of path loss model for terrestrial radio propagation," *Electronics*, vol. 12, no. 24, Dec. 2023, Art. no. 4959, doi: 10.3390/electronics12244959.

[20] Z. L. Wu, Y. L. Hao, J. Wang, Q. Z. Hao, and C. Yang, "Assessment and exploring three propagation prediction models for FM broadcasting over Beijing and its surrounding regions," *Radio Science*, vol. 61, no. 1, Jan. 2026, Art. no. e2025RS008391, doi: 10.1029/2025RS008391.

[21] J. Wang, Y. Hao, and C. Yang, "An entropy weight-based method for path loss predictions for terrestrial services in the VHF and UHF bands," *Radio Science*, vol. 58, no. 9, 2023, Art. no. e2023RS007769, doi: 10.1029/2023RS007769.

[22] K. C. Igwe, "Characteristics of VHF line-of-sight propagation for point-to-area network in a tropical atmosphere," *Journal of Science and Technology*, vol. 14, no. 2, pp. 8−19, 2022, doi: 10.30880/jst.2022.14.02.002.